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# THE EFFECTS OF FLOOD CONTROL MANAGEMENT AT YANGTZE RIVER DELTA IN THE PAST AND PRESENT

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### **KeyWords**

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### ABSTRACT

The purpose of this study is to illustrate the evolution of China's tactics for dealing with overflowing rivers created by two of the country's largest rivers, the Yellow and Yangtze, from ancient to modern times, as well as the effect on recent days. China's mother river's statement is also entirely true; from 2350 to 2250 BC, the huge flood happened under the reign of Emperor Yao, the ancestor of the Han Dynasty, till the present day in Zhengzhou, Henan Province, in July 2021. The location of early civilization was adjacent to enormous rivers, which are prone to floods, and so safeguarding the river's catchment lands was farmed in a variety of ways. The first temptation was to build great dykes along the river to contain the river when it overflows; secondly, Emperor Shun divided the flood-prone area into 12 administrative regions and developed them into a stable, harmonious, and well-governed society; and thirdly, the Emperor Shun divided the flood-prone area into 12 administrative regions and developed it into a stable, harmonious, and well-governed society. The Great Yu dredged the Yellow River and the other three major rivers, the Ji, the Huai, and the Yangtze; also, the Great Yu formed a new river corridor through the mountains, dredged it, and redirected it to the mother river. Then, in the modern era, the Chinese government implemented a flood control program that included the construction of 1800 kilometers of dykes, 46 river dams, and irrigation canals, as well as terracing and tree planting. By addressing soil erosion and silt problems through these water-conservation projects, the flooding problem was finally resolved. Especially on the south bank of the Yangtze River, which is the lowest stretch of major rivers, the flood problem has the potential to have catastrophic consequences for civilization and the nation's economic and political well-being. Ecologically, Jiangxu, Jiaxing, and Zhejiang Provinces suffered the most severe consequences of the river overflow because these provinces are home to the largest water town in China Culture, remnants of the ancient social order, and the route of army conquest. Exploring the transformation of a flood-prone river valley into a heritage water town may not immediately prevent the harm caused by floods that have occurred virtually everywhere in China, but the struggle to overcome it will serve as a lesson for other nations with similar geographical conditions.

### 1. Introduction

Simply China is a country of ridges, rugged terrain, and fewer than one-fifth of its land area is below 1000 feet in elevation. The north-east are on the huge delta plains, whereas the north and west are in central Asia's high plateaus and mountains. Two-thirds of Sichuan's vast province is made up of impassable mountains that border Tibet and reach altitudes of up to 16000ft [1]. China has over 50.000 natural rivers, ten main rivers with catchment areas over 100 kilometers square, and approximately 900 lakes. The Yangtze (6,300 kilometers), Yellow (5,464 kilometers), and Lancang (4,350 kilometers) are the three longest rivers [2].

Rivers contributed either advantages or losses in ancient times. In his book, The Water Kingdom, Philip Ball. A. Secret History of China revealed that the early civilization was located in the fertile valley of the river, where inhabitants began and developed agriculture and expanded the social organization. However, due to excessive cultivation of the land, they began to expand the area arbitrari-

ly, resulting in the soil losing its ability to absorb river overflow, destroying agricultural and incurring losses (pp. 57,99,199). Second, a river serves as a barrier to barbarian conquest and a transportation network, or it serves as a conduit for foreign invasion (pp.32). In summary, waterways serve two fundamental functions: they deliver grain to feed troops and they transport troops back and forth during conflict. China's wars were frequently fought on and around rivers; they were the arteries of military conquest and the fluid arenas of dynastic change (pp.173) [3].

On the other hand, rivers have caused significant damage and loss. The Yellow River, the mother of rivers, flows north from the western highlands (the city of Lanzhou) toward Inner Mongolia, then turns south along the border of Shaanxi and Shanxi Provinces, eventually turning east through Henan and Shandong before reaching the Yellow Sea (pp.26) [3].

The Yangtze River (Chang Jiang River) is the world's longest river at 6,300 kilometers in length. It originates in the Qinghai-Tibet Plateau, flows through the upper Yangtze River above Yichang City in Hubei Province, flows to Jiangxi Province, and empties into the East China Sea downstream of Hukou [4].

The Yellow and Yangtze rivers are to blame for China's recent disasters. The Great Flood of 1917 was the first major flood to occur and lasted nine years before Yu, a flood control engineer, began dredging, deepening, and opening a new section of the river with the purpose of slowing the flow of water and managing it in controllable stages (pp.62) [3]. When the Yellow River overflows its banks, it creates a new channel to the shore, resulting in the construction of dozens of such shifts, eight of which are classified as 'major' since the outflow into the ocean may be hundreds of kilometers from its previous site.

