WATER TECHNOLOGY INDUSTRY IN SOUTHERN TAIWAN

JUNE 2017

This report is conducted by the Commercial Section of the American Institute in Taiwan's (AIT) Kaohsiung Branch Office. This review is based upon reviews of academic literature and news media conducted by AIT staff.

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Dear Water Technology Leaders:

Southern Taiwan's water sector is experiencing unprecedented need. Coupled with the island's Southbound Policy, the importance of Kaohsiung as a platform to South East Asia makes this need front and center in President Tsai's Forward Looking Infrastructure Development Program. This bill estimates 28 billion USD to be allocated by the Taiwan authorities for infrastructure buildup over the next thirty years, of which 8 billion is allocated to water related infrastructure buildup in the next 8 years. With flooding, drought, water treatment and storage being a critical need in southern Taiwan, it is the goal of the Commercial Service Kaohsiung team to bring quality American products and services to the region.

While there are excellent opportunities for U.S. companies throughout Taiwan, southern Taiwan offers an especially significant business platform for American companies as the potential for development and growth is significant. The Commercial Service Kaohsiung team is committed to helping American companies find new international business partners in southern Taiwan, and towards that end, this report analyzes the opportunities for companies in water related industries. Despite some challenges, our research suggests that these submarkets are poised for dramatic growth. We look forward to welcoming you to southern Taiwan.

Best wishes,

Sarah K. Fox
Principal Commercial Officer
Kaoshiung, Taiwan

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Executive Summary

Taiwan is facing a water crisis and is in search for solutions. While abundant precipitation is received each year, water shortages continue to challenge authorities due to Taiwan's uneven rainfall distribution, dense population, storage capacity, and geographical characteristics. Furthermore, global climate changes continue to worsen the current shortage situation and present unprecedented challenges to Taiwan's water system.

Taiwan's central authorities recently announced the Forward-looking Infrastructure Development Program for 2017-2024. Within the program, water resources and aquatic environment is listed as one of the five key areas where US $8.3 billion will be invested to solve current issues and meet future needs. The objective is to address challenges including water provision, flood prevention, and water-related infrastructure build up as priorities.

The Reclaimed Water Resources Development Act has also strengthened Taiwan authorities' emphasis on recycled water, especially in industrial areas where large and stable amounts of water is needed to ensure company production. Taiwan authorities aim to increase the amount of water gathered and distributed, at the same time, ensure that every drop of water is fully-utilized.

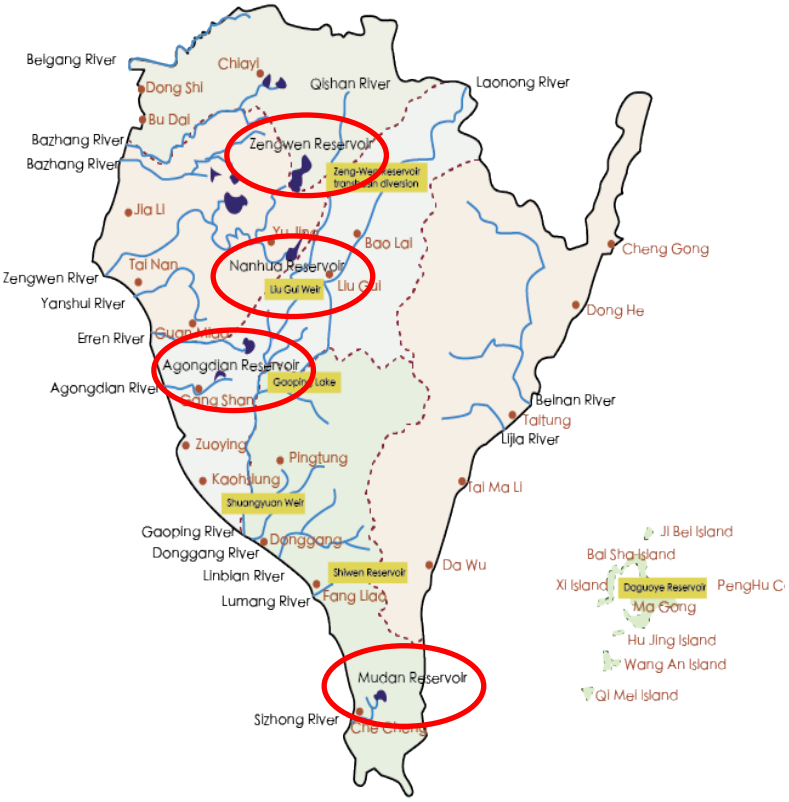
Although solutions have been implemented, most systems and procedures are still considered relatively new and incomplete. The search continues for integrated solutions that can assist Taiwan in achieving water sustainability. With the support of local and central authorities, great market opportunities are observed for American companies looking to export in this industry.

Introduction

This report is the product of research conducted by the Commercial Section of the American Institute in Taiwan's (AIT) Kaohsiung Branch Office. This review is based upon reviews of academic literature, interviews, and market research conducted by AIT staff. The purpose of this review is to provide an in-depth understanding of the opportunities for U.S. companies in southern Taiwan and provide market insights that may be beneficial for market entry strategy.

