TECHNICAL REPORT OF ASRWG ON IRRIGATION AND DRAINAGE FOR ASIAN FOOD SECURITY–CHINESE TAIPEI

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1. Introduction

The territory of Taiwan administratively consists of Taiwan Island, also known as Formosa, and several offshore islets. As these islets are very small and hence have little arable land, the crop production as well as agricultural water resource management in Taiwan mainly focused on Taiwan Island, where the total area is about 36,000 km^2.

Taiwan is located on the eastern edge of the Asia Continent, off the China mainland, southeast of the main islands of Japan, and north-northwest of the Philippines. It borders east by the Pacific Ocean, north by the East China Sea, west by the Taiwan Strait, and south by the South China Sea and Bashi Channel. Approximately 70% of its total area is mountainous, mainly lying in the central region, stretching from north to south. The remaining 30% of the land is mostly the plains and mild sloping lands with elevations below 100 m, mainly spreading in the western corridor and along both banks of rivers.

There are 118 river systems on the island of Taiwan, mostly running to the Pacific Ocean on the east and the Taiwan Strait on the west. The locations of the major rivers on Taiwan Island are as shown in Figure 1. However, only nine of these river systems have basin areas each exceeding 1,000 km^2. The Choshui River is the longest in Taiwan, with its main course of around 186.6 km. The second largest river is the Kaoping River, with the largest watershed of about 3,257 km^2. In general, Taiwan's rivers are among the steepest gradients and rapidest flows in the world. With these characteristics, the river flows have been vigorously scouring and eroding the riverbeds.

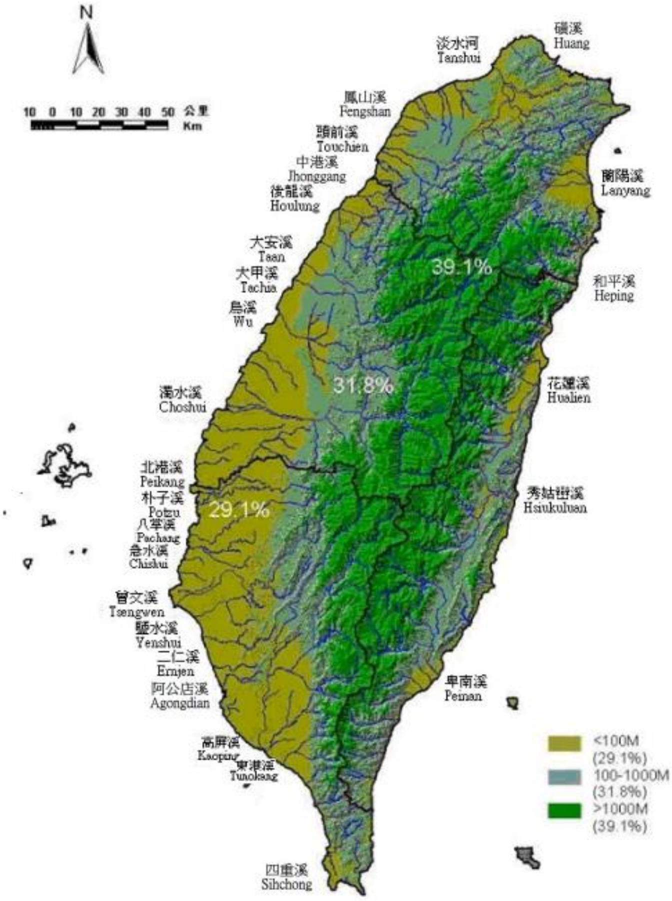

Figure 1. The terrain of Taiwan Island and the locations of the major rivers

2. Population

Taiwan is facing a rapidly aging population due to a declining fertility rate, which may lead to a shortage of human resources in the future. Taiwan's total population peaked at 23.6 million in 2019 (Figure 2a), with 178,000 births in the same year. After 2020, the population shifted from a natural increase to a natural decrease. In terms of population aging, the proportion of people aged 65 or more reached 7% in 1993, making Taiwan an aging society. As the number of elderly people increases, the number of deaths also rises rapidly, leading to an accelerating rate of population decline in the future. According to the estimation of the National Development Council, by 2025, the proportion of elderly people aged 65 or above will exceed 20% of the total population, making Taiwan a super-aged society, and the number will continue to rise to 43.6% by 2070 (Figure 2b).

