# Impact of Reservoir Water Level and Precipitation on Agricultural Channels: Field Investigation and Analysis


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# Abstract

After learning about the news of drought in Kinmen, we decided to conduct observation of the agricultural water supply channels adjacent to our home, as we noticed that the supply of water seemed unstable. We wanted to understand the reason for the unstable water supply by observing the relationship between the water supply channels, the linked Chin-Sha Reservoir , and the local rainfall. Through field exploration, we found that due to the unique structure of the channels, only the central channel could directly receive water from the Chin-Sha Reservoir , while the ends channel could only receive the excess water from the central channel, causing large fluctuations in the water level. Additionally, after 10 weeks of filming and observation, we observed the varying water levels at the ends channel. We then compared the rainfall data, reservoir water level data, and the water levels of the ends channel and found that although the water levels of the ends channel was not linearly correlated with rainfall, they were positively correlated with the water levels in the channels.

# Motivation

Kinmen is a small island with a simple terrain surrounded by the sea. Despite experiencing a tumultuous wartime era, it has preserved profound relics, culture, and local customs. Its unique military position has always shrouded Kinmen in a mysterious veil, until it slowly became active after opening up in 1993.

Kinmen receives an average of about 1,100 millimeters of rainfall per year, but its water resources are not abundant. Through the construction of reservoirs, channels, and other water conservancy facilities, farmers grow dry crops such as sorghum and wheat for their livelihoods. As time progressed, the people on the island began to think about how to innovate in agriculture and developed surrounding products. Among them, Kinmen sorghum wine became famous overnight at the World Baijiu Awards, attracting a steady stream of tourists and becoming Kinmen's economic lifeline.

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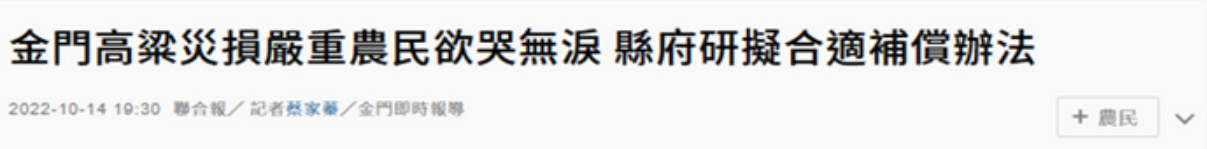
However, in the summer of 2022, we saw news about drought, "Kinmen's sorghum harvest suffered severe losses, and farmers were crying with no tears," mentioning that channels can make water supply slightly more stable and alleviate the impact of drought. At this point, Jing-Sian suddenly thought, "But it doesn't seem like that next to my house?" This aroused our curiosity, and after field exploration, we found that the channel supply was not stable as she said, and the water level changes at both ends were particularly severe. We were puzzled: What factors affect the water level in the channel? Is it rainfall or related to the reservoir? So we followed the channel to the supply source - Chin-Sha Reservoir , and traced the rainfall and channel changes, hoping to understand the relationship between the three.




▲Fig1: The news about drought in Kinmen

▲Fig2: Sorghum field besides the channel

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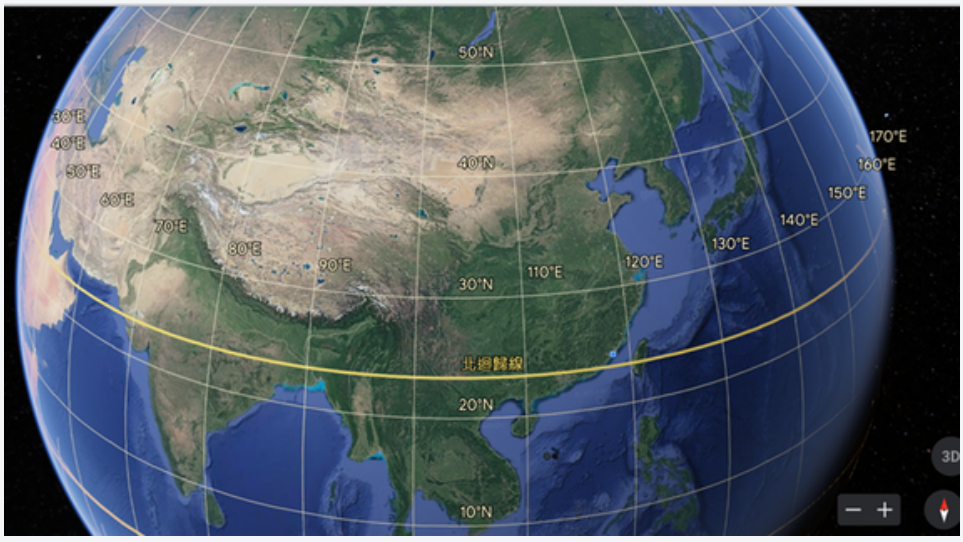
# Research purposes