Taiwan, located at the heart of East Asia, is surrounded by oceans on all sides including the Pacific Ocean, Taiwan Strait, and the North China Sea. The climate falls between subtropical (northern) and tropical (southern) as Taiwan is separated through the middle by 23.5N(Tropic of Cancer). Taiwan is also affected by the East Asian Monsoon climate which affects the rain precipitation throughout the year. Because of its geographic locations and features, Taiwan receives abundant amounts of rainfall annually as compared to the world average. Nevertheless, Taiwan remains challenged by water resource management. The rainfall average distribution per person falls to roughly 1/5 of the world average. The main reason behind this figure is Taiwan's uneven rainfall distribution, lack of storage capacity, dense population, and geographical landscape.

Southern Taiwan consists of 7 municipalities, including Chiayi City, Chiayi County, Tainan City, Kaohsiung City, Pingtung County, Taitung County, and Penghu County. Taiwan has 96 reservoirs with 46 reservoirs providing household water usage. The main reservoirs in southern Taiwan are Zengwen Reservoir (Dapu Township, Chiayi County), Agongdian Reservoir (Yanchao District, Kaohsiung City), Mudan Reservoir (Mudan Township, Pingtung County), GaoPing River Weir(Dashu Township, Kaohsiung City), and Nanhua Reservoir(Nanhua District, Tainan City).



◀ Rivers and Reservoirs of Southern Taiwan

Data Source: Southern Region Water Resources Office, WRA, MOEA

Forward-looking Infrastructure Development Program (2017-2024)

Taiwan's central authorities recently announced the Forward-looking Infrastructure Development Program (2017-2024) to address future development needs and investment expansions in five focus areas including: railways, water resources and aquatic environment, green and renewable energy, digital technology, and urban and rural facilities. This eight-year plan aims to accelerate economic transformation while boosting Taiwan's overall competitiveness.

"Investment under the infrastructure development bill is expected to reach approximately NT$882.49 billion (US$28.78 billion) over eight years (2017-2024), with approximately 85 percent devoted to new development projects and 15 percent to accelerating or expanding previously approved projects. The Forward-looking Infrastructure Development Program will also drive investment of NT$1.78 trillion (US$57.98 billion) by public and private enterprises. Over the program's eight-year term, cumulative investment should thus raise gross domestic product by NT$975.90 billion (US$31.83 billion) while creating 40,000 to 50,000 job opportunities."-Executive Yuan[1]

In response to the challenges brought by global climate change, industrial structure shifts, and land security issues, the water aspect of the program aims to combine resources across local and central authorities to develop sustainable water-related infrastructures for the upcoming thirty years. According to the Deputy Minister of Economic Affairs Yang Wei-fu, the plan focuses on four main targets: first, to solve the problems in response to climate changes including floods and droughts; second, to renew disaster prevention facilities; third, to promote renewable water in response to the increasing demands of industrial water; fourth, to update water infrastructure and incorporate new technology.[2] The ultimate target is to achieve "No water shortages, no floods, drink good-quality water, befriend water (不缺水、不淹水、喝好水、親近水)" The three core strategies in regards to water are to develop capabilities, build safer communities, and construct friendly environments.[3]

*** In June 2017, Taiwan faced heavy rainfall that resulted in flooding in many cities. Discussions were raised to reconsider the water aspect of the Forward-looking Infrastructure Development Program. Authorities urge the Tsai Administration to reallocate project budgets and focus on the water aspect*

[1] http://english.ey.gov.tw/News_Content2.aspx?n=8262ED7A25916ABF&sms=DD07AA2ECD4290A6&s=069D45795F8BFE5B

[2] https://udn.com/news/story/7238/2398974

[3] http://english.ey.gov.tw/News_Hot_Topic.aspx?n=377551852C56AE6B&sms=9BC48536CE1E978C

for it is a fundamental issue that should be dealt with first. Further development regarding this issue requires future tracking. [4]

Strategy	Budget (NT$ Billion)
Water and Development	107.6
Water and Safety	115.1
Water and Environment	28
Total	**250.7 (US$8.18 billion)**

▲ Summary of Planned Water Projects, *Data Source: Water Resources Agency*

Water and Development

- Mission: To stabilize water supply through creating new resources and effectively managing current resources to obtain sustainability.
- Objectives:
  - Increase regular water provision by 1 million metric tons/day (10 percent).
  - Increase emergency water provision by 2 million metric tons/day (20 percent).
- Projects:

	Plan	Budget (US$ Million)	Time
Rehabilitate Reservoirs	**Shimen Reservoir Amuping Desilting Tunnel Plan**	94.62	**2015-2021**
	Baihe Reservoir Improvement Plan	65.26	2019-2027
	Hushan Reservoir Second Raw Water Pipeline Plan	32.63	2018-2020
	Shuangxi Ecological Reservoir Plan	332.81	2019-2027
	Tainhua Ecological Reservoir Plan	420.91	2020-2027
	Reservoir Conservation and Catchment Management	424.17	2017-2024
Increase Water Provision	**Wuxi-Niaozuitan Artificial Lake Plan**	619.94	**2015-2024**
	Offshore Island Water Provision Improvement Plan	61.99	2019-2024
	Non-Water Provision Area Improvement Plan	381.76	2017-2024
	Disaster Prevention and Emergency Well Construction Plan	110.94	2017-2020
	Da-an and Dajia River Connection Plan	290.39	2019-2023
	Zengwen and Nanhua Reservoir Connection Plan	391.54	2019-2024
	Jinsha and Qianpi River Development Plan	48.94	2020-2024
Diversify Water Resources	Water Recycling Plan	114.20	2018-2023
	Deep Sea Water Development Plan	13.05	2017-2021
	Subsurface Water Resources Development Plan	65.26	2018-2021

[4] http://www.chinatimes.com/newspapers/20170605000264-260102

Smart Water Management	Smart Water Management and Conservation Technologies	42.42	2017-2020
	Total	**3510.84**	

▲ *Data Source: Water Resources Agency*

Water and Safety

- Mission: To prevent floods and ensure national land security.
- Objectives:
  - Improve flood protection in 200 square kilometer area of flood-prone territories (17 percent).
  - Construct levee revetments and sewers for 250 kilometers managed by local authorities.
  - Clean 120 kilometers of rivers and regional drainage systems managed by central authorities.
  - Improve the condition of 16 kilometers of coastal sea walls.
- Projects:

Plan	Budget (US$ Billion)	Time Frame
Local Authoritative Rivers and Regional Drainage System Improvement Plan	2.35	2017-2024
Central Authoritative Rivers and Sea Wall Improvement Plan	1.40	2020-2024
Total	**3.75**	

▲ *Data Source: Water Resources Agency*

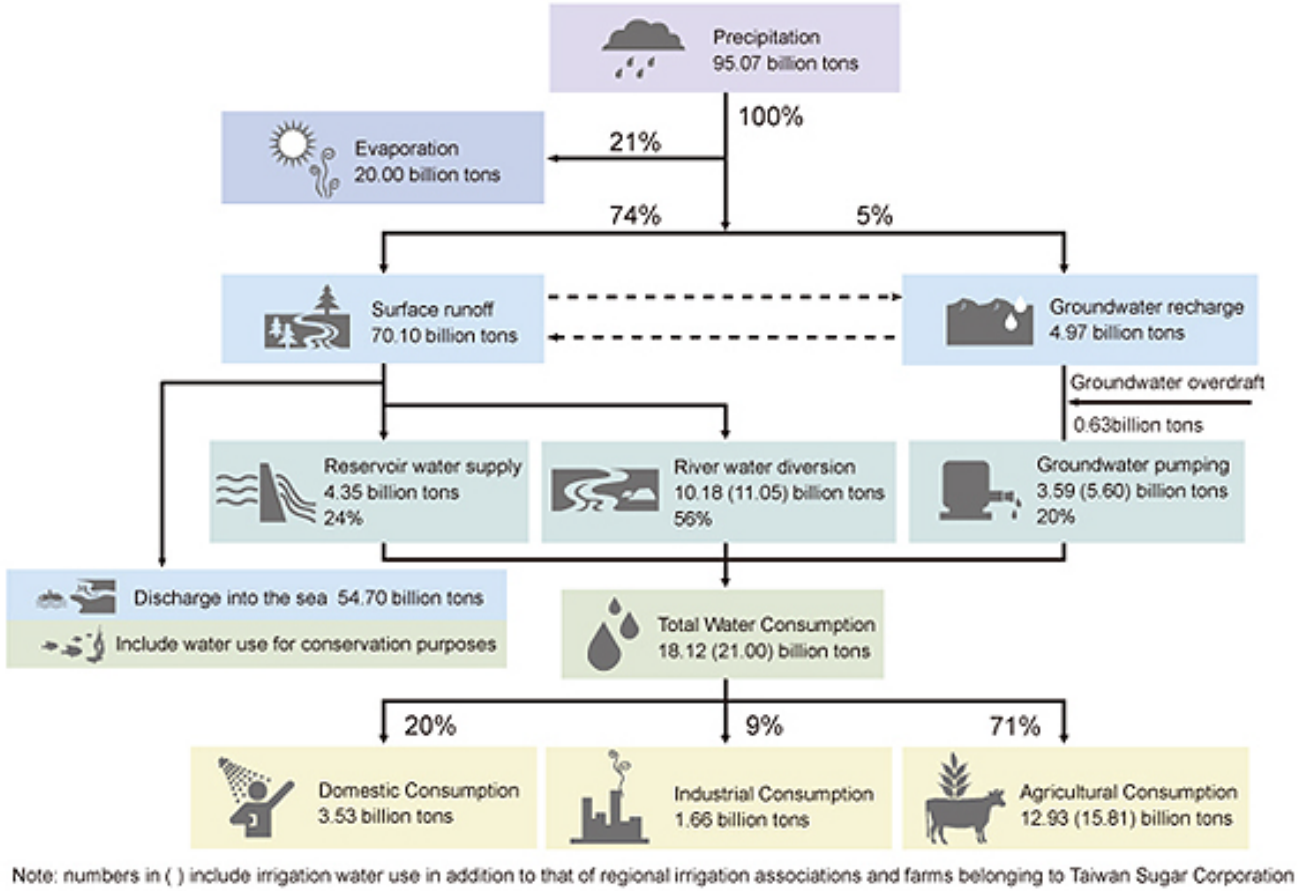
Water and Environment

- Mission: To improve water quality and create water-friendly environments.
- Objectives:
  - Promote one river landscape or water habitat per city.
  - Create 420 hectares of waterfront recreational spaces.
- Projects:

Plan	Budget (US$ Million)	Time Frame
National Water Environment Improvement Plan	913.60	2017-2024
Total	**913.60**	

▲ *Data Source: Water Resources Agency*

Water Utilization



▲ Utilization of Water Resources in Taiwan (2000-2009)
Data Source: Water Resources Agency

Agricultural

Agricultural water use takes up roughly 71 percent, followed by household water use at 20 percent, and industrial use at 9 percent. Out of the 12 billion tons of agricultural water use, roughly 60 percent or 7.34 billion tons of water is used for the rice industry. Agricultural industry takes up a majority of water resources, but contributes to less than 2 percent to the national GDP. This is the main reason that water rationing procedures usually begin with limiting agricultural water use. From 2002 to 2015, agricultural water use has been rationed 6 times in order to provide water use in other sections.[5] Southern Taiwan includes several agricultural areas, including Jianan Plain, which is the largest plain in Taiwan. This provides massive opportunities for accurate irrigation methods that can help lower costs and more importantly, provide more effective usage of water resources.

[5] https://www.newsmarket.com.tw/blog/63279/

Industrial

Heavy industries contribute to more than 50 percent of the national GDP, but uses only up to 10 percent of the water resources. A study conducted by the Industrial Technology Research Institute states that 85 percent of industrial water use in Taiwan is from 6 major water-consuming industries including the oil industry, textile industry, metal industry, paper industry, electronic industry, and chemical industry, of which most of these industries are clustered in southern Taiwan. It is important to note that from these industries, chemical and electronics take up over half of the industrial water consumption. If sorted by functions, 49 percent of industrial water use goes to production procedures that include cleaning equipment, purifying equipment, and air-conditioning facilities. 40 percent goes to cooling procedures and 8 percent to boiling procedures. Recycling and treating this water is critical in southern Taiwan.

According to Article 18 of the Water Act in Taiwan[6], water priority goes to (1) household and public use (2) agricultural use (3) hydraulic use (4) industrial use and (5) transportation use. Under this regulation, the manufacturing industry is at a disadvantage since it is low in priority. When water shortages arise, industries are under more pressure to recycle and treat their waste water. This creates a tremendous opportunity for waste water management in Taiwan, and especially in southern Taiwan. Details of these opportunities are in the latter part of the report.

Companies based in southern Taiwan have also expressed concern towards this issue. For example, Taiwan Semiconductor Manufacturing Company (TSMC) is looking to invest their new 3 nano-tech plant in Luzhu Kaohsiung; however, water supply remains one of their major concerns[7]. Because of this, central and local authorities are prioritizing stable water supply as a main issue to stop companies from pulling back potential investments.

Household

Household water usage takes up roughly 20 percent of the total water utilization. Even though Taiwan is short on water resources, most of the public fail to understand its urgency due to the low water tariffs collected in Taiwan. In addition, since water distribution is scarcer in southern Taiwan, often times it is southern Taiwan that first implements water rationing measures, of which household usage are affected. Water conservation concepts are actively promoted by public and private sectors, thus, water-conserving products also present huge market potential in order to help realize the common goal and save water.

[6] http://wralaw.wra.gov.tw/wralawgip/cp.jsp?lawId=8a8a852d1fd9cb2d011fd9fd315b013e
[7] http://news.ltn.com.tw/news/local/paper/1092325