As discussed previously, rivers naturally follow two paths: they extend through broad swaths of land, bringing sediments and forming tributaries, and in rare instances, they form natural reservoirs or big lakes. For example, the Yangtze River ceased to flow at one point and drowned a vast area that we now refer to as Dongting Lake in the north and Poyang Lake in the south [4].

These characteristics have an effect on the southern Yangtze River Valley, particularly in Jiangsu and Jiaxing, Zhejiang provinces. Jiangsu Province is located in the Yangtze River delta and is home to numerous lakes and rivers, including Taihu Lake and Tongli Lake (which are directly connected to the Tongli Canal), Dianshan Lake (which is directly connected to the Zhouzhuang water town), Chenghu Lake, Jiuli Lake, Huangnidou Lake, Yuandang Lake, and Fenghu Lake. Jiaxing, Zhejiang is home to numerous rivers and lakes. Taihu lake, in particular, is an important supply of water in this province.



Figure 1: Drainage Basin Distribution in South of Yangtze River

Apart from its natural reservoirs (lakes) that can be used for flood control, the region south of the Yangtze River has numerous advantages. The most popular is Suzhou in Jiangsu Province. It is a treasure trove of Chinese gardens, culture, architecture, painting, art, and craft [5], as it is located precisely at the intersection of the northern and southern-ocean routes, the major north-south inland artery (the Grand Canal), and the empire's east-west Yangtze River corridor. It was renowned for bringing together the goods of all the provinces [6]. Suzhou's status as the capital city of the Wu Kingdom and the economic and cultural center of South China in 512 BC [5] explains why China built the Grand Canal System, a magnificent feat of Imperial Chinese hydraulic engineering. At the height of the Ming Dynasty (1368-1644 AD), the system stretched to a length of 2500 kilometers [8].

Mostly, the Chinese government constructed canals with high dykes along the river's banks, as well as a large number of reservoirs. Initially focused on flood prevention, water supply, irrigation, and transportation network development, the system's success has resulted in China's socioeconomic and political development [9]. According to the Bulletin of the First National Census for Water, China had 98,002 reservoirs as of 31 December 2011 [9], a national irrigated area of 66 million ha of effectively irrigated land, 46

million ha of arable land irrigated with water-saving irrigation, and million ha of forage land in pastoral areas to be covered by irrigation systems [11]. However, the focus of this paper is on how the system developed into some fantastic heritage water towns in China, the relationship between the system and philosophy, and most importantly, the impact of heritage water town existence on China's development to the present day. Additionally, adaptation in floods considered how to sustain their existences within the system, whether through technology or natural means.

### 2. The South of Yangtze Valley Drainage Basin

The Yangtze River is divided into three sections. The upper segment, which runs from the source to Yichang, is 4504 kilometers long and covers an area of 100.104 kilometers square. Between Yichang and Hukou, the middle Yangtze flows for 955 kilometers and drains an area of 68104 kilometers square. The lower Yangtze is characterized by low relief topography and meandering platforms from Hukou to the river mouth. It is 938 kilometers long and has a drainage basin area of 12104 kilometers square [12]. The Yangtze drainage basin has three distinct morphological levels. In the southwest, the Tibetan Plateau serves as the apex. The second step is characterized by a southwest-to-northeast orientation of high mountains and mountain-girt basins. The third step encompasses eastern China's lower fluvial to coastal plains [12].

The Yangtze River basin is primarily subtropical, with a cold, dry winter and a warm, wet summer. The river basin's climate is dominated by the Asian monsoon, of which the Indian summer monsoon primarily affects the Yangtze River's upper reaches, while the East Asian summer monsoon frequently affects the middle and lower reaches. The basin's mean annual temperature is approximately 13°C, with a maximum of 20°C in July and a minimum of 1°C in January. The Yangtze River basin receives an average annual precipitation of approximately 1100 mm. Precipitation decreases east to west in this river basin, ranging from 859 to 1528 millimeters in the upper reaches [4].



Source: <u>https://en.wikipedia.org/wiki/Yangtze</u> (Modification By Author)

### Figure 2: The Yangtze Valley

Historically, the Yangzi Valley has been a significant food producer. The river has long been the economic lifeblood of the region, bringing commerce and influences from far-flung lands. Throughout the twentieth century, damming the Yangzi has altered the land-scape, economy, and lives of the people who live in the Yangzi Valley, forcing many to relocate [7].