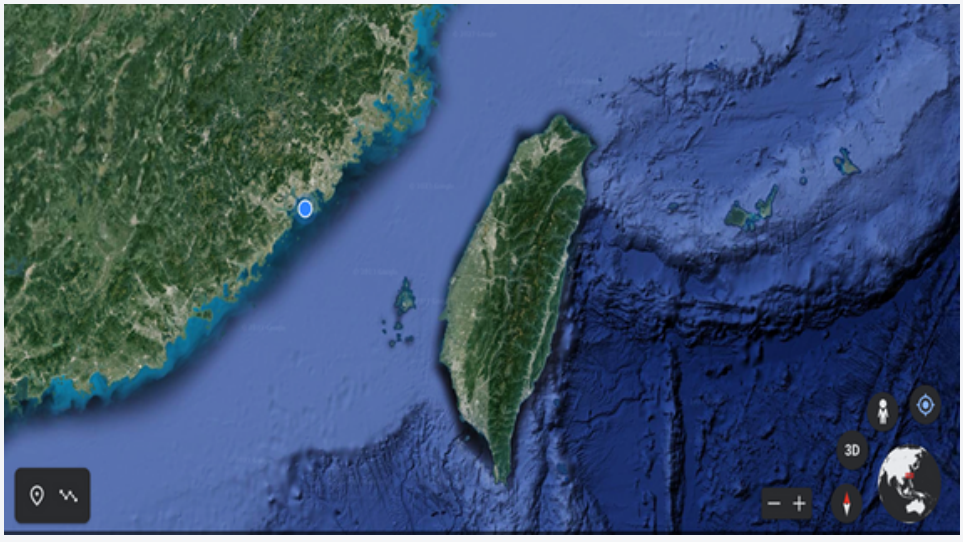
- To explore the relationship between the water level of Chin-Sha Reservoir and the water level of the channel
- To analyze the reason that the water level of the ends channel dropped

# Background

## 1. Geography Location of Kinmen




▲Fig3: Kinmen, an island on the east of Asia,
is at latitude 24°26'39.9"N, longitude 118°22'17.9"E



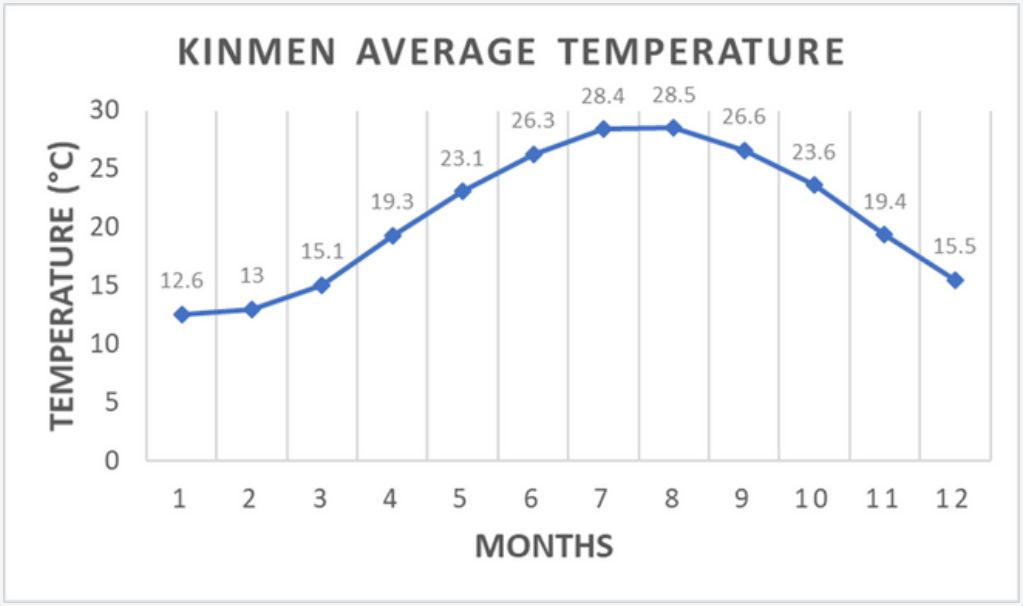
▲Fig4: located at the estuary of the Min River

## 2. The Relative Position Of The Observation Object

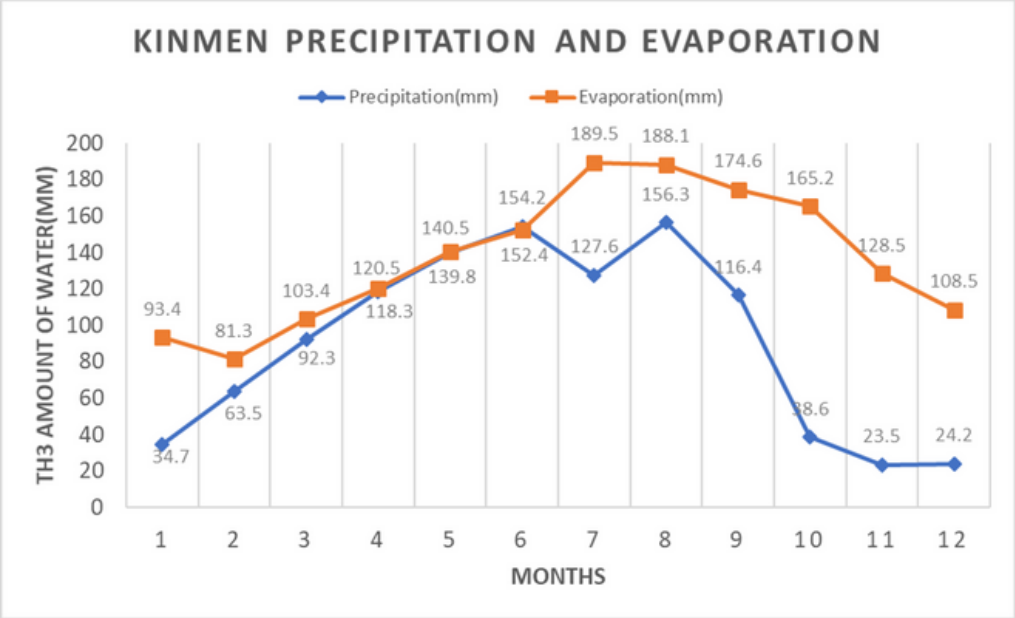

▲Fig5: Chin-Sha Reservoir is about 950 meters distant from the observation object (the channel)