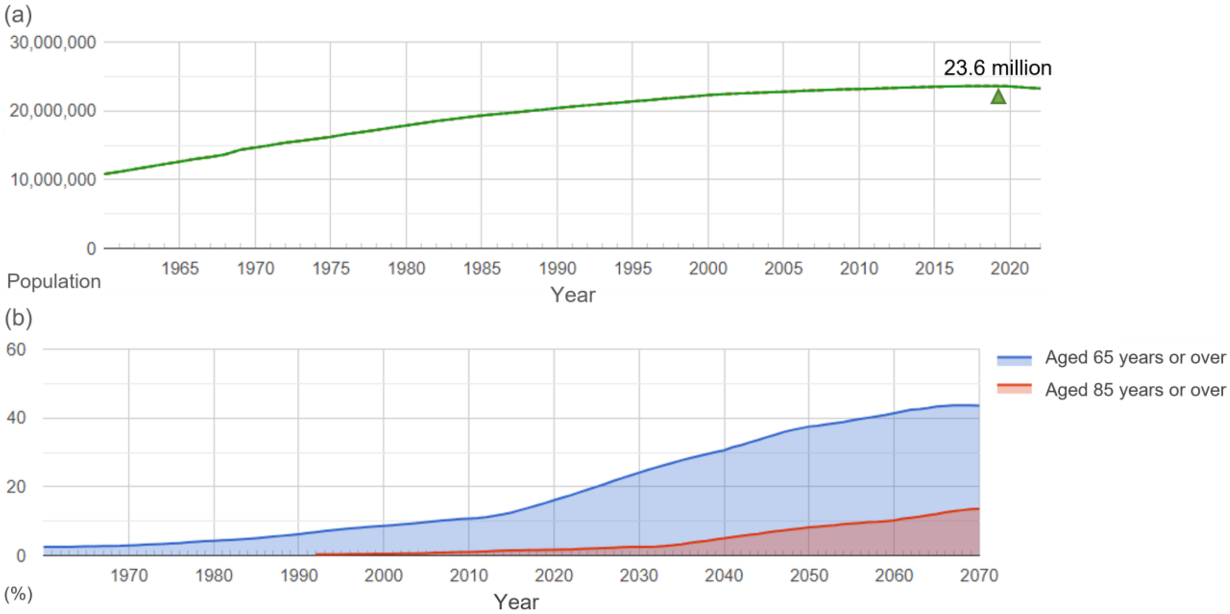

Figure 2. Year-on-year changes in (a) the actual total population and (b) the projected proportion of elderly population in Taiwan

Because Taiwan's population has continued to rise since 1960, the nation's population density has increased each year as well. Figure 3 shows that in 1961, the population density was 310 people per square kilometer of land. By 2001, the population density had grown to 619 people per square kilometer, twice as high as the number had been 40 years earlier. In line with the growing population, the population density peaked at 652 persons per square kilometer in 2019 and declined slightly in 2020 due to natural population decline.

In addition to the problems of low fertility rate and population aging, Taiwan is also experiencing urbanization as a result of the migration of the rural population. According to statistics from the Council of Agriculture, the number of farming households in Taiwan has been decreasing year by year as a percentage of the total number of households in the country, dropping below 10% in 2008, and was 8.5% in 2021, or about 759,000. In 2023, the employed population in agriculture in Taiwan is 523,000, a decrease of 25,000, or 4.6%, compared to three years ago (in 2020). Among them, 485,000 people (89.5%) were employed in agriculture and livestock farming in 2021, while another 10.5% in fisheries (9.8%) and forestry and logging (0.7%).

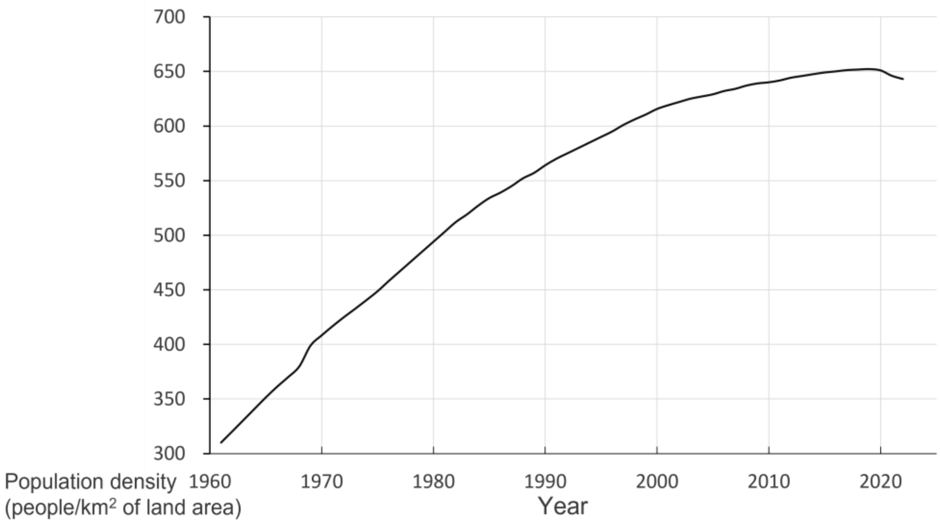

Figure 3. Year-on-year change in population density in Taiwan

3. Climate and rainfall

Situated in the Asian monsoon region, and having a large ratio of mountainous land on the island, the climate in Taiwan is greatly influenced by the monsoons as well as the landforms.

