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Collaborating on Sustainable Interflow Water Collection: The Erfeng Irrigation Canal System from the Period of Japanese Rule in Taiwan

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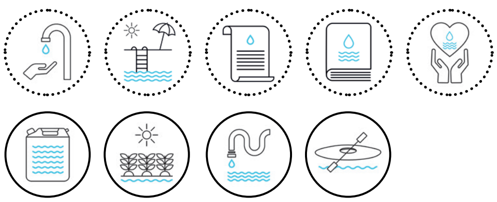
While the world struggles with limited water resources, interflow water is a hidden gem of a solution. Interflow is an important water source contributing to river flow. It is the movable water in the unsaturated zone, or vadose zone, which may return to the stream or go into the riverbed. The collection of interflow water was included in the design of the Erfeng Irrigation Canal System (EICS) during the Japanese period in Taiwan (1895–1945), and it is still used in the EICS in Pingtung in southern Taiwan. Today, urbanization and changes in land usage have reduced the EICS's irrigation function. At the same time, intensive habitation has introduced pollution to the canal area. Furthermore, new extensions and rebuilt facilities of the irrigation infrastructure have minimized historic values. We are involved in working to maintain the canal in a way that safeguards cultural heritage values and to expand other functions of EICS, such as by installing micro-hydro facilities over the canal to preserve its importance to local communities.

KEY THEMES



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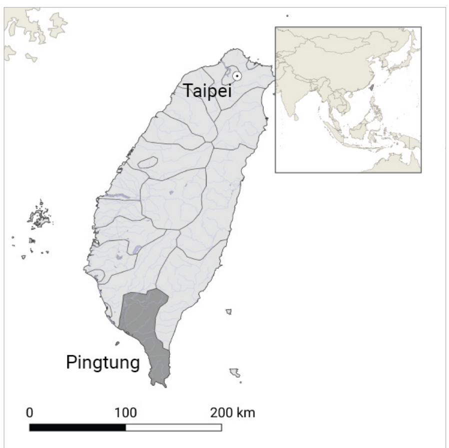


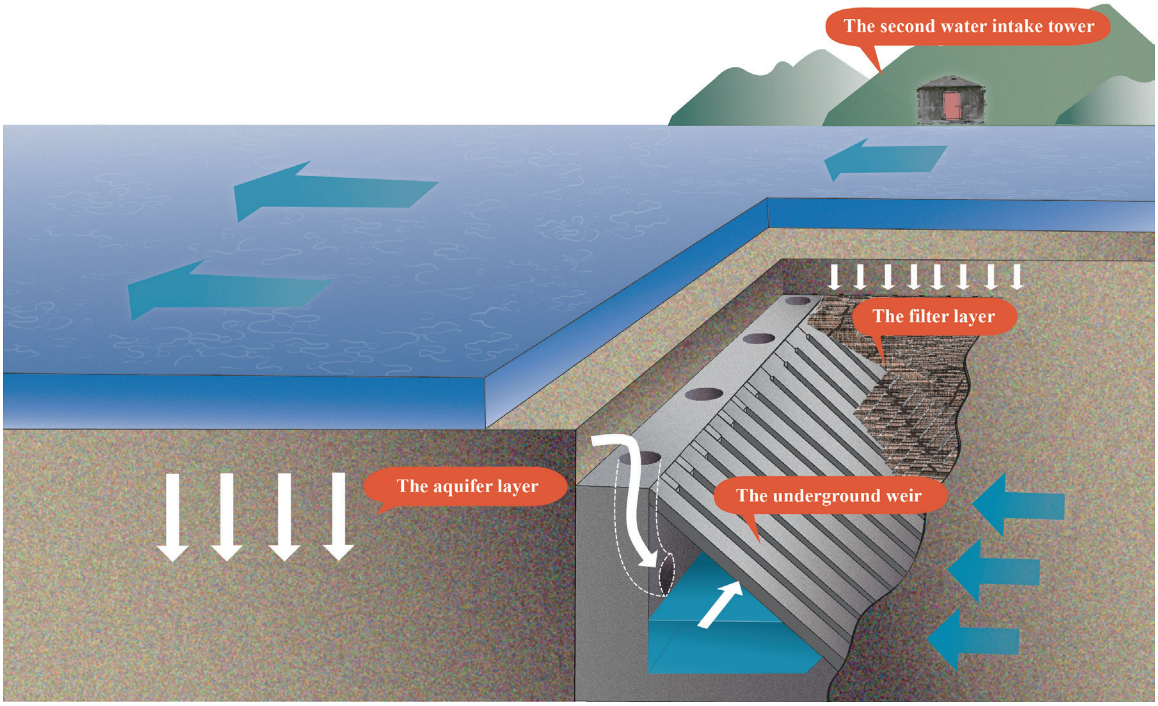
< Fig. 1 The EICS canal in the Pingtung farming area (Source: Szu-Ling Lin and Cheh-Shyh Ting).