## 3. The Natural Environment of Kinmen

### (1) Climate

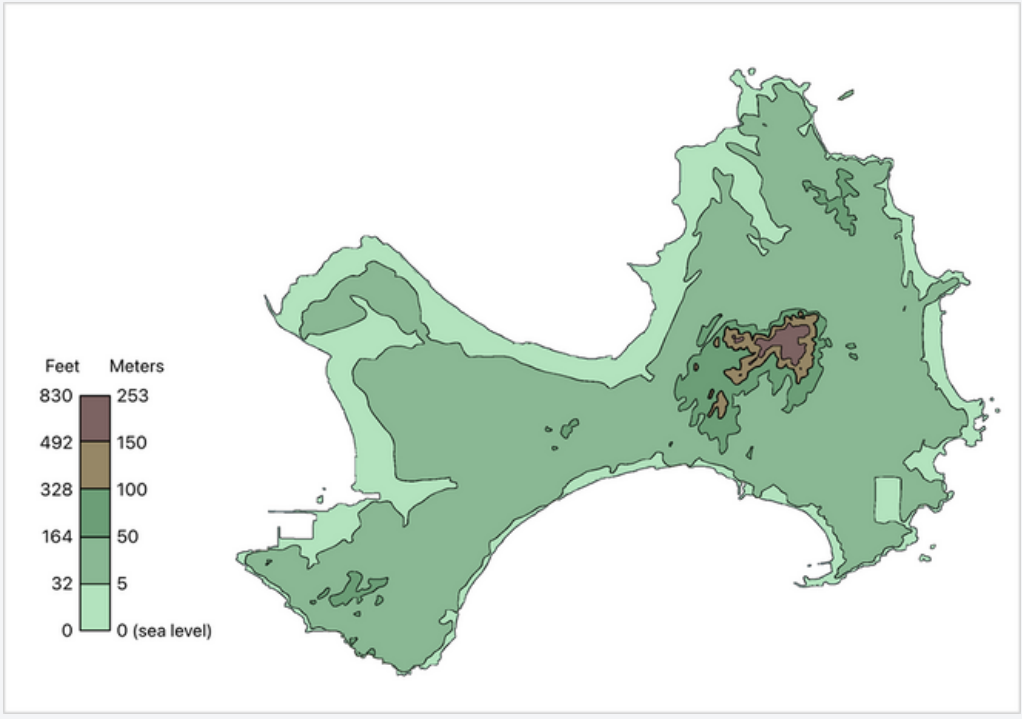



▲Fig6: Monthly average temperature chart of Kinmen (2015)




▲Fig7: Relation between monthly precipitation and evaporation in Kinmen (2015)

## (2) Terrain




▲Fig8: The hypsometric map of Kinmen

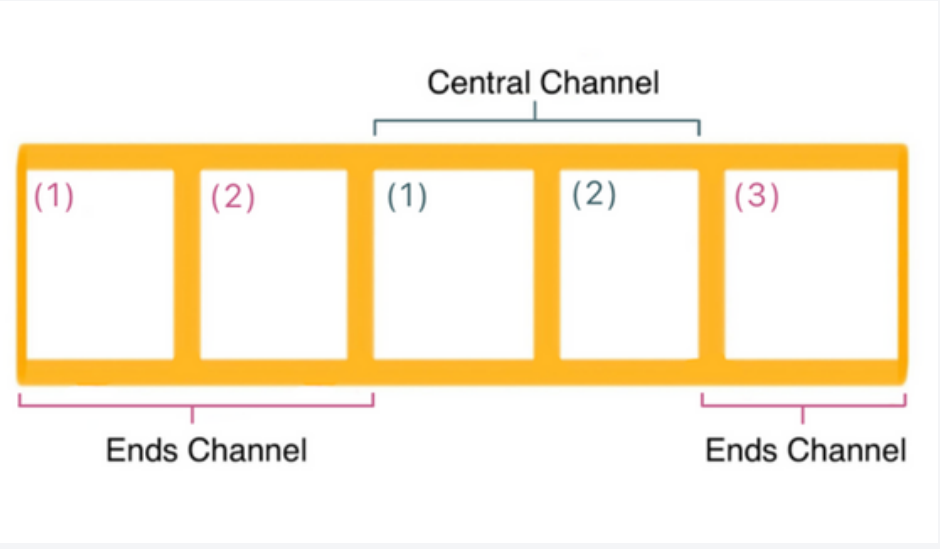
### (3) Natural Features

- Subtropical monsoon climate with a large annual temperature difference (as shown in Figure 6).
- Rainy season from May to September and dry season from October to February (as shown in Figure 7).
- Annual rainfall reaches 1200mm.
- Water scarcity is caused by the lack of high mountains, which allows unobstructed wind to blow in and results in slightly higher evaporation than precipitation. In addition, the island has a small land area and the upstream areas of rivers have no vast catchment areas, resulting in short streams that quickly flow into the sea without retaining water. Therefore, overall, Kinmen lacks water resources for agricultural irrigation (as shown in Figure 8).