Life and culture are dominated by fishing and boat commerce. Cities such as Chongqing (in Sichuan province), Wuhan, and Nanjiang are propelled forward by economies based on waterborne transportation and commerce, rather than agriculture or even food processing. Major manufacturing centers are located along the river because it is a relatively inexpensive mode of transportation. Numerous people spend their entire lives on small or medium boats, earning a living by transporting goods and people through the Yangtze valley's numerous lakes, canals, and rivers [7].

Suzhou, Wuxi, Jiaxing, Hangzhou, Shanghai, Huzhou, and Changzhou are all located on the same level flat land, with a slope of up to 40% (See Figure 3) and a maximum level of almost >300%. Almost all of this flat land is drained by rivers and streams, which channel their water into lakes, either large or small. The connection between rivers and the sea transforms this region into the richest in terms of soil, resources, and climate, as well as the birthplace of civilization. According to history, regions located near water resources are on the verge of becoming the most developed in any field.



Figure 3: Land Slope at the South of Yangtze River

South of the Yangtze River, there are numerous natural reservoirs, lakes, rivers, and marshes (figure 1). Each has its advantages and disadvantages. Taihu Lake is China's third largest lake with a depth of less than 2m. It is home to 108 species belonging to 24 families and serves as a feeding ground for migratory and semi-migratory fish from the Yangtze River and East China Sea, providing revenue for the surrounding community [14]. Yangcheng Lake, located in northeast Suzhou, is one of the province's major sources of freshwater. With an average depth of 2.1m, it contributes to biological diversity conservation and ecological balance. It is used for a variety of purposes, including irrigation, flood control, agriculture, and fishing [15]. It is also famous for its pen aquaculture shallow lake in Eastern China, which produces high-quality cultivated Chinese mitten crab [16]. Dianshan lake is Shanghai's largest freshwater body, covering an area of 63.7 kilometers square and averaging a depth of 2.5 meters. It possessed abundant fisheries resources in China. Chenghu Lake is a shallow lake with an extremely flat bottom composed primarily of stiff clay [19]. Ge Lake is a shallow land lake located northeast of Taihu Lake. It has a surface area of 164 km2 and an average depth of between 0.8 and 1 m [18]. Shallow lowland lakes are critical components of the water cycle because they perform critical functions such as water storage and purification, animal habitat provision, biodiversity protection, and irrigation [18]. In a nutshell, Shallow Lake has an economic impact on the residents and general public. It has a greater variety of plants, is nutrient-dense, and attracts wildlife. Additionally, communities utilized water-bodies for recreational, sporting, and land-use purposes [20].

The Yangtze River's final section empties into the Yellow Sea via the Yangtze River estuary. The Yangtze River Estuary is China's most populous and industrially productive region, owing to its location at the confluence of the ocean and rivers, which contain abundant freshwater and ecological resources. It is home to four major drinking water reservoirs that provide abundant water to Jiangsu Province and Shanghai [21]; in addition to the reservoirs, the Yangtze River Estuary is home to the Jiuduansha wetland, which serves as a water storage area and separator for the two rivers that discharge into the north and south passages. All of these advantages contribute to rapid economic development and progress. Currently, industrial business is the country's primary source of revenue.

### 3. Historic of Flood Control of Yangtze River Delta

Generally, a large number of flat, lowland, and delta rivers are embanked to prevent flooding of agricultural fields and urban areas. For years, flood-prone areas have been protected by building embankments, levees, or dykes [22]. In the Netherlands, specifically in the village of Neer on the Maas River, they constructed a flood wall with a massive steel gate and a 10 cm thick glass panel on top to withstand the heavy rainfall from Germany and Belgium; in the southern Netherlands, they constructed dikes, a dam, and another flood wall as part of flood control projects called Delta Works [23]. In Slovakia's Denube River Basin, flood control barriers consisting of mobile barriers, fixed flood control walls, and earth embankments were constructed to mitigate natural disasters [24]. China released Policies and Measures on Flood Mitigation in 1997. The policies focused on eight areas: protecting mountains for tree planting, returning arable land to forest, demolishing polders to allow floods to flow freely, transforming farmland into lakes, contributing labor, relocating people to new townships, reinforcing levees along main stem rivers, and dredging river channels and lakes [25].