Building the Erfeng Irrigation Canal System

The use of underground weirs to collect interflow water as a sustainable method of irrigation is not unique to Taiwan and Japan, but is an important hydraulic technology found worldwide. During the Japanese period in Taiwan, the Japanese wanted to plant sugarcane in a dry plain. Because of the slope of river and stone in the Pingtung area, dry plain conditions are common. The EICS used underground weirs to collect interflow water under the riverbed of the Linbian River to solve the problem of water shortage during the dry season. This kind of technology depends on precise water conservancy surveys to find a suitable water intake location. Then, an underground weir is installed to intake interflow water. With correct measurements of terrain height, it is possible to use gravity to send the captured interflow water to a farm 3436 meters away. In this way the EICS turned waste rubble into fertile fields of sugarcane.

During the Japanese colonial rule of Taiwan, the Japanese-owned Taiwan Sugar Company built two irrigation canals to irrigate sugarcane plantations and rice fields in the Pingtung Plain area in 1923 and 1925: the EICS and the Lili River Irrigation Canal System. EICS is larger and more famous than the Lili River Irrigation Canal System. EICS and its underground weir was designed by engineer Nobuhei Torii, who sought a way to collect interflow water from the riverbed of the Linbian River and solve the problem of water shortage during the long dry seasons in the Pingtung Plain (Torii 1936). After five years of investigation, Nobuhei Torri chose the proper site to bury the underground weir of EICS.

To build this irrigation canal system, the Japanese had to negotiate with local Indigenous people to obtain the territory and hire workers to build the irrigation canal system. Therefore, this irrigation canal system is a water conservancy project made possible by cooperation between the colonists and local Indigenous people. The underground weir of EICS consists of four parts: a trapezoidal weir, an arched tunnel, a catchment culvert and two water intake towers (a translation of the Japanese “*第一與第二取入水塔*”) that function as manholes for maintenance access. The foundation of a water intake tower is laid underground, with the rest of its structure extending above ground. The trapezoidal weir, arched tunnel, and catchment culvert are laid to a depth of 2–7 meters beneath the alluvium gravel of the riverbed. The trapezoidal weir is 2.87 meters high, 0.91 meters wide at the top, increasing to 3.94 meters wide at the bottom. Its water intake surface consists of inclined concrete columns arranged to create a 25 per cent slotted seepage surface, forming a right-triangular water channel that is 1.82 meters wide at the bottom with a height of 1.82 meters. The trapezoidal weir, the main structure of the canal system, has a total length of ca. 328 meters, stretching from east to west at a gradient of 1/100 (figs. 2 and 3). The western end of the weir is connected to the eastern end of the arched tunnel, which admits interflow water from the weir into the water intake tower. The tower, which is the endpoint of the structure, is ca. 1.5 meters in width and 8.4 meters in height. The interflow water flows from the arched tunnel through the water intake tower and eventually enters the conveyance waterway. The conveyance waterway is ca. 3.6 kilometers long. A diversion structure (figs. 1 and 4) divides the irrigation water into three routes leading to farms. Using precise topographical measurements, Nobuhei Torii designed a suitable underground weir structure that can successfully collect interflow water without electricity and can use natural gravity to allow water for irrigation to flow to farms 3.6 kilometers away. The area of the irrigated farms were about 3,000 hectares



^ Fig. 2 In the EICS, the underground weir and the second water intake tower (Source: Szu-Ling Lin and Cheh-Shyh Ting).

during the Japanese period. Today, the area of irrigated farms is 2,193 hectares.

Preserving and Managing the Water Heritage of the Erfeng Irrigation Canal System

The canals and sugarcane plantations continue to be maintained by the Taiwan Sugar Company, which was inherited from the Japanese after World War II. The farms stopped growing sugarcane in 1998, and the company is leasing most of its farms, which are being used to grow other crops. Furthermore, some water from EICS contributes to the local Indigenous communities' daily water supply. In 2008 the system was registered as a cultural landscape under the Cultural Heritage Preservation Act because it qualified as industrial heritage with scientific value. This cultural landscape demonstrates one way that human beings can overcome constraints of the natural environment and use its characteristics to create irrigation canals that make it possible to grow crops. In 2017 the underground weir in EICS was part of a large-scale excavation and restoration project after damage occurred as a result of changes in the topography of the riverbed. The construction of the underground weir could then be documented by the EICS (fig. 5).