## 4. Channel structure

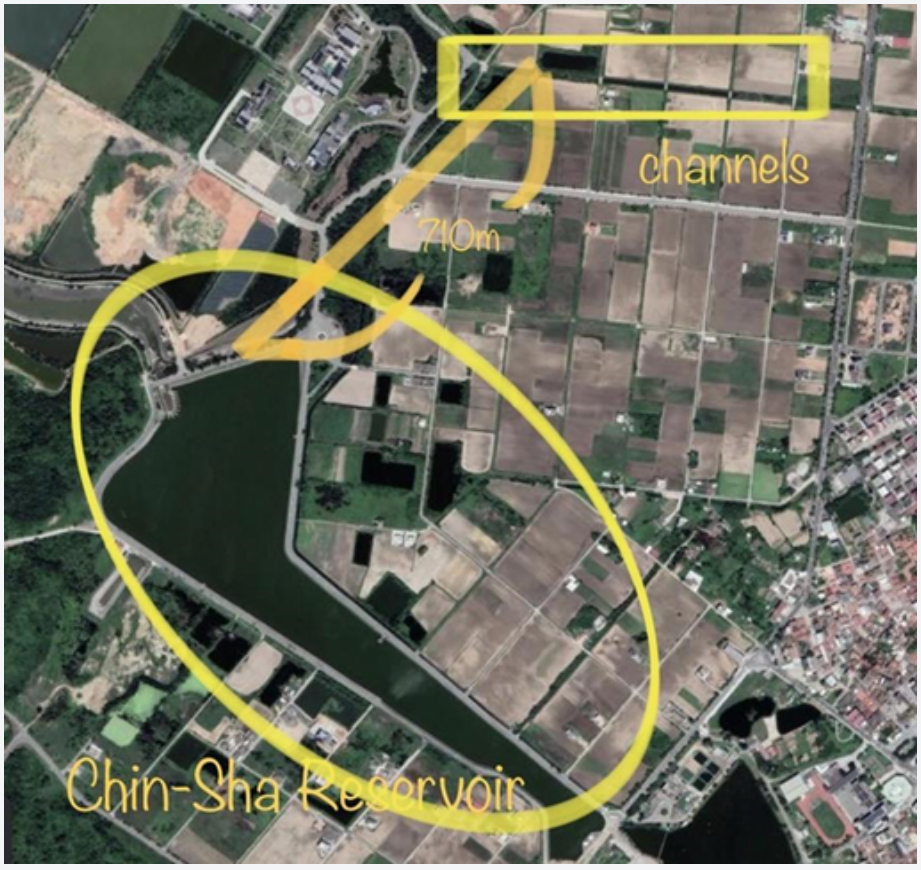
### (1) Noun explanations

- Channel:refers to the entire channel
- Central Channel: refers to the two central sections of the channel
- Ends Channel: refers to the two end sections of the channel

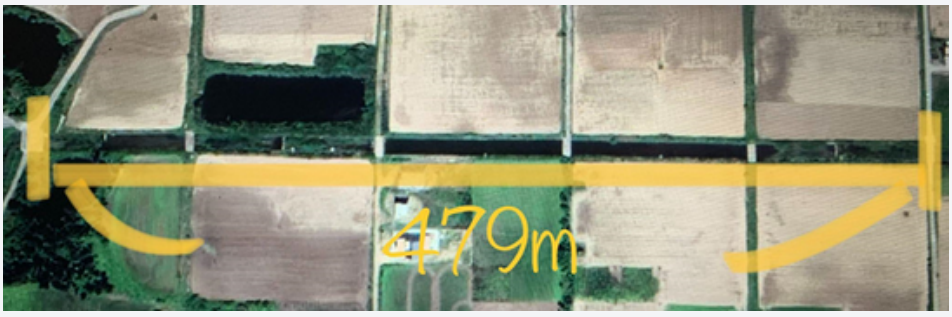



▲Fig9: Schematic diagram

## (2) Channel and Chin-Sha Reservoir satellite map

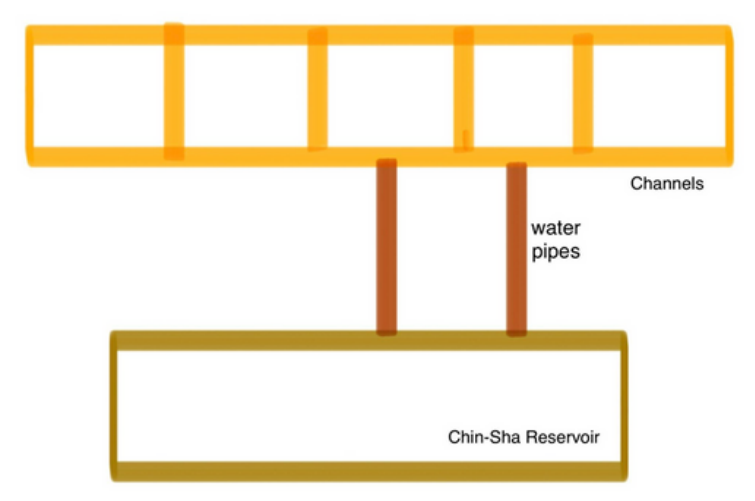



▲Fig10: Relative position of the channel and the Chin-Sha Reservoir




▲Fig11: The Channel

- The straight-line distance between the channel and Chin-Sha Reservoir is approximately 710 meters.
- The total length of the channel is approximately 479 meters.




▲Fig12: Schematic diagram of the channel connecting to the Chin-Sha Reservoir

- The central channel is connected to the Chin-Sha Reservoir through water pipes.