In the plain areas, the average annual temperature is as warm as about 23.9 ℃. The average temperature is about 27–29 ℃ in the warm/hot season (June–September) and around 18–22 ℃ in the cool season (November–March). The yearly rainfall in Taiwan between 1949 and 2021 ranged from 1,572 to 3,241 mm or averaged about 90 billion cm^3 in volume, equivalent to about 2.5 times the world's average. Taiwan, accordingly, is categorized as a region of abundant rainfall. Owing to the present dense population (around 23 million), the average annual precipitation per capita is merely 3,913 m^3, which is roughly one-fifth of the global average; therefore, Taiwan falls under the category of water-scarce regions.

Each year, about 78% of the island's rainfall occurs during the wet season from May to October, mainly sourced by plum rains, storms, and typhoons. During the months of the dry season, the total rainfall amount is just around 22% of the yearly sum. Amounts of annual rainfall vary drastically, and the hydrological uncertainties in Taiwan are quite acute. According to the statistics from the Central Weather Bureau, there were about 3 to 4 typhoons every year striking Taiwan between 1911 and 2021. Typhoons usually hit Taiwan from July to September, and August is the month with the highest number of strikes.

Rainfall patterns are not only subject to temporal variability due to the influence of the rainy season, summer convective rains, and typhoons but also show spatial variability across regions. In winter, the northeast monsoon brings moisture and rainfall to the northeastern region, so the region also receives a moderate amount of rainfall in winter, accounting for about 40% of the annual rainfall. The southern part of the country, however, is less likely to receive rainfall from the Northeast Monsoon due to the obstruction of the mountain ranges, and receives less rainfall in winter, making it the region with the greatest difference in rainfall timing, with about 90% of the rainfall occurring in the period of abundant rainfall from May to October. About 90% of the rainfall is concentrated in the rainy season from May to October. The difference in rainfall in the central and eastern parts of Taiwan is similar to the average for the whole of Taiwan.

In Taiwan, the regional annual evaporation is approximately 1,250 mm in the northeast, 1,600 mm in the west, 2,000 mm in the south, and 1,700 mm in the eastern regions. The highest monthly evaporation rates usually happen in July.

4. Area under agriculture, irrigation, and drainage

The land resources of Taiwan Island are generally composed of plains, hilly slopes, and mountains. The plains of Taiwan are mainly used for agriculture, industry, commerce, and housing. With undulating terrain and uneven depths of soil zones, the hilly slopes are utilized in accordance with the land use limitations specified in the Slopeland Conservation and Utilization Act. The Act stipulates that the hilly slope lands shall be classified into two categories: the land suitable for agriculture and livestock, and for forests. The first category of land is mostly arable land. In 2021, the total arable land, including the plains and the hilly slope, covered 787,026 ha. Of these areas, the irrigation associations' total service area was 377,905 ha.

The general arable lands in Taiwan have been used as far as possible for paddy fields, which has been attributed to the relatively stable feature of paddy rice production, farmers' farming customs, and the prevailing concept of self-sufficiency in the food supply. Therefore, in the plains and plateaus where the topographies are flatter and water resources are plentiful year-round, the wetlands have been generally reclaimed for double rice-cropping areas coupled with secondary crops growing during the short periods between the dry and wet cropping seasons. On the other hand, the single rice cropping farmlands located in arable areas, where water resources are scarce in dry seasons, are suitable for one paddy cropping in wet seasons and, subsequently, secondary crop cultivation in dry seasons. In the areas with sandy soils that perform poor water retention capacity or the areas where slopes are steeper, the arable lands are used for upland crop production.

Table 1. The records of the total arable area and the area with irrigation and drainage service in Taiwan, from 2002 to 2021

Year	Arable area (ha)	Annual change of arable area based on 919,680 ha in 1976		Irrigation and drainage area	
		(ha)	(%)	(ha)	(% of total arable area)
2002	847,334	-72,346	-7.87%	374,309	44.17%
2003	844,097	-75,583	-8.22%	377,058	44.67%
2004	835,507	-84,173	-9.15%	378,460	45.30%
2005	833,176	-86,504	-9.41%	377,390	45.30%
2006	829,527	-90,153	-9.80%	378,096	45.58%
2007	825,947	-93,733	-10.19%	382,229	46.28%
2008	822,364	-97,316	-10.58%	382,137	46.47%
2009	815,462	-104,218	-11.33%	383,165	46.99%
2010	813,126	-106,554	-11.59%	383,041	47.11%
2011	808,294	-111,386	-12.11%	382,660	47.34%
2012	802,876	-116,804	-12.70%	381,898	47.57%
2013	799,830	-119,850	-13.03%	380,814	47.61%
2014	799,611	-120,069	-13.06%	380,418	47.58%
2015	796,618	-123,062	-13.38%	377,858	47.43%
2016	794,005	-125,675	-13.67%	375,198	47.25%
2017	793,027	-126,653	-13.77%	375,162	47.31%
2018	790,680	-129,000	-14.03%	378,368	47.85%
2019	790,197	-129,483	-14.08%	377,564	47.78%
2020	790,079	-129,601	-14.09%	377,825	47.82%

2021	787,026	-132,654	-14.42%	377,905	48.02%

Data Source: Annual Report on Agricultural Statistics, Council of Agriculture, Ministry of Agriculture.