Today, maintaining and using water as a resource has become a major focus of human activity. Systems of land reclamation, water supply, irrigation, submergence, sewage and micro-hydropower generation help build, define and sustain societies. Water control has long been a strategic social and political consideration for communities.

After World War II, Indigenous people moved

^ Fig. 3 The interior of the underground weir in the EICS (Source: Szu-Ling Lin and Cheh-Shyh Ting).

from their original village to an area along the line of the delivery waterway (conveyance waterway) of EICS. In the early period of the initial relocation in the 1950s, the Indigenous people of this area did not pay close attention to domestic wastewater treatment and facilities. Nor did the government invest adequately in infrastructure. At present, the use of interflow water by the residents along the EICS has significantly increased and pipes are covering the conveyance waterway (fig. 6). Residents have been improperly withdrawing water from the EICS. In recent years, the number of residents has increased, and the Pingtung County Government is making progress improving wastewater treatment facilities. In the future, the EICS's excess interflow water could be diverted to the Taiwan Water Company and used for people's livelihoods, so that the EICS can continue to operate sustainably.

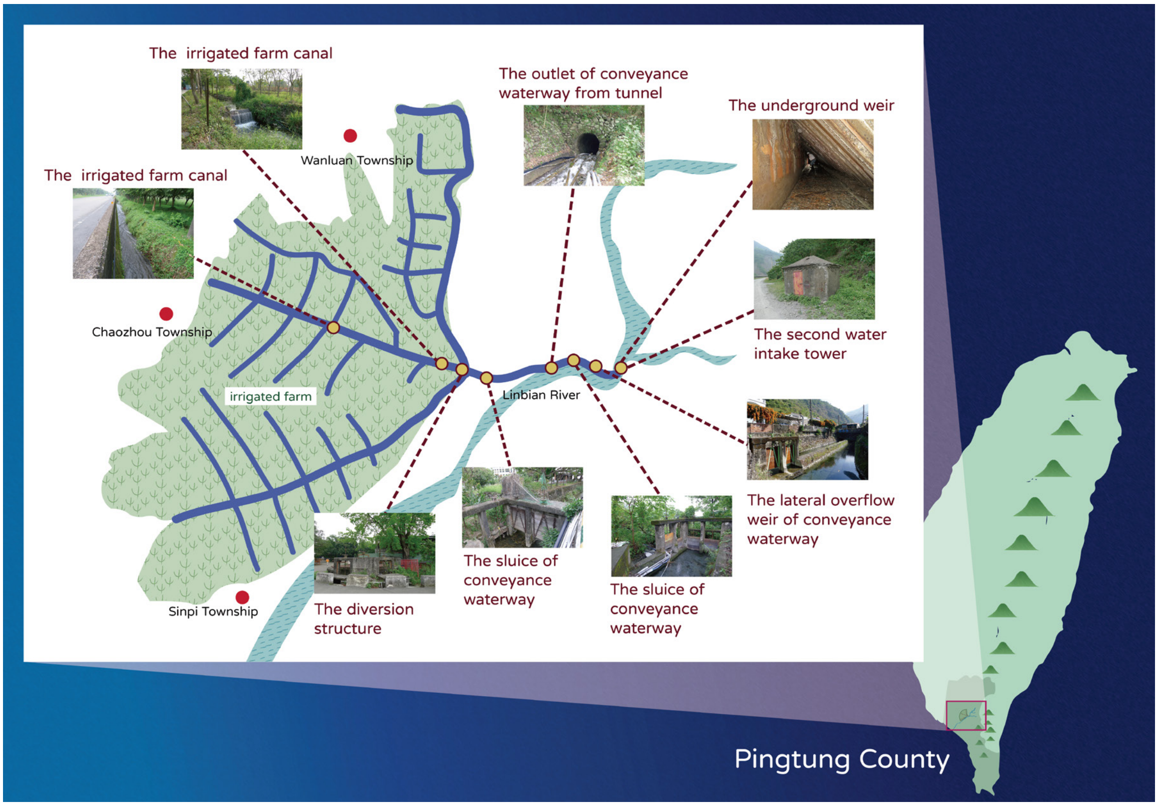
Water heritage conservation has a diplomatic function. The design and construction of the EICS is an example of sustainable and ecological thinking from a century ago. In 2008 when the EICS was listed as cultural heritage in Taiwan, the value of science and technology in the cultural landscape that was shaped by academic and cultural exchanges between Taiwan and Japan was recognized. This recognition is the basis for sustainable management as well. For the people of Taiwan and Japan, the need for management has led to a greater awareness of history. The preservation of the cultural heritage of the EICS has even led to cultural exchanges between Taiwan and Japan. Many Japanese tourists have been drawn by the EICS to visit the Pingtung Plain area. Because of such achievements, Prof. Cheh-Shyh Ting, one of the authors of this article, was honored with an award by the Japanese imperial family in 2023.