▲Fig13: Water pipes connecting to the reservoir

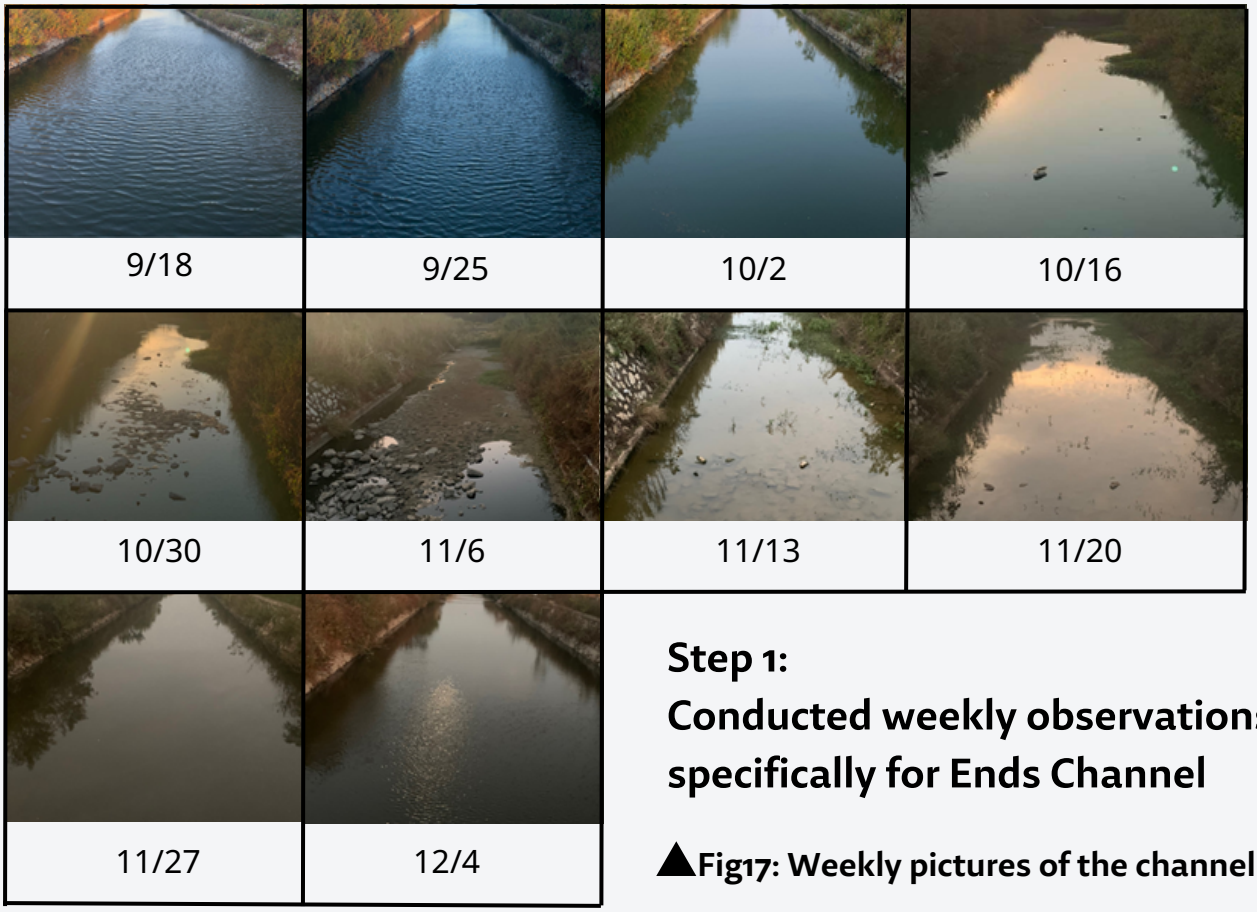

▲Fig14: The scenery between different channels

- Bridges are built at the top of the channels to allow pedestrians to pass through between the channels.

# Methodology

## 1.Observation


▲Fig17: Schematic diagram of Central Channel (2) and Ends Channel (3)