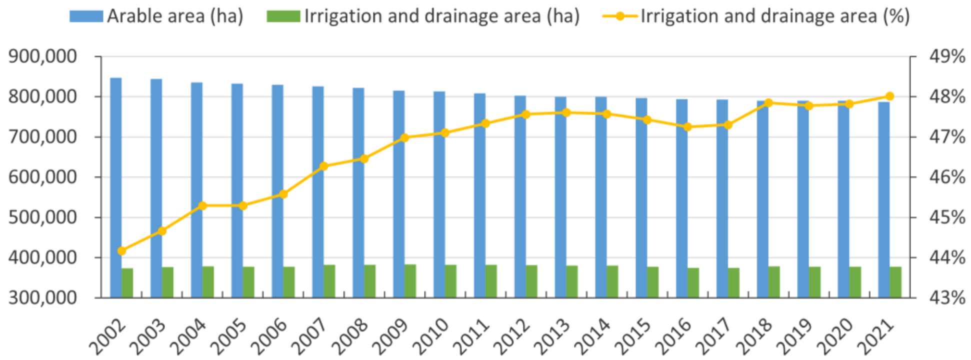

Figure 4. The percentage of arable area with irrigation and drainage service in Taiwan, from 2002 to 2021.

The area of the arable lands in Taiwan reached the highest record of 919,680 ha in 1976. Thereafter, the use of arable lands for non-agriculture purposes such as housing complexes, industrial parks, public transportation, and new cities, caused the shrinkage of the arable land. Table 1 shows that the arable land gradually decreased year by year between 2002 and 2021. Fortunately, there has been little change in the arable area with irrigation and drainage service during the same period, so the percentage of irrigated areas has increased, as shown in Figure 4.

5. Role of water resources management

Owing to topographic and geographic factors such as steep mountains, short rivers, and rapid flows, about 60% of rainfall in Taiwan returns directly to the ocean, as shown in Figure 5. Only 19% of rainfall can be converted as available water resources. Additionally, the large differences in precipitation amounts between wet periods and dry periods all indicate unfavorable hydrological conditions in Taiwan and lead to irregular water deficits.

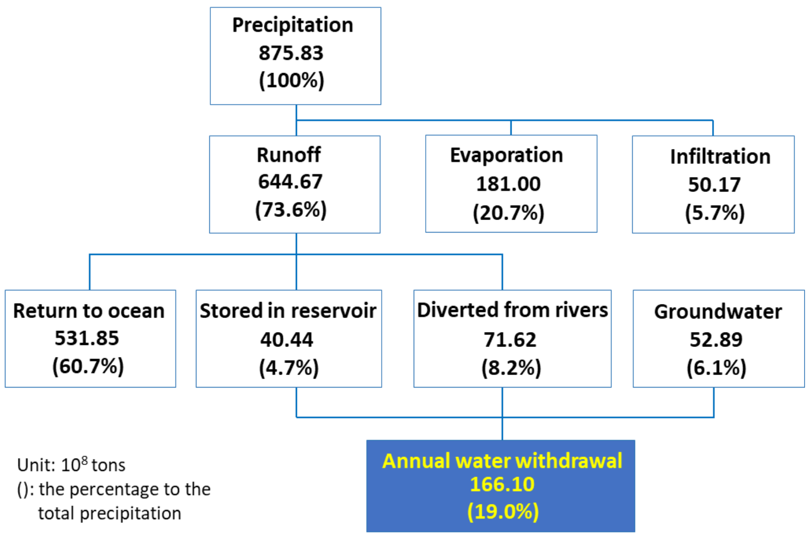

Figure 5. Rainfall and water utilization in Taiwan

According to the statistics from the Water Resources Agency, the average annual total water withdrawal from 2012 to 2021 was 16.6 billion tons. Among all the water consumption sectors, the agricultural sector consumed about 11.9 billion tons, which was 71% of total water withdrawal (Figure 6). The statistical connotation of agricultural water for the current stage is made of three parts: irrigation water, aquacultural water, and livestock water. Irrigation water is the major consumption activity in agriculture. It consumed some 10.9 billion tons, which was 92% of agriculture water consumption, and 66% of the total.

Among 10.9 billion tons of irrigation water in Taiwan, 87% was diverted from stream flow and surface water, 10% from reservoirs and various farm ponds, and 4% was pumped from groundwater (Figure 6). Although 66% of total water withdrawal was used for irrigation, 87% of irrigation water was diverted from rivers or other surface water, whose quality and quantity were less stable than those stored in reservoirs.