China's method entails constructing dike systems along the river's middle and downstream reaches totaling 280,000 kilometers, as well as 85,000 reservoirs for storing and regulating floodwaters in upstream areas. Additionally, they constructed large flood detention basins in the major river basins (Yangtze River, Yellow River, Heilong River, Songhua River, Songhua River, Liao River, Pearl River, Hai River, Yarlung River, Lancang River, and Nujian River) to manage larger floods. They have reservoirs with flood pools along inland waterways to capture flood inflows and mitigate downstream flooding during flood season. Sea walls provide coastal defenses against storm surges along the eastern seaboard's estuaries. Additionally, they developed bank stabilization techniques for preventing river banks and dikes from eroding [26].

One of the benefits of maximizing the use of water resources is the power supply system. There are three major pumped water storage stations in China: Liyang, Yixing, and Tianhuangping. As China's most developed province economically, the power supply system is critical for city operation. A combination of thermal generating plants and pumped water storage is required to meet growing demand for peaking power.



Figure 4: Pumped Water Storage Station at South of Yangtze River

The south has abundant water resources, accounting for approximately 80.9 percent of the nation's total [27]. Irrigation demand has become critical for resolving water resource shortages in the absence of excessive rainfall. The south is classified as a supplementary irrigation zone because it receives more than 1000mm of precipitation and has a maximum irrigation area of 3573 ha (type of crop is rice, wheat, corn, and cotton).

The increase in population results in an increase in demand for domestic and industrial water use. China anticipated water scarcity and oversupply by developing sprinkler irrigation, drip irrigation, and micro irrigation systems for water-saving irrigation. They construct pipe irrigation and canal seepage treatment systems for agricultural irrigation water transfer. They constructed reel sprinkler irrigation, central pivots, and traditional land leveling and furrow irrigation in the south for farmland crops such as wheat and corn, and controlled irrigation and gardenization in rice paddies. They invented drip irrigation, micro irrigation, and infiltration irrigation for cotton [27].

Other flood control measures include the construction of dikes and detention areas. China has a total length of 413.700 kilometers, of which 280.00 kilometers were built in the middle and downstream reaches of rivers [25]. The Yangtze Delta is divided into eight distinct linear waterways – Jiang/, He/, Tang/, Pu/, Gang/, Lou/, Jing/, and Bang/ – to distinguish them by their length, width, and/or function [28]. the small waterways that circle the Tai Lake shore (Lougang) to regulate inflow and outflow from and to the lake and extend nearly to the Yangtze River Delta's land. The waterways are protected by dikes on both sides of the river banks, which resulted in the formation of a canal network that connected numerous waterways. The dikes act as a retaining wall between the wa-

tershed and the bodies of water, preventing excess water during flood seasons from passing through both. The canal system functions as a transportation system that transports natural resources between cities, or more precisely, as the focal points of commercial activity.

The Polders System is another method of preventing floods from inundating community land. The arable land was defined by a diverse array of polders, the majority of which were used to shape agricultural landscapes bordered by streams or canals. The polders consist of paddy fields or fish ponds surrounded by an earthen dike or embankment, while the other represents a community exchanging and sharing agricultural outputs, as well as a location for cultivating rice and producing raw silk or other agricultural activities *[28]*.



The Grand Canal connects a vast network of inland waterways in China's north-eastern and central-eastern plains. It connects Beijing's capital to Zhejiang Province in the south. Constructed in sections beginning in the 5th century BC, it was first envisioned as a unified mode of communication for the Empire in the 7th century AD (Sui Dynasty). It connects five of China's largest river basins: the Hai coastal river in the north, which flows into the Bohai Gulf at Tianjin; the Yellow River, which today flows north of Shandong but previously ran south of Shandong until 1855; the Huai River, whose lower course merged with the Yellow River's southern arm; the Yangtze River further south; and finally, the Qiantang coastal river. The Grand Canal system connects them north-south, passing through five major natural regions: the great plain of north-eastern China and the Yellow River's downstream basin; the low hilly zone of Shandong; the Yangtze delta with its numerous lakes; the coastal plain of Ningbo – Shaoxing; and the Qiantang estuary region.