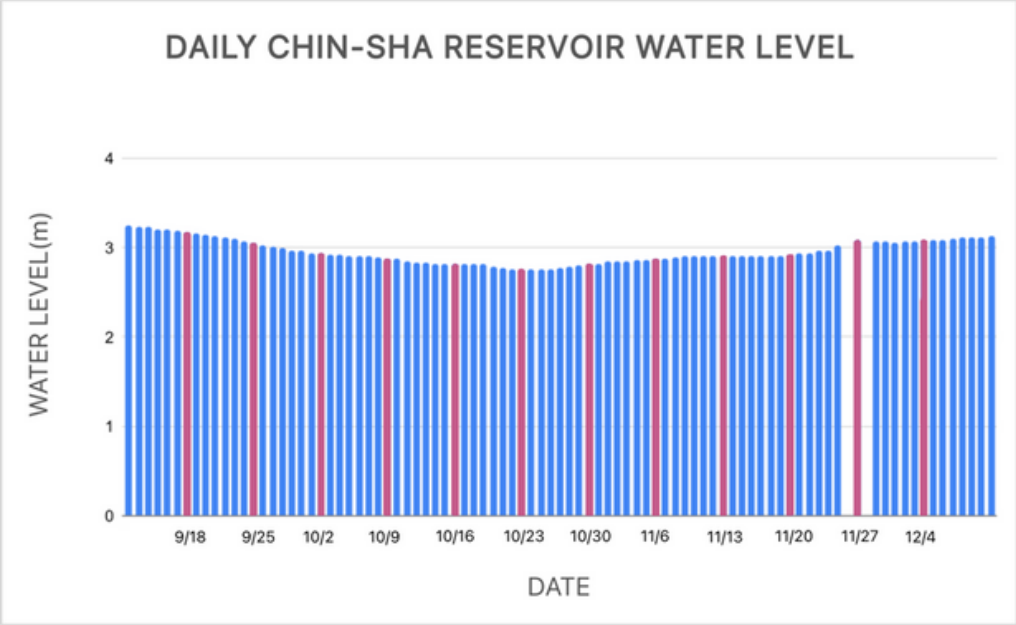



**Step 1:**
**Conducted weekly observations specifically for Ends Channel**

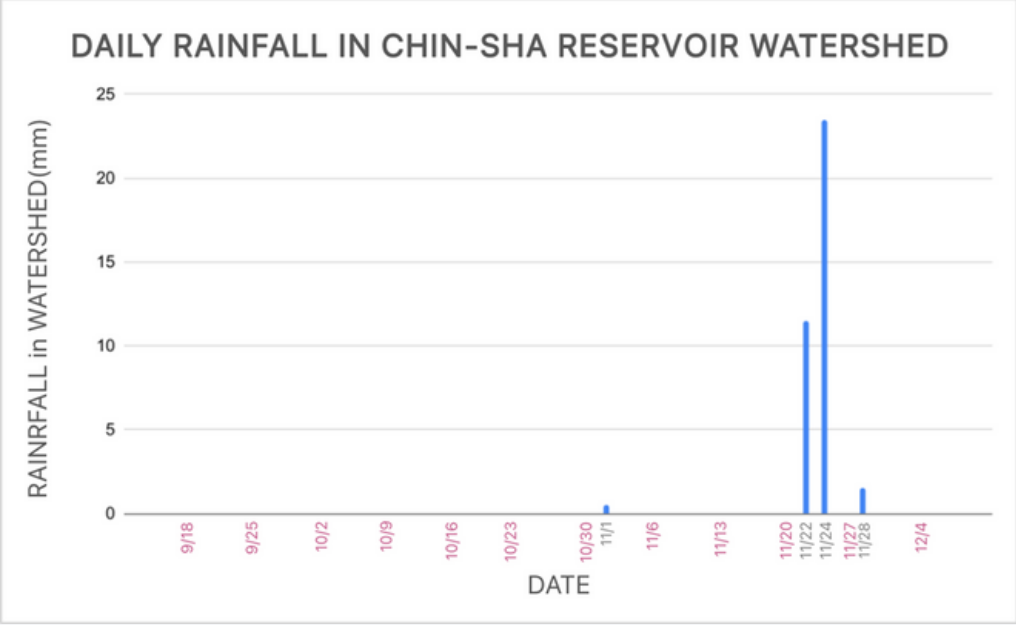
▲Fig17: Weekly pictures of the channel

## 2.Collecting data

We extracted the daily water level (m) and daily rainfall (mm) data of Chin-Sha Reservoir from the Information Service Network of the Water Resources Agency, Ministry of Economic Affairs, and plotted them into charts.




▲Fig18: Water level of Chin-Sha Reservoir (m), with the observation dates for the channel marked by the red line



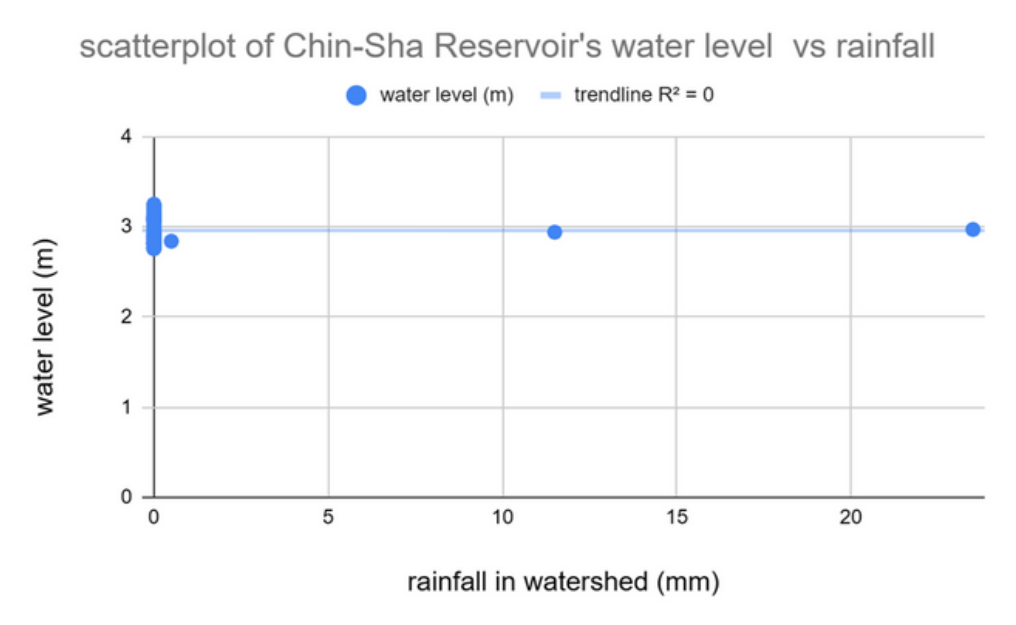

▲Fig19: Rainfall in Chin-Sha Reservoir watershed (mm), with the observation dates for the channel marked in red

## 3.Data comparison

In order to better illustrate the correlation, we plotted scatterplots between reservoir water level and rainfall, reservoir water level and channel water level, as well as rainfall and channel water level, and observed the correlation coefficient (R-squared).

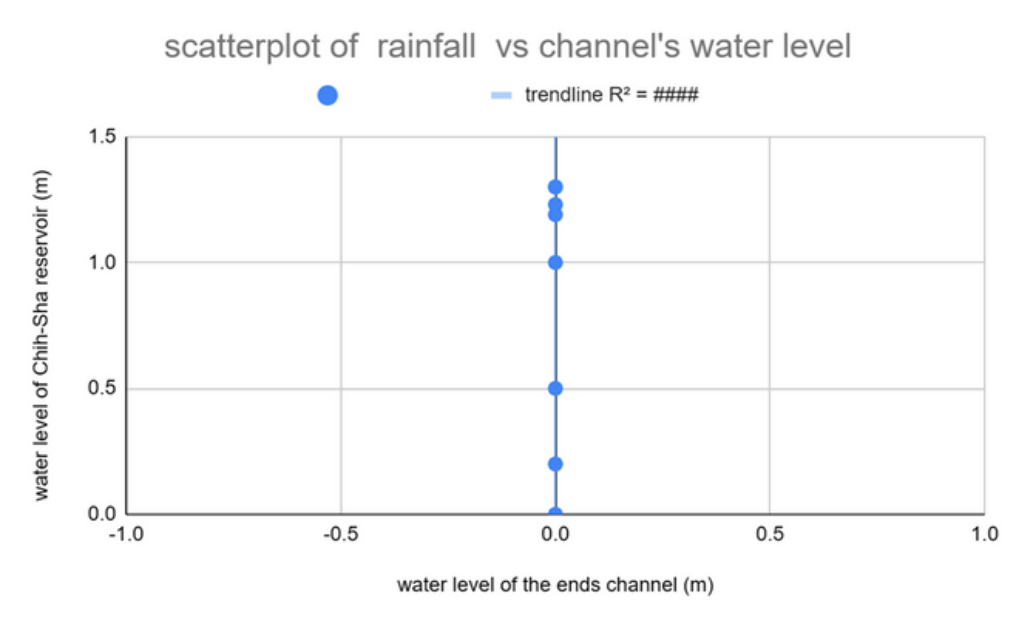
### (1) Rainfall vs water level of Chin-Sha Reservoir

We can infer that there is no correlation between rainfall and the water level of Chin-Sha Reservoir based on the correlation coefficient of R=0.