To expand the value of the EICS, engineers have been attempting to develop green micro-hydro power energy from the water collected by the EICS irrigation system. The power can be used by the local communities. Pingtung County is an area with abundant water resources, and the county government currently promotes special Green Micro-hydro Power Energy Development Projects in the EICS. In demonstrating and coordinating the micro-water green belts, the equipment has been installed, without interfering with the original water conveyance, to promote the monitoring and development of water conservation and green energy in the community.

Conclusion: Challenges to Developing a More Sustainable Water System

There are three main concerns motivating the current conservation approaches toward the EICS:

1. With intensified urbanization and rap-



^ Fig. 4 The location and layout of the EICS (Source: Szu-Ling Lin and Cheh-Shyh Ting).

id changes in land use, many irrigation canals in the farming area have been destroyed.

2. The improper use of water by residents living along the delivery waterway pollutes and damages canals.

3. To improve the efficiency of water delivery or to expand the road, some canals in the farming area have been rebuilt, which has resulted in the loss of historical value.

Meanwhile, many EICS canals in the farming area have been partially destroyed. Moreover, some of the EICS canals in the farming area were converted to modern canal technology because of enhanced hydraulic efficiency. For the farming area of 3,000 hectares irrigated

^ Fig. 5 The construction of the underground weir in EICS (Source: Szu-Ling Lin and Cheh-Shyh Ting).

^ Fig. 6 The pipes covering the conveyance waterway of the EICS (Source: Szu-Ling Lin and Cheh-Shyh Ting).

by the EICS, urbanization has brought many changes to the irrigation route. The function of the town has changed and reduced the scope, raising questions about how to preserve the original irrigation function and the original facilities of the ECIS in the future. Preservation of the century-old irrigation project will also preserve important cultural heritage that includes knowledge of people, things, time and place. For this to happen, it will be necessary for the government and the public to strengthen communication.

In 2022 the Pingtung government launched a cultural heritage conservation plan to ensure a conservation area covered all the EICS canals in the farming area. This project is attempting to balance new kinds of land use with the preservation of the original EICS canals in the farming area. Interviews with stakeholders are clarifying the complex issues surrounding land use and preservation. Light detection and ranging (LIDAR) technology is being used along with field investigation and historical document research to reconstruct the original EICS channels in the farming area. The project follows proper preservation methods. According to the LIDAR results, we can observe changes in the canal structures in the farming area of EICS from the Japanese period to the present.

Here we recommend some important principles to follow in the conservation of EICS. When discussing the cultural heritage value of water resource engineering, it is necessary to pay attention to the integrity and authenticity of the operation of a single water resource engineering system, and to fully understand the systematic or serial relationship between different kinds of water resource engineering systems, to avoid a narrow vision that focuses on the value or preservation of a single or partial building or structure. It is important to clearly discuss the value of water as cultural heritage. Therefore, efforts to conserve the cultural heritage of water infrastructure should recognize the importance of

1. The integrity of a single water resource engineering system.
2. The authenticity of single water resource engineering equipment and structure. This will involve the application of engineering technology in different periods, which must be categorized according to the timing of the application of the engineering technology.
3. The systematic and serial correlation of different water resource engineering systems.

Implementing these steps will take time.

Furthermore, in terms of the national development of green energy policy, due to the stable flow of the waterway, it has been evaluated as suitable for hydropower generation. A set of demonstration micro-hydraulic power generation units was set up as a test, and the results were positive. The development of the power system makes the development of water conservancy resources on the waterway more sustainable. With cultural preservation, the interflow water conservancy wisdom of the past can be passed on to future generations and the new function of green energy can expand the system's value.

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