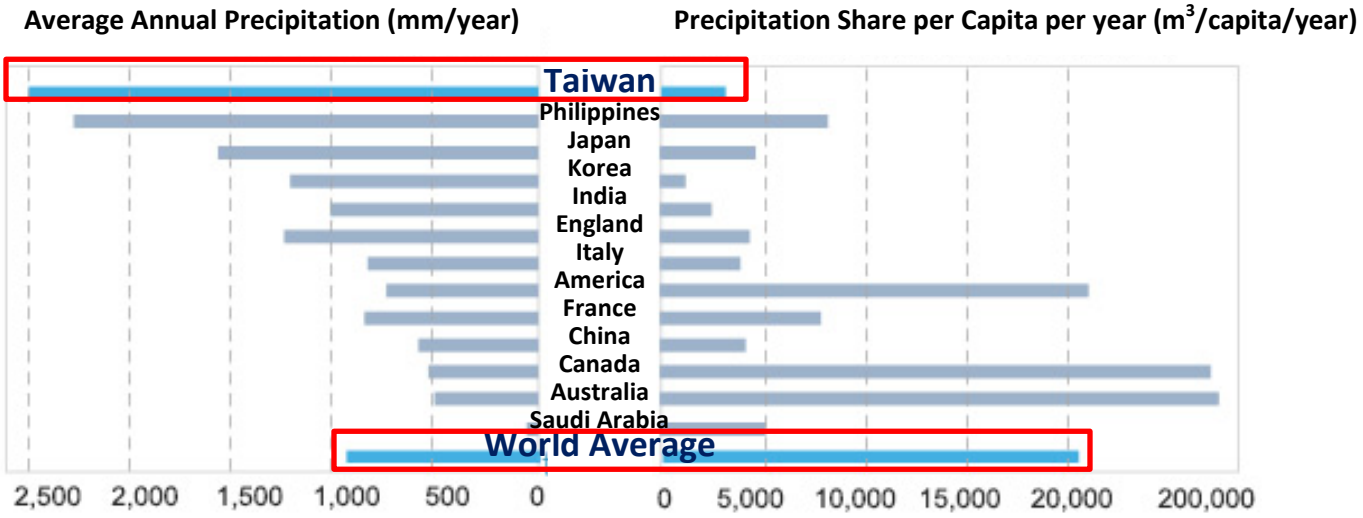
Water Challenges

Water Distribution

Water distribution issues are comprised of several factors that concern authorities. Since the cumulative amount of precipitation is not an issue for Taiwan, Taiwan aims to tackle these individual factors to ensure that each and every drop of precipitation is not wasted but instead fully utilized. In the following section, the discussion will be focused on the current situation leading to water distribution issues, including dense population in a few places of the island, spatial scale, temporal scale, and geographic features. Each factor may present great market potential for companies to enter and provide solutions.

Dense Population

As an island located at the tropical region of Asia, Taiwan receives abundant rainfall each year. As seen from the chart below, Taiwan has an average rainfall of 2,500mm per year. This number is 2.6 times the world average. However, this does not translate to abundant water usage for each person. With an area of 13972mi^2, Taiwan has a population of around 23 million people, with greater clusters in the west lowland regions. This dense population results in a rainfall distribution/person at 4,000 m^3 per year. This amount is less than 1/5 the world average.



▲ Average Rainfall (left) Average Rainfall Distribution per person (right)
Data Source: Water Resources Agency, MOEA

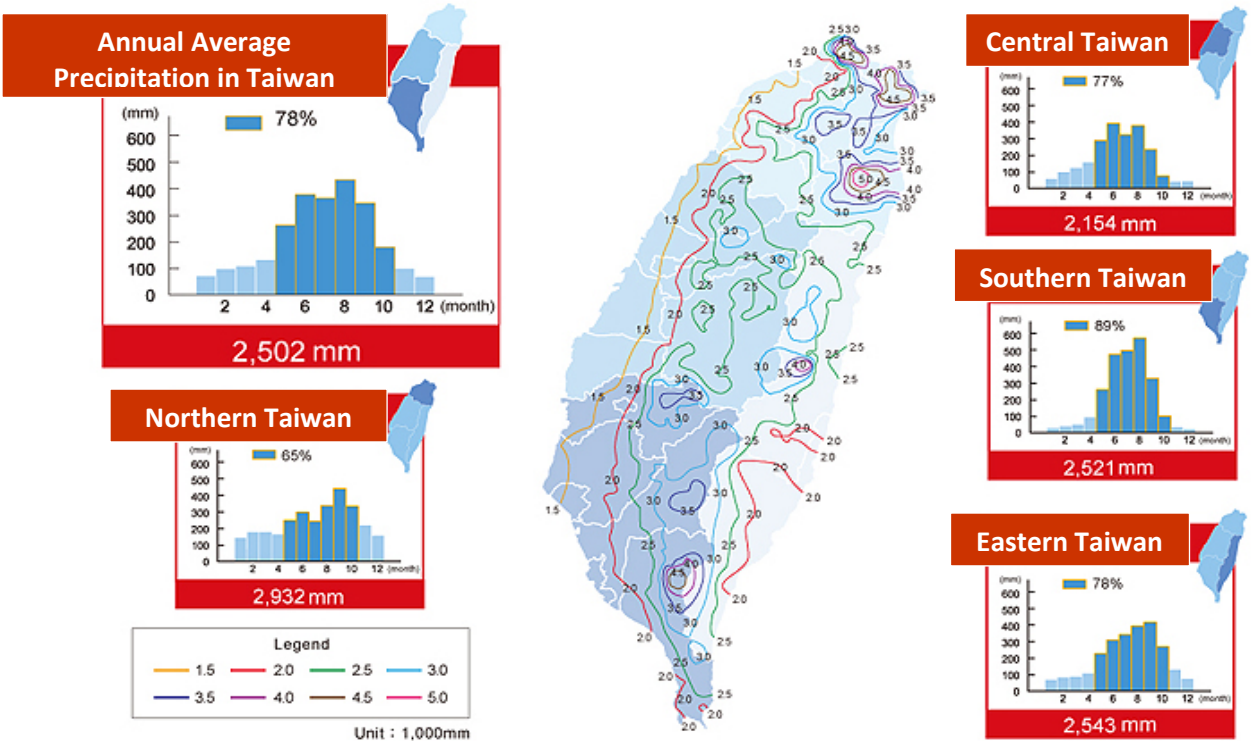
Spatial Scale

Precipitation in Taiwan is more abundant in northern Taiwan as compared to southern Taiwan. Mountain areas also receive more precipitation than lowland areas. The accumulated precipitation

in northern mountain may go up to 8,500mm while in comparison, Penghu, an archipelago off the western coast, would have precipitation less than 1,000 mm.[8]