▲Fig20: Rainfall vs water level of Chin-Sha Reservoir

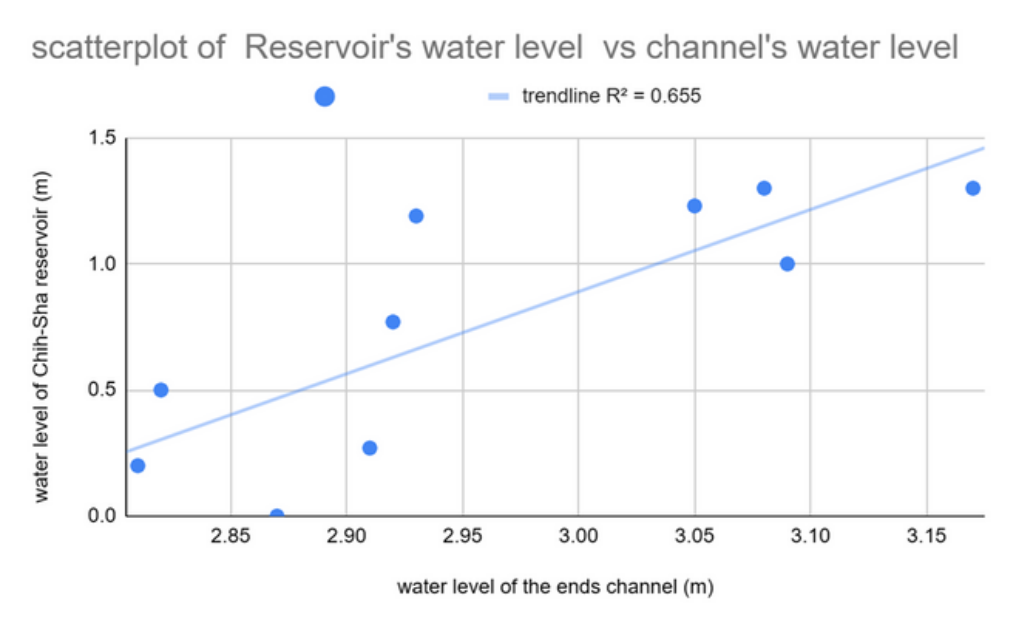
## (2) Water level of ends channel vs rainfall




▲Fig21: Scatterplot of rainfall vs channel's water level

We can infer that there is no linear relationship between the water level of the ends channel and rainfall based on the non-existence of a correlation coefficient.

## (3) Water level of ends channel vs water level of Chin-Sha Reservoir




▲Fig22: Scattergplot of reservoir's water level vs channel's water level

We can infer that there is a moderate positive linear relationship between the water level of the ends channel and the water level of Jinsha Reservoir based on the correlation coefficient of R=0.655. However, the significance of the correlation should be further tested with appropriate statistical methods, such as hypothesis testing and p-value analysis.

·Supplement

$R^2$=0.3 low correlation

$R^2$=0.3-0.6 moderate correlation

$R^2$=0.6-0.9 high correlation

$R^2$=1.0 perfect correlation.

# DISCUSSION

## 1.About Cross-Strait Water Supply

Q: During our search for news, we also came across a news article titled "Cross-Strait Water Supply: Three Thousand Villagers Witness a Historic Moment," which talked about how due to long-term shortage of domestic water supply, water was purchased from mainland China and a submarine pipeline was constructed as the water transmission channel. Therefore, we are curious if there has been any impact on the Jinsha Reservoir after Kinmen started to import water from mainland China since 2018? If so, what is the impact?