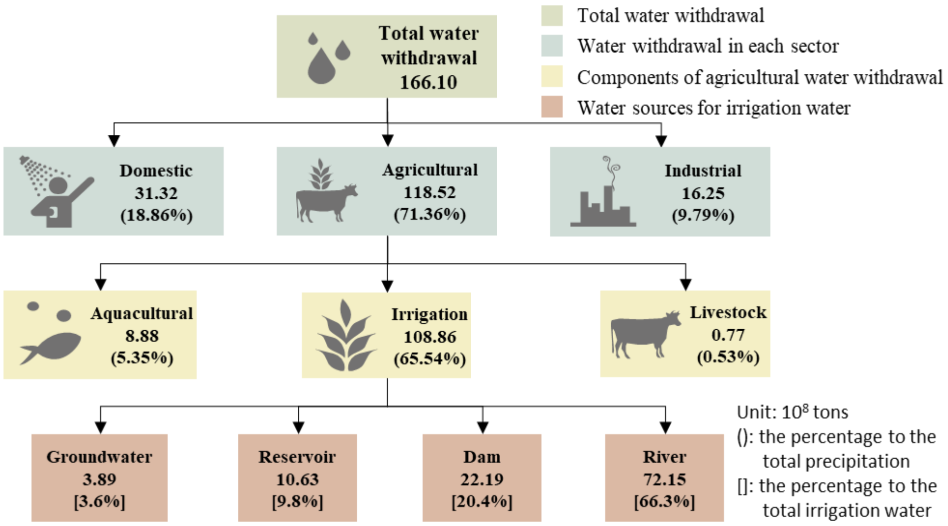

Figure 6.

Water Consumption and Proportion of Water Used by Each Section, and Composition of Irrigation Water Sources in Taiwan

Taiwan's topography and characteristics of rainfall make it difficult to store water, and much of the water brought by rainfall isn’t fully utilized. Therefore, the construction of water conservancy facilities and the implementation of water resource management policies are crucial for people's livelihoods, industries, and agricultural water needs. There are 95 reservoirs in Taiwan's main island and outlying islands. Among these, Tsengwen Reservoir in Chiayi County has the largest storage capacity. Tsengwen Reservoir was built to regulate and utilize the water resources of Tsengwen River to improve and expand the irrigation of agricultural land in the Chainan Plain. The water from Tsengwen Reservoir is discharged to the off-channel Wushantou Reservoir, through which the water demands for rice field irrigation in the Chainan plain as well as for public water supply are met. Meanwhile, the reservoir also provides the benefits of hydroelectricity and flood control. As shown in Figure 7, Tsengwen-Wushantou Reservoir has the highest percentage of annual water use for hydropower among the various uses, but the water used for hydropower is not consumptive and can be reused. In terms of water supply and demand, irrigation requires a large amount of water, and the main objective of the construction of the Tsengwen-Wushantou Reservoir is to stabilize the water supply for rice irrigation in the Chiayi and Tainan regions. Therefore, from 2011 to 2020, more than 70% of the water supply was used for irrigation. The Chiayi and Tainan region has the largest irrigated farmland in the country about 738 square kilometers. With a warm climate and gentle topography, Chiayi and Tainan plains are important food production areas, and the Tsengwen-Wushantou Reservoir is important in supplying irrigation water.

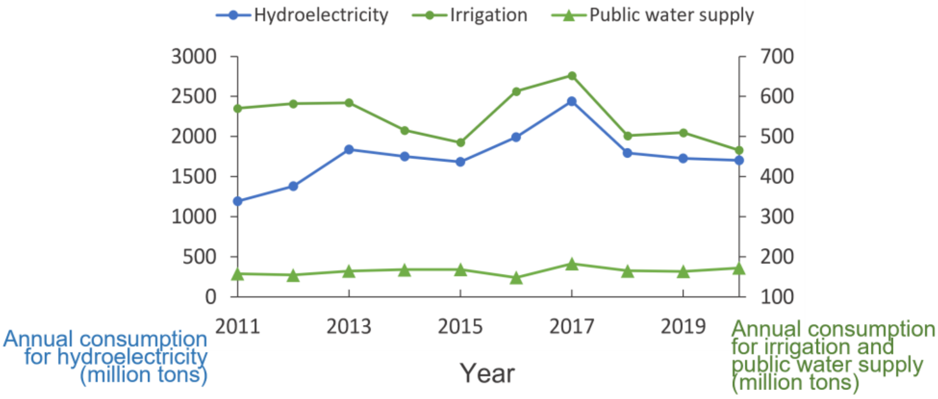

Figure 7. The amounts of water discharged by the Tsengwen-Wushantou Reservoir and used for different purposes, from 2011 to 2020.

Central Taiwan lacks large-scale water storage facilities but has the nation's longest stream, which is the Choshui River. Jiji Weir is about 50 kilometers from the sea. Because of its construction, a water storage space of about 5 million cubic meters was created upstream. However, the purpose of building it was not to store river water but to raise the water level of the river, so that it would be easier to obtain water, and the water supply would be more stable. The weir is the largest weir in Taiwan in terms of water intake and is responsible for providing water for agriculture, industry, and domestic use in Changhua and Yunlin counties.