The Grand Canal is comprised of ten major sections of ancient man-made waterways. Tongji Canal, Wei Canal (Yongji Canal), Huaiyang Canal (Li Canal), Jiangnan Canal, Zhedong Canal, Tonghui Canal, Bei Canal, Nan Canal, Huitong Canal, and Zhong Canal comprise the ten principal sections. The Grand Canal system exemplifies imperial Chinese hydraulic engineering at its finest. During the Ming dynasty (1368-1644 AD), the system reached a length of approximately 2,500 kilometers, with Beijing at its northernmost extension, Hangzhou at its southernmost extension, and Luoyang at its easternmost extension. The canal gradually ascends to a height of more than 40 meters above the Yangtze. To ensure safe circulation, a system of locks (a type of system that enables water transportation to move at varying water levels), feeder lakes, and lateral canals was constructed. (Adapted from R. Delfs's 1990 article "Arteries of the Empire," Far Eastern Economic Review, 15 March 1990, pp. 28-29.) No 1443 Grand Canal.

Furthermore, China has history of Canal Development. It was concluded in to table below. Each Canal has its time and origin puposes which is the most were used for transportation either supplies or people.

No	Dynasty	Canal	Time	Origin Purposes
1	Wu Kingdom	Hangou Canal	5th BC	Transport Troops and Supplies
2	Wu Kingdom	Jiangnan Canal	5th BC	Extend of Hangou Canal
3	Wei Kingdom	Hangou Canal	4th BC	Transport Supplies
4	QIn Dynasty	Hangou Canal	221-206 BC	Provide Supplies to Xianyang, Shaanxi
				Province
5	Western Han	Hangou Canal	206 BC –25	Extend of Hangou Canal and River Navi-
	Dynasty		AD	gation to Chang'an
6	Eastern Han		25-221 AD	As a system of navigable waterways
7	Sui Dynasty	Tongji Canal	589-618 A	To ensure political. Military and adminis-
				trative zones and to ensure the regular
				supply of food
8	Sui Dynasty	Yongji Canal	589-618 A	network of interconnected canals with
				centralised management
9	Sui Dynasty	Zhejiang Canal		Extend of Jiangnan Canal
10	Tang Dynasty	Grand Canal	960-1127 AD	carrying busy traffic between the major
	and Song			poles of the empire, to supply their
	Dynasty			needs
11	Yuan Dynasty	Southern Canal	1276-1368	As a link to the north where its capital
		& Northern Can-		was there with the eastern part of the
		al		country
12	Yuan Dynasty	Huitong Canal	1289	Connecting from the eastern to the
				southern part
13	Qin Dynasty	Zhong Canal.	1644- 1912	Connecting Huai-Yang & Huitong Canal

Table 1: Development of Canal Construction in China

### 4. Problems of Flood Control

Urban flooding occurs for a variety of reasons, the primary one being geographic location. The majority of China's major cities are located near rivers, estuaries, or the coast, while others are scattered throughout areas such as the intermountain basin. Once flooded, these cities are prone to drowning [30]. China is the world's most populous country, accounting for nearly 19 percent of the global population. China's mainland population increased at a rate of 1.8 percent per year and no less than 1.5 percent almost every year. Over the last three decades, China's mainland has seen rapid expansion of built-up land due to population growth. Between 2000 and 2010, the area of built-up land in urban and rural areas increased by 11.17 percent. Particularly in urban areas, built-up land has increased significantly. This urbanization has inevitably resulted in a slew of resource and environmental problems, as well as concerns about environmental protection, throughout China. Additionally, urbanization has resulted in unprecedented shifts in land use patterns, most notably the loss of arable land [31]. Spatial and temporal changes in China's built-up land. The increase in population growth has resulted in an increase in reinforced concrete building construction.

These buildings have a much lower specific heat than greenbelts, which means that greenbelts can absorb more heat. In other words, buildings in cities will raise the temperature more than greenbelts. Additionally, buildings always block wind, resulting in temperatures inside cities being 1 to 3 degrees Celsius higher than in rural areas, effectively turning cities into an island of heat. This is referred to as the urban heat island effect (EPA). Combining with those air pollution particles increases the amount of rainfall condensation nucleus. As a result, the frequency of severe rainstorms increases significantly in cities as they grow faster, resulting in another phenomenon known as the urban rain island effect. As a result, precipitation volume and frequency have increased by more than 10%.

The drainage system in China's cities was designed with a lack of foresight; the capacity was primarily determined by the average precipitation at the time the system was built. On average, the flood control standard for drainage systems in the majority of China's cities is designed to minimize runoff caused by urban flooding, which occurs every one to two years. Due to the frequent occurrence

of heavy rainstorms, the amount of rainwater entering the drainage system is always greater than its capacity, resulting in severe stagnant water on the ground. Urban flooding occurs when the situation deteriorates. Apart from drainage system issues, another factor contributing to urban flooding is environmental degradation. Historically, people were unaware of the value of a green environment. Ditches and ponds were once critical for water division and absorption; however, they were filled in to make way for roads and buildings. Cities become more vulnerable to flooding as ditches and ponds disappear.