兩岸通水 三千鄉親見證歷史時刻

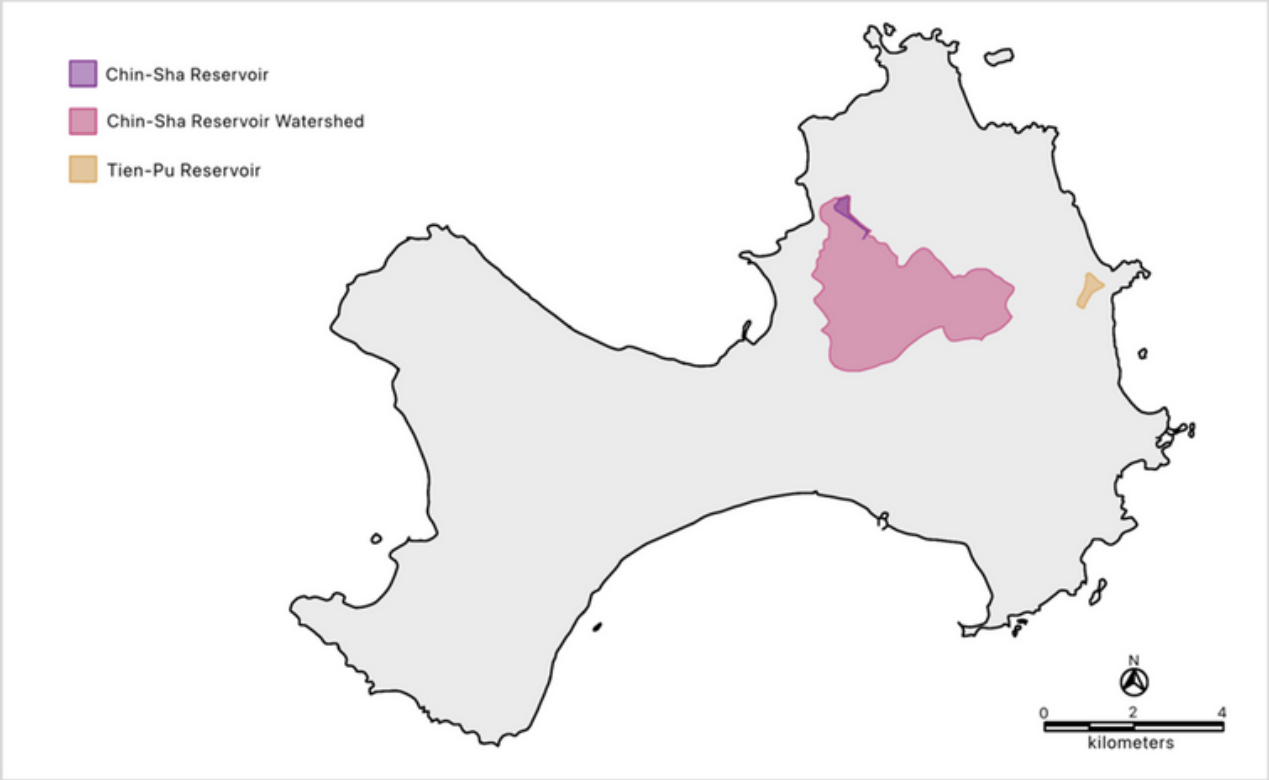
日期：107/08/06　資料來源：行政院金馬聯合服務中心

金門自大陸引水歷經二十三個年頭，相關工程也歷時三年辛勞始完竣；昨（五）日在田埔受水調節池舉辦兩岸通水儀式，金門縣長陳福海、立委楊鎮浯和縣議員蔡水游等人，在約三千位鄉親和中外媒體見證下，共同轉動水閘門，正式宣告兩岸通水啟用；這時彩色氣球緩緩飄上天空，整個通水儀式順利圓滿成功，更為繼小三通之後，再一次開創兩岸民生交流合作及寫下歷史新一頁！

自大陸引水工程-兩岸通水儀式於昨天上午九時舉行，一早現場就有絡繹不絕的人潮湧進，出席這項盛事，並由寧鼓隊、天震堂醒獅隊帶來震撼的獅鼓精彩表演，為兩岸通水儀式揭開序幕及炒熱現場歡喜氣氛，之後，通水儀式也播放回顧自大陸引水工程影

▲Figure 23: News image of the water supply connection between Mainland China and Kinmen.

**A: The answer is that there is no impact. The pipeline runs from Jinjiang undersea to the Tien-Pu Reservoir, and the catchment areas of the Tien-Pu Reservoir and the Chin-Sha Reservoir do not overlap.**




▲Figure 22: The relative position of Chin-Sha Reservoir Watershed and Tien-Pu Reservoir


▲Figure 23: The relative position of Chin-Sha Reservoir and Tien-Pu Reservoir

## 2.Rainfall and Water Level Data Correction

Q: In theory, rainfall and reservoir water levels are closely related, but the data shows completely opposite trends, which puzzles us. Why was rainfall not correlated with the water level of Chin-Sha Reservoir ?
A: Because of evaporation. Evaporation is as important as rainfall in determining the water level. In other words, even if the amount of rainfall remains the same, the water level can still change due to evaporation. After realizing this, we corrected the two axes of the scatterplot to "rainfall" and "variation of water level of Chin-Sha Reservoir " and obtained moderately correlated results.

## 3.Channel water quality testing

Q: What is the pH value of channel water?
A:  The pH value of the channel water was measured to be around 6.9 using a pH meter for water quality testing.


▲Figure 24: The pH value of channel water

## 4.Channel Design

**Q: In theory, the entire channel should maintain a plentiful water source to ensure smooth irrigation for farmland. However, in reality, sometimes little or no water flows from the central channel to the ends channel because only the upper parts of the central channel and ends channel are connected. What is the reason for designing the channel in this way?**

**A: We speculate that the reason is to filter out sediment. In flowing water, sediment is heavier and tends to settle at the bottom. If the central channel and ends channel are connected at the bottom, sediment will inevitably flow into the ends channel. However, if only the upper parts are connected, the water in the ends channel will contain less sediment. But the designers may not have considered that the water in the central channel is not always sufficient to flow into the ends channel.**

▲Figure 25: Schematic diagram of the relationship between the central channel and ends channel.

- The central channel and the ends channel are only connected in the upper part, so the water in the central channel will only flow into the ends channel when the water level in the central channel is higher than the walls surrounding the channel.

# CONCLUSION

Based on the observation of the water level of the channel, rainfall, and water level of Chin-Sha Reservoir , the following can be concluded:

(1) Rainfall has no correlation with the water level of Chin-Sha Reservoir .
(2) The water level of the ends channel is not related to the rainfall.
(3) The water level of the ends channel is positively correlated with the water level of Chin-Sha Reservoir .

# PROSPECT

We plan to improve the channel structure to solve water scarcity issues and increase efficiency for agricultural irrigation. This will involve exploring new materials and technologies, such as eco-friendly materials and modern control systems, to enhance durability, stability, and sediment filtration. These improvements will help protect the island's agricultural industry and environment, ensuring sustainable resource utilization and development while also promoting local economies.

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