The average annual flow rate of the Choshui River is about 6 billion cubic meters, and the utilization of water resources is limited due to factors such as steep slopes and turbid water quality. Because of the huge difference in the amount of water during the wet and dry seasons, before the construction of the Jiji Barrage Weir, farmers along the lower reaches of the Choshui River built temporary dams and diverted the water for irrigation individually. During the wet season, the flow of water was extremely large and rapid, and these simple water-blocking facilities were often washed out and couldn’t be easily repaired. In addition, Choshui River is high in sand content and turbidity, and the siltation of sediments often affects the function of water conveyance. Therefore, during the wet season, the farmland couldn’t be irrigated despite the abundance of water. To cope with the huge difference in water supply during the wet and dry seasons, groundwater in the Changhua and Yunlin areas was often extracted as an alternative water source. With the development of Yunlin Outlying Islands Industrial Park and central Taiwan, water demand has been increasing. To stabilize the water supply and reduce the amount of groundwater extracted, Jiji River Weir was built in the 1990s and was opened in 2002.

With the help of the Jiji weir, more than 2 billion cubic meters of water in the Jhuoshuei River can be regulated per year. As shown in Figure 9, from 2011 to 2020, irrigation water accounted for more than 90% of the annual water supply of the Jiji Weir, and the remaining 10% was used for industry and people's daily needs. Changhua County and Yunlin County are located on the north and south banks of the Jhuoshuei River. 1,000 square kilometers of farmland in the Changhua-Yunlin area was irrigated from the Jiji Weir. Therefore, we can tell that Jiji weir is significant when it comes to the sustainable operation of the agricultural industry in the central region and the issue of food security in Taiwan.

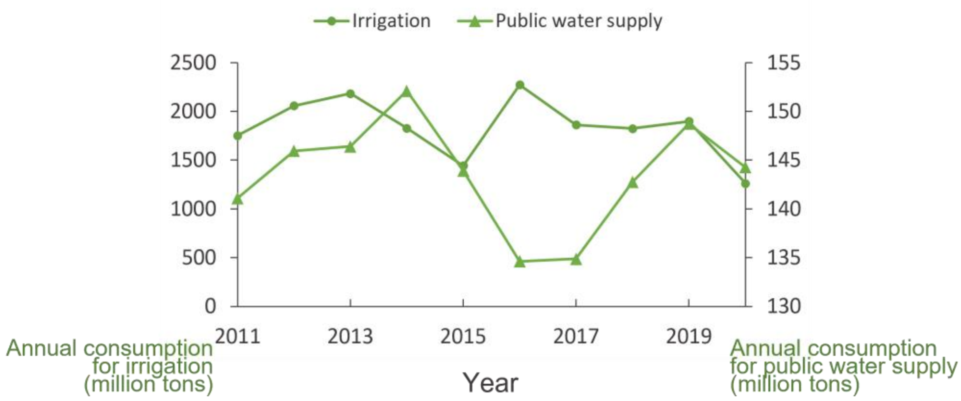

Figure 9. The amounts of water diverted from the Jiji Weir and used for irrigation and public water supply, from 2011 to 2020

In addition to the construction of reservoirs, dams, weirs, and other water conservation facilities, the management of groundwater is also important in Taiwan. When surface water resources are insufficient, groundwater pumping can be used as a supplemental water source. In the southwestern region of Taiwan, the rapid development of industries has led to a rapid increase in the demand for water resources. To meet the demand for domestic and industrial water, there are often cases of over-pumping of groundwater, which has led to subsidence of the earth's strata, and the coastal areas are faced with the problems of salinization of the land and the intrusion of seawater into the underground aquifers. Because of climate change, sea level rise, and accelerated urbanization, the environmental management of groundwater should be emphasized to ensure the sustainable use of soil and water resources.

As mentioned earlier, the Yunlin-Changhua area has often extracted groundwater in the past to cope with the shortage of surface water, making it one of the areas in Taiwan with serious subsidence problems. Through economic, industrial, legal, and scientific research, the government has endeavored to implement subsidence prevention and control policies over the past 30 years. For areas with serious subsidence problems, treatment projects have been carried out. In order to reduce groundwater extraction, the government has actively developed alternative groundwater sources, such as installing additional water storage and extraction facilities at appropriate locations, developing artificial lakes and water storage spaces to increase the amount of groundwater recharge, enacting regulations to control the drilling and utilization of wells, and promoting inter-departmental and inter-unit cooperation to strengthen the collection of information on wells in various regions. In recent years, modern monitoring equipment and big data internet have been combined to improve the management of groundwater resources, in order to safeguard agricultural production areas and national security.

6. Intercessions for food security

Various initiatives have been undertaken to enhance food security and agricultural sustainability in Taiwan.

1. Agricultural Adaptation Program on Climate Change: Taiwan faces the challenges of climate change, and it has taken steps to align with international standards, such as the Paris Agreement. The government has implemented the Climate Change Adaptation Action Plan, focusing on resource management, crop system adjustments, and stress-resistant plant varieties. The goal is to stabilize the food supply, ensure food security, and protect biodiversity.