As urbanization progresses, the rate of surface hardening increases, and the area of impervious surface increases in locations such as rooftop and outdoor parking lots. These impervious surfaces, constructed of cement or asphalt, prevent rainwater and snowmelt from infiltrating the ground. It directly increases the coefficient of surface runoff (U.S. Geological Survey). The greater the coefficient of surface runoff, the less water can be absorbed by the ground. Additionally, when compared to greenbelts, the construction of roads and buildings significantly reduces the roughness coefficient of the ground, reducing the time required for surface runoff to concentrate (Zhang et al., 2016). Additionally, certain construction processes obstruct brooks. Numerous roads, railways, and buildings have encroached on lands that were once water bodies such as rivers or lakes, all without regard for urban sustainability. All of these factors have a significant impact on the drainage capacity of Chinese cities.

There is currently no system in place to monitor urban flooding in real time. As a result, people cannot receive precise information about urban flooding. When combined with a lack of administrative staff to manage drainage facilities and a deficient management system, urban flooding cannot be controlled in a timely manner. Additionally, drainage system maintenance is never completed on time. Funding alone is insufficient. Additionally, the drainage system is outdated in comparison to some developed countries' cities.

In China, a regulation known as "Land Finance" allows local governments to sell land-use rights to finance fiscal expenditures. This regulation accelerates the loss of natural surface area with a high capacity for flood discharge. Surface areas that are low-lying and prone to flooding are particularly inexpensive; demolition of these areas is easier, and cost recovery is faster. When the low price of these lands is considered, the potential risk of urban flooding is overlooked. Additionally, the central government's financial investment in drainage pipelines is insufficient. Around 90% of the investment comes from local governments. As local governments' debts grow, it becomes more difficult for them to invest more in urban flooding prevention [30].

Coastal flooding occurs as a result of typhoons or other storms that coincide with high tides. On average, the PRC experiences approximately four coastal floods per year, mostly between July and September, and particularly in Fujian, Zhejiang, and Guangdong provinces. Sea walls have been constructed in a variety of coastal areas, but construction standards vary and all are susceptible to damage. Storm tide losses are expected to increase as a result of global warming and associated sea level rise.

### 5. Modern of Flood Control of Yangtze River Delta

Maintaining is more critical than constructing, as there is an aging legacy of flood defense structures that require monitoring: Due to the fact that dikes are frequently unreliable due to a variety of factors such as geotechnical faults in embankments, unsound foundation conditions, erosion, and scour, many endangered reservoirs are unable to store enough water to meet design levels and thus cannot control flooding. Flood diversion channels are becoming clogged with sediment due to low flow velocity during non-flood periods, necessitating extremely costly dredging and clearing [25].

Since 1949, China has conserved soil and water on an area of 10.47 million km2, harnessed over 70,000 watersheds, constructed over 1,000 ecologically clean watersheds, restored an area of 720,000 km2 via water and soil conservation, and covered over 600 counties suffering severe water loss and soil erosion through the implementation of national water and soil conservation policies. Existing water and soil conservation measures have the potential to prevent 1.5 billion metric tons of soil erosion per year, increase water storage capacity by more than 25 billion m3, and increase grain production by 18 billion kilograms [32].

Constructing flood control infrastructure alone will not ensure 100 percent security; a 32-word policy issued in the aftermath of the 1998 flood emphasized the recovery of flood plain storage and soil conservation in upper basins. It resulted in a massive program to reclaim farmland, demolish polders, resettle displaced people, reforest mountainous areas, and modify agricultural practices.

Sediment deposition in streams is a significant moderator of flood hazard, generally having negative consequences. Sediment deposition reduces the amount of storage available in reservoirs and lakes for downstream flood mitigation, as well as the capacity of river channels to transport sediment. Deposition of sediment reduces the longitudinal gradient of the river bed near estuaries and at grade breaks where flow velocities decrease, such as transitions from mountain valleys to plains. This results in waterway instability as rivers attempt to reclaim conveyance capacity through river bank erosion, which may result in avulsions and the formation of new river courses in flatter landscapes such as deltas and floodplains [25].