Temporal Scale

Taiwan's rainy season occurs during the summer months from May to October. Typhoon season also falls around June to August, during which the precipitation will boost even higher. The precipitation that occurs during this season can account up to 78 percent of the annual precipitation[9]. Dry winter season occurs from November to July. It is common to see both floods and droughts throughout the year. During the early part of the year, reservoirs would panic as water levels drop to the lowest point. As rainy season approaches, heavy rainfall cannot be fully alleviated and stored, which is when floods and other natural disasters occur. This difference is more dramatic in southern Taiwan than in northern Taiwan. The rainy season and dry season ratio in northern Taiwan is 6:4 while it is 9:1 in southern Taiwan.[10] This dramatic distribution difference makes it extremely difficult for southern Taiwan to effectively store and utilize water resources.

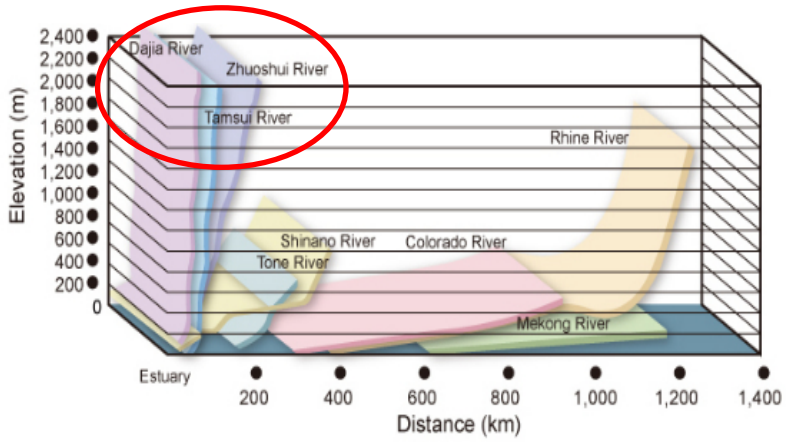


▲ Isohyetal Map Indicating Distribution of Average Annual Precipitation in Taiwan (1949-2009)
Data Source: Water Resources Agency, MOEA

[8] http://www.wrasb.gov.tw/knowing/knowing01_detail.aspx?type=47&tno=13
[9] http://www.wrasb.gov.tw/knowing/knowing01_detail.aspx?type=47&tno=13
[10] http://www.wrasb.gov.tw/knowing/knowing01_detail.aspx?type=47&tno=13

Geographical Figures

High mountains in Taiwan form steep slopes and rapid rivers. Steep slopes allow the precipitated water to quickly flow down-river, making it difficult to keep. Because of this, over ¾ of the water precipitation evaporates or flows to the ocean. Steep slopes also wash down soil from riverbanks and carry sediments into reservoirs. As a result, reservoirs in Taiwan have severe sedimentation issues, which not only affects the storage capacity but also the life expectancy of the reservoirs.



▲ River Slopes in Taiwan in Comparison to Major Rivers in the World
Data Source: Water Resources Agency, MOEA

Water Leakage

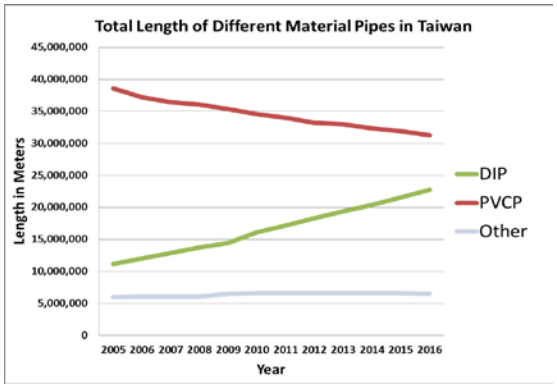
As of the end of 2015, Taiwan had a water leakage of 16.63 percent, with Non-Revenue Water (NRW) that accounts for 24.73 percent.[11] The leakage adds up to 1 billion tons of water going to waste each year, equivalent to 2.5 times the Shimen Reservoir capacity.[12] According to the Green City Index study conducted by the Economist Intelligence Unit in 2010, the average water leakage rate in Asia Index cities is 22 percent, with Tokyo leading the Asia index at 3 percent. Across the five regions investigated, 27 cities in the U.S. & Canada had the lowest leakage rate at 13 percent in 2011. U.S. companies can enter with their experiences and relevant technologies/products that can lower leakage rates and transfer its success to Taiwan.