2. APEC Action Plan for Reducing Food Loss and Waste: Taiwan actively participates in APEC initiatives to reduce food loss and waste. Knowledge sharing and cooperation between public and private sectors are emphasized to contribute to regional food security.
3. Reinforced Facilities Agriculture: To combat climate change and enhance agricultural efficiency, Taiwan promotes the use of agricultural facilities like greenhouses. The government provides subsidies for constructing structurally reinforced greenhouses, promotes eco-friendly farming, and supports research and development in this sector.
4. New Technology for Facilities Agriculture: Taiwan focuses on developing technology for facilities agriculture, including water-saving and energy-saving methods, environmental control systems, and disease prevention technologies. The aim is to increase efficiency and reduce damage from insect pests.
5. Big Granary Project: Taiwan seeks to increase self-sufficiency in mixed staple crops by converting rice-growing land to cultivate crops like sweet potatoes, soybeans, and corn. The project includes creating production zones, integrating collective production, and enhancing marketing.

These initiatives collectively aim to improve food security, promote sustainable agriculture, and address challenges related to climate change and resource management in Taiwan (Ministry of Agriculture, R.O.C.(Taiwan), 2017).

7. Role of research and development

To maintain agricultural development and food production, and to meet the challenge of increasingly frequent droughts and water shortages, the government has taken into account the competitive relationship between water demand and water supply capacity of different regions and adopted a number of measures to stabilize irrigation water supply and provide a stable and reliable foundation for agricultural production, including (1) installing additional storage facilities to retain water resources, (2) expanding and upgrading the irrigation system to enhance the efficiency of water conveyance and increase the area of irrigated land, (3) utilizing emerging technologies to build an intelligent irrigation system, and (4) strengthening cross-departmental collaboration to enhance the prevention and control of pollution.

7.1 Additional storage facilities to retain water resources

To increase water storage space for storing water resources during wet seasons, and to utilize the stored water during dry seasons to survive drought events, regular inspection and desilting of water storage facilities can help increase the storage capacity of reservoirs, ponds, and other water storage tanks. In addition, utilizing unused space near water sources or water conveyance systems to build additional water storage tanks can also reduce the loss of water resources during wet seasons and provide a steady supply of water for agricultural irrigation.

7.2 Expansion and upgrade of irrigation system construction to improve water transfer efficiency and increase irrigated area

Targeting old and damaged water conveyance channels or irrigation facilities, the government has carried out renewal and improvement works and taken the irrigation system as the scope of operation to carry out systematic maintenance work, including water intake facilities at water sources or weirs at rivers and streams, as well as major water conveyance channels. In addition, the government has identified potential water resources in suitable areas, built new water intake, storage, and transmission facilities, expanded the area of irrigated cropland, and constructed water pipelines to transmit water resources, to precisely allocate water sources and provide crops with water, and to increase the efficiency of water resources used for agricultural production.

7.3 Building an intelligent irrigation system with emerging technology

By combining emerging technologies such as the Internet, monitoring instruments and data transmission equipment are built into the water distribution system to continuously monitor water level/volume automatically. All monitoring data are stored in a cloud database and displayed on a website for irrigation managers to remotely understand the situation of water supply in the canal; and electric remote-control gates are built to allow water distribution managers to open and close the water gates without having to go to the site, making irrigation management operations more instantaneous, saving workers' physical effort, and ensuring their work safety. In addition, by combining reservoir water source observation data, weather forecast data, field soil water content, crop growth schedule, water demand, and other information, the irrigation simulation module can be developed to anticipate possible difficulties in future irrigation supply, so as to facilitate the early adoption of contingency measures, such as adjusting irrigation schedules, staggering peaks in water use, implementing regional irrigation rotation, using alternative water sources such as rivers or drainage water, utilizing return water, and activating drought-resistant wells. Enhancement of water distribution operations and other management measures can save water and stabilize farming performance at the same time.

7.4 Cross-departmental collaboration to enhance pollution control

Since most irrigation networks are constructed in open canal mode, pollutants are easily emitted into the agricultural production system. Thus, strengthening irrigation network management with related rules and regulations would be fundamental for irrigation water quality protection. In fact, the domestic or industrial wastewater directly or indirectly discharged into irrigation networks is the major factor influencing irrigation water quality. With the Water Pollution Control Act, the effluent standard for wastewater discharge is stipulated. Besides, it is important and effective to monitor and inspect the water quality in the irrigation network. Through the cooperation between the departments of central government as well as between central and local governments, the measures taken to protect irrigation water against pollution can be improved, therefore enhancing the irrigation water quality monitoring network.

8. Progress in reducing food insecurity

In the face of climate change, extreme weather, increasingly insufficient natural rainfall, and the growing disparity between the abundance and scarcity of water resources, the implementation of reasonable and fair water resource management is one of the key issues for the future operation of agricultural water use, and a prerequisite for the sustainable development of agricultural production and the rural environment.

In the 1970s, Taiwan’s agricultural development put stress on agriculture, farmers, and rural villages; since the 1990s, the emphasis has been shifted to crop production, livelihoods, and ecology. After Taiwan's accession to the WTO in 2002, Taiwan has faced the impact of economic and food production, and the focus on agricultural development has gradually changed. The government has promoted a production policy centered on health, efficiency, and sustainability in response to the domestic demand for food and the international trade environment.