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Land use management in upper watersheds entails afforestation efforts as well as programs aimed at increasing awareness of the negative consequences of inappropriate land use practices and modifying behavior in agricultural communities. Field programs and agricultural extension activities in rural areas should educate land users about how their current land use practices are incompatible with the conditions and how improved practices can increase and sustain their incomes while conserving soil fertility and moisture and minimizing runoff and erosion.

China piloted the NFMS in 2008 and 2009, with assistance from the ADB, in case studies of flood detention on the Li River and Lixian County in Hunan Province, as well as a flood area in Lichuan, Jiangxi Province [7]. NFMS was the formulation of an appropriate framework and action plan for implementing the transition from flood control to integrated flood management, which resulted in an increased use of nonstructural measures.

In terms of development and management of small hydropower, over 47,000 rural hydropower stations were completed by the end of 2014, with a total installed capacity of over 73 million kW and a power output of over 220 billion kWh in 2014, which is equivalent to the substitution of 73 million standard coal and the reduction of 183 million metric tons of CO2 emissions. Simultaneously, an ecological protection project is underway to replace fossil fuels with small hydropower. It not only alleviates millions of mountain farmers' fuel problems and raises their living standards, but also protects and restores over 300,000 hectares of forest and the local ecological environment [34].

Since 1950, the Grand Canal has been conserved by widening the canals and constructing new sections and port facilities. Nonnavigable sections serve as drainage reaches, removing rainwater and protecting against flooding; they are also used for irrigation. Restoration and maintenance of the canal itself, the hydrological zones associated with it (lakes, marshland, and irrigation zones), and existing facilities

Sets forth a series of measures aimed at enhancing environmental quality in general and water quality in particular, and is based on a water distribution plan for the Grand Canal's various zones.

Since 2006, the hydraulic management has included systematic monitoring of the property's overall heritage conservation. Protection measures have been implemented to prevent deterioration and intrusion, including back-filling excavation sites in some cases. Control of urban development within the nominated property's boundaries and buffer zones (urban density, building height, industrial and logistical facilities).

Special emphasis is placed on the Grand Canal's historic urban zones, particularly in light of the canal's rapidly growing tourism industry. The conservation programs are extensive, encompassing the appearance of the canal banks as well as the preservation of streets and quarters historically associated with the Grand Canal's life and economy. The primary difficulties are social in nature, as increasing the housing stock creates numerous compatibility issues (access to modern conveniences versus maintaining the existing ancient appearance of houses and quarters). Additionally, extensive work on networks (water, sewerage, and electricity) is required. Certain more targeted programs, typically located in urban areas or park zones adjacent to urban centers, are aimed at rehabilitating the landscape and environment as a whole. Environmental measures are also being implemented in certain sectors, including the controlled management of land and buildings and the improvement of water quality [33].

### 6. The Progression of Flood History in Delta Yangtze River

China began managing floods in ancient times; according to the data cited, flood disasters occurred at an increasing rate between 1840 and 1949, with the lowest frequency occurring between 1850 and 1859 at about 20% and the highest occurring between 1930 and 1939 at about 130 percent [29]. The increasing trend indicated that flood control is either ineffective or that external factors influenced the success of the flood control.

Between 1980 and 2016, the area affected by flood was approximately 10.4 million hectares, with an average of around 9.9 million hectares; however, the area affected by flood is gradually decreasing. However, if the number of potential flooded cities is considered, the average number in the 1980s was 37, while the average number from 2010 to 2017 was 48, indicating that the number of potential flooded cities increased by approximately 30% from 1980 to 2017. According to MWR, approximately 25% of cities in China were flooded annually between 2006 and 2016. *[30]*.

In the early 2000s, specifically during the summer flood season of 2001, landslides caused by heavy rains and flooding in Fujian, Guangdong, and Henan occurred in May 2003, landslides caused by heavy rains and flooding in Sichuan region central China occurred in July 2003, and torrential rains and flooding occurred in central China, Henan Province, in September 2003. Dongting Lake in Hunan Province overflowed its banks in August 2002 due to heavy rains. The rains swollen rivers, which flowed into the lake the size

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of Rhode Island, causing the lake's waters to rise seven feet above dangerous levels.