The main reason behind water leakage in Taiwan is the deterioration of old pipelines, especially those made of plastic. Due to past budget issues, alongside the focus to provide mass coverage

[11] Taiwan Water Corporation https://www.water.gov.tw/ct.aspx?xItem=159779&ctNode=1346&mp=1
[12] The Control Yuan
http://www.cy.gov.tw/sp.asp?xdURL=./di/Message/message_1.asp&ctNode=903&mp=1&msg_id=5656

within a short period of time, Taiwan Water Corporation, the state-owned water utility installed mostly plastic (PVC) material pipes for pipelines that are smaller in diameter and closer to consumers[13]. However, these plastic pipes have a 20-year life expectancy and are mostly long overdue for renewal.[14] An investigation done by the Control Yuan suggests that more than 80 percent of the current pipes are past their life expectancy.

Moreover, frequent vibration of vehicles and construction sites contribute to the situation. Connecting pipelines also may be a significant contribution to the issue. Other reasons include earthquakes, land subsidence, and other natural disasters.[15] The current average renewal rate is roughly 1 percent. At this rate, it would take 100 years to completely renew all pipes.[16]



◀ Types of Material Currently used for Pipelines
Data Source: Taiwan Water Corporation

Taiwan Water Corporation developed a plan since 2013 going on to 2022 to decrease water leakage. The plan focuses on four key strategies: pressure control and management, efficiency and quality fixation, active leakage control, and pipelines and asset management. [17] In correspondence with the Executive Yuan's Investment Expansion Program[18], Taiwan Water Corporation also expects the leakage rate to lower to 14.25 percent by 2020, which is earlier than planned.[19] Significant opportunities are present in alignment with Taiwan Water Corporation's strategic plan. Companies may look into bringing in technologies and best practices to ensure more effective renewal of pipelines.

In 2016, Taiwan Water Corporation partnered with TaKadu, an Israeli company, to leverage big data and reduce water leakage rates through a Smart Water Network. The partnership is signed for a 13-month trial and the solution has been implemented on pipelines that account for a total of 3,000 km in Yilan, Penghu, and LiuQiu. Although the results have been positive thus far, Taiwan Water Corporation is hesitant about mass coverage in Taiwan due to its high costs (roughly US

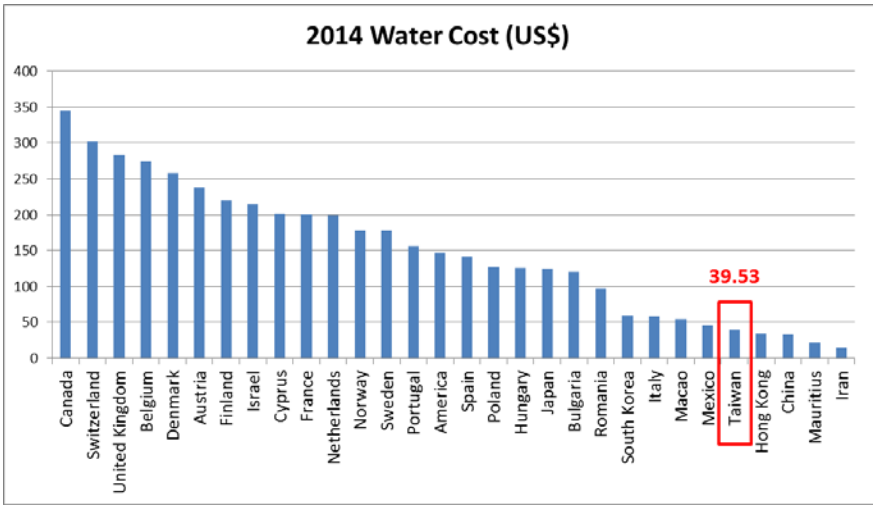
[13] http://data.gov.tw/node/25686
[14] Liberty Times, http://news.ltn.com.tw/news/life/paper/868101
[15] http://www.water.gov.tw/ct.aspx?xItem=159772&ctNode=1346&mp=1
[16] http://www.cy.gov.tw/sp.asp?xdURL=./di/Message/message_1.asp&ctNode=903&mp=1&msg_id=5656
https://www.thenewslens.com/article/46018
[17] http://www.epochtimes.com/b5/17/4/17/n9046969.htm
[18] http://www.ndc.gov.tw/en/Content_List.aspx?n=D8575E82A7CD2331&upn=E33FCB208599A8E6
[19] http://news.ltn.com.tw/news/politics/breakingnews/1900233

$100,000 for 1,000 km per year). Taiwan currently has approximately 60,000 km of pipelines in total. [20]

Taiwan Water Corporation is also cooperating with MWH Global, Inc (美商傑明工程顧問(股)台灣分公司) and TSS Tokyo Water Co., Ltd. (東京水道服務股份有限公司) to form a highly experienced consulting team to resolve water leakage. The priority would be for Keelung, Taichung, and Kaohsiung, which have the top three highest water leakage rates in Taiwan.[21] It is important to note that although some solutions have been tested and implemented, tremendous opportunities are still present as the issues still exist in most of Taiwan.

Cost of Water

One would assume that the limited amount of water resources in Taiwan would result in a higher water cost. In reality, cost of water in Taiwan is considered low. Research conducted by the International Water Association (IWA) in 2014 show that the average annual water cost per household in Taiwan is US $39.53. This price is relatively low in comparison to other countries.