In order to cope with the demand for water resources and reduce the risk of water shortage in agriculture in areas supplied by reservoirs, the government promotes the policy of adjusting the farming system in areas supplied by reservoirs for both irrigation and public water use, and guides farmers to adjust their farming patterns by replanting the first stage of paddy rice to drought-induced crops in a zonal and yearly manner or adjusting the paddy rice planting period to match the dry and wet seasons, so as to alleviate the pressure on the water supply in the region. This not only reduces the risk of water shortage in reservoir-type irrigation areas in times of drought but also maintains the stability of grain prices and ensures farmers' profitability, as well as strengthens the effectiveness of water conservation in agriculture during the dry season and supports public water demand.

As shown in Table 2, Taiwan's self-sufficiency rate in food in recent years has been about 32.4%. However, if we disaggregate the important foodstuffs by category, rice can satisfy the needs of the nation completely, and the self-sufficiency rate of meat is also over 75%. The self-sufficiency rate is so low due to climatic conditions, that Taiwan provides a poor environment for wheat and soybeans to grow, resulting in a reliance on imports. The fragmentation of farmland also makes it difficult for Taiwan to utilize machinery as the U.S. to carry out rough agricultural production. Therefore, improving the fragmentation of farmland can reduce the limitations of large-scale mechanized cultivation. By upgrading the agricultural labor force, increasing the amount of land available for agricultural production, and addressing the availability of irrigation water resources, the policies mentioned above ensure the availability of water, land, and human resources for agriculture and stabilize food production in Taiwan.

Table 2. Taiwan's total food self-sufficiency rate and self-sufficiency rate of important food categories from 2011 to 2021

Year	Total self-sufficiency rate (%)	Grain self-sufficiency rate (%)				Soybean self-sufficiency rate (%)	Meat self-sufficiency rate (%)
		Sum	Rice	Wheat	Corn		
2012	32.67	27.13	106.94	0.02	1.54	0.01	82.71
2013	32.89	25.82	100.37	0.03	1.89	0.04	81.89
2014	34.04	29.28	107.89	0.06	2.42	0.05	78.77
2015	31.37	26.64	97.09	0.11	2.50	0.11	75.51
2016	31.01	26.64	99.77	0.10	2.50	0.13	78.09
2017	32.30	29.63	107.85	0.10	2.86	0.18	75.88
2018	34.53	32.32	120.28	0.11	2.70	0.18	73.60
2019	32.10	28.72	110.26	0.10	2.71	0.19	73.78
2020	31.68	28.28	110.10	0.07	3.04	0.17	73.90
2021	31.27	26.31	101.98	0.07	3.17	0.17	76.49

Data Source: Ministry of Agriculture.

9. Way forward: country strategy for food security

The 21st Century is universally known as the water century and also the life century. According to the ideological trend of sustainable world development, the sustainability of agriculture development, specifically irrigation water supply and food production, has been highlighted. In the near future, it will become an issue that cannot be overlooked by all nations, especially because we are confronted with the challenges of climate change. In addition, the impact of the Coronavirus epidemic from the end of 2020 to 2022 has increased the risk of international exchange of commodities and resources, thus emphasizing the importance of self-sufficiency.

In Taiwan, in order to protect sufficient areas of good agricultural land to ensure stable food production, the government approved the implementation of the National Land Plan in 2018, which delineated the total amount of maintainable agricultural land in the country to be 810,000 hectares, and put forward three strategies for the protection of agricultural land resources:

1. Agricultural development areas should avoid the addition of new non-agricultural use facilities and behaviors to avoid the environment from being damaged and resulting in the continued fragmentation of agricultural land; those who have to set up such facilities should be compatible with the nature of the use or apply for users by the National Land Planning Act and should not affect the surrounding agricultural production environment.

2. The agricultural development area prioritizes the investment of agricultural resources to strengthen the construction of important infrastructure facilities for agricultural production (irrigation facilities, protective facilities, etc.) and effectively integrates the investment of land, water, and agricultural industry support resources to facilitate large-scale, centralized utilization, and enhance the efficiency of agricultural operations.

3. To protect the environment of agricultural production, strict environmental control is adopted to prohibit all kinds of possible polluting behaviors and to strictly investigate illegal use.

In addition to land management, the green environmental benefit program provides incentives to attract labor to join the agricultural industry, which is also a policy that the government has been promoting. Additionally, irrigation water, as one of the elements of agricultural production, involves the utilization of both water and land resources. Through the four major measures mentioned above, namely (1) increasing storage facilities to retain water resources, (2) expanding and upgrading irrigation system construction to improve water transfer efficiency and increase the area of irrigation, (3) applying emerging technologies to build intelligent irrigation systems, and (4) strengthening inter-departmental cooperation in pollution prevention and control, the management of water use efficiency of irrigation water resources will be achieved. Water use efficiency management will strengthen agricultural productivity and contribute to other sustainable development issues, including maintaining national domestic needs, improving microclimate, and promoting groundwater recharge. Therefore, the maintenance of agricultural land, irrigation water, farm labor, and other factors of agricultural production are the outlook for food security in Taiwan.

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