Summer flooding occurred in southern China in 2004, particularly in the provinces of Guangdong, near Hong Kong, Hunan, and Guizhou, and in northeastern China in July 2004. In southern China, Hunan, Yunnan, Henan, Guizhou, Guangxi, and Sichuan were the hardest hit provinces, with floods, mudslides, caved-in roads, and landslides. On September 4, 2004, once-in-a-century rains triggered massive floods and mudslides in Sichuan Province. On March 5, 2005, flooding and landslides were caused in Xinjiang by the rapid melting of heavy winter snows. Torrential downpours from the heaviest rains in a century in July 2005 caused severe flooding in and around the city of Dazhou in Sichuan, southwest China. In August 2005, Hubei's central province was hit by torrential rains and landslides. On July 6, 2006, Anhui and Jiangsu Provinces experienced their worst rains in 45 years. Flash floods ripped through Guizhou Province in southwestern China in June 2006. Floods, lightning strikes, and landslides struck southern and central China in May, June, and July 2007. Several of the worst floods occurred along 1) the Huai River in Anhui, Henan, and Jiangsu Provinces; and 2) the Jiangsu River, a Yangtze tributary in Sichuan. In Yunnan, several people were killed by violent mudflows. In Chongqing, dozens died as a result of the drainage system's inability to handle large amounts of steady rain. Landslides triggered by heavy rains struck Garze, a Tibetan region in Sichuan, in May 2007.

Several rivers, including the Yangtze and the Huai, overflowed their banks in July 2007, displacing hundreds of thousands. Anhui has a population of half a million. Henan and Jiangsu fled a deadly flood zone along the swollen Huai River, which had been flooded for the majority of June and July. Although water had been diverted to other rivers and designated low fields, the waters continued to rise to dangerous levels. People were swept away by rain-swollen rivers in the normally dry provinces of Gansu and Xinjiang. Heavy rains in Shaanxi, northeast China. On August 7, 2007, heavy rainstorms in Sichuan and Yunnan Provinces, during the summer of 2007, an infestation of mice around Dongting Lake in Hunan Province destroyed thousands of acres of crops and damaged important dikes by burrowing through them to reach crop

In June 2008, southern China experienced torrential rains and flooding associated with the early summer rainy season. Tropical Storm Fengshen killed at least nine people in southern China in July 2008. A month later, Tropical Storm Fung-wong wreaked havoc, causing flooding. Tornado in Anhui Province in June 2008. Heavy rains in Sichuan, Jiangxi, Hunan, and Guizhou provinces in July and August 2009. In the summer of 2010, China experienced its worst flooding in more than a decade. Flooding, torrential rains, and landslides. In Fuzhou, Jiangxi Province, dikes were breached and rivers overflowed their banks. Soldiers and workers piled rock and sandbags to patch holes as the area braced for more torrential rains. In August 2010, heavy rains flooded an area along the North Korean border, swelled the Yala River. Since June 2011, after extreme summer weather triggered massive floods and deadly landslides, Hainan Island has experienced the worst flooding in nearly half a century. In June 2011, central and southern China were hit by severe floods caused by relentless heavy rains. Numerous major rivers became swollen and overflowed their banks, affecting millions and resulting in the death or disappearance of dozens. June 2011 floods in Southern China. Floods in Eastern China in June 2011. Beijing's Summer 2012 was drenched in rain. Flooding in Shanxi Following Dam Collapse En février 2013. Southern China receives rain in May 2013. Flooding in Western China in July, 2013 and June and September 2016, severe weather, including torrential rain, thunderstorms, and hail, began in Southern China, triggering deadly floods. Floods struck Guangxi, Guangdong, Hunan, Hubei, Jiangxi, Jiangsu, Anhui, Zhejiang, Shandong, Shaanxi, Yunnan, Sichuan, Gansu, and Henan in early June 2017. In June-September 2020, heavy rains associated with the regional rainy season resulted in severe flooding across a large portion of southern China, including the Yangtze basin and its tributaries. July brought rains and flooding to central and eastern China. 17-31 July. Since 17 July 2021, China's Henan province has been afflicted by severe flooding caused by a prolonged period of heavy rainfall, with the provincial capital Zhengzhou receiving a maximum rainfall of 201.9 millimeters in an hour.

### 7. Conclusion

Geographically, the Yangtze River Delta has a flat surface, which has both advantages and disadvantages. Flood data spanning thousands of years demonstrates that there is no significant flood mitigation in this area, and that the majority of floods occur not due to a lack of effective techniques, but due to the world's climate being unstable. Each year, China experiences scorching summer temperatures, torrential rainfall, tropical storms, and other climate changes. Positively, the Yangtze River Delta has numerous assets, including a heritage water town, the world's largest lake, which sustains the ecosystem and its inhabitants, and countless tributaries, which have become a distinctive feature of this territory. The conclusion is that while the flood cannot be stopped, it should be managed to avoid catastrophic damage to residents.

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