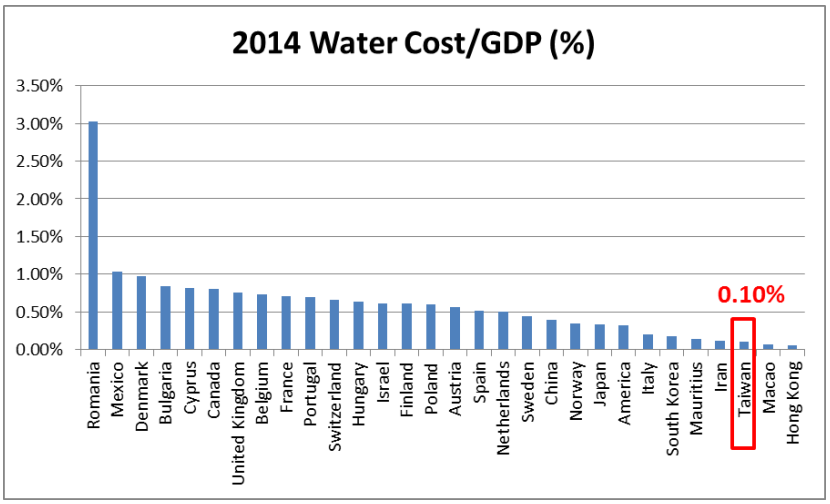


▲ Water Cost

Data Source: Taipei Water Department[22]

A simple comparison of water cost may be unfair without considering the development of each country. When we take into account the GDP of each country, the cost of water to GDP ratio for Taiwan is 0.10 percent.

[20] https://udn.com/news/story/7266/2335299
https://www.water.gov.tw/ct.aspx?xItem=136492&ctNode=917&mp=mobile
[21] http://www.epochtimes.com/b5/17/4/17/n9046969.htm
[22] http://www.water.gov.taipei/ct.asp?xItem=69929754&ctNode=47806&mp=114001



▲ Water Cost / GDP

Data Source: Taipei Water Department[23]

Taiwan Water Corporation managed to maintain a stable cost of water for the past 23 years. However, a recent news release from the president of Taiwan Water Corporation suggests costs tariffs may be raised in 2018. [24] Currently, Taiwan has only 4 intervals at 1-10, 11-30, 31-50, and 51 and above. Respectively, each range has a unit price of US$0.23, US$0.30, US$0.37, US$0.38. The plan involves increasing the number of cost intervals, focusing on more detailed separations for 51 and above. Taiwan Water Corporation is now looking to present proposals to the Ministry of Economic Affairs by the end of 2017. With more detailed separations at high intervals, it will mostly be industries that rely heavily on water supply that will be affected, more specifically heavy industries. Therefore, industries will then be under more pressure to effectively utilize their water resources to maintain their low production costs. This creates tremendous opportunities for waste water management as well as other water conserving procedures that can aid companies maintain or lower costs.

Reservoir Sedimentation

Severe reservoir sedimentation is caused mainly by Taiwan's steep geographic features, loose soil structure, frequent earthquakes, and concentrated rainfall. Although cleaning processes are carried out, the rate at which sedimentation is disposed of, fails to catch up with the rate at which it accumulates. The average reservoir sedimentation in Taiwan is approximately 29.5 percent.[25] Reservoir sedimentation not only decreases storage capacity but also life expectancy of the

[23] http://www.water.gov.taipei/ct.asp?xItem=69929754&ctNode=47806&mp=114001

[24] https://www.epochtimes.com.tw/n207463/ percentE6 percentB0 percentB4 percentE5 percent83 percentB9 percentE6 percent98 percent8E percentE5 percentB9 percentB4 percentE8 percentAA percentBF percentE6 percentBC percentB2- percentE5 percentB7 percentA5 percentE7 percentB8 percentBD- percentE8 percentA6 percent81 percentE5 percent90 percent88 percentE7 percent90 percent86.html

[25] https://www.thenewslens.com/article/14308

reservoir. Therefore, measures to dispose current sedimentation and to protect the surrounding environment have become a front and foremost issue. New technologies are needed in Taiwan to speed up the sedimentation disposal process and ensure maximum capacity within the reservoirs. Although there are a total of 96 reservoirs in Taiwan, the total capacity of the 17 main reservoirs make up 93 percent the capacity of all reservoirs. Among these main reservoirs, 8 reservoirs have sediment disposition rates higher than 30 percent, including three of the main reservoirs in southern Taiwan: Zengwen Reservoir, Nanhua Reservoir, and Wushan Tou Reservoir. Therefore, southern Taiwan possesses significant opportunities for companies with relevant filtration technologies.

In 2009, Typhoon Morakot severely hit southern Taiwan and caused serious sedimentation to the reservoirs within a short period of time. According to the Southern Region Water Resources Office, Zengwen reservoir, which is the main supplier of agricultural water in Chiayi and Tainan water supply, shrank 1/6 in capacity to less than 500 million cubic meters (580 million before Typhoon Marakot), which is equivalent to forming 90 million cubic meters of sedimentation. The reservoir life expectancy has also shortened 20 years as the result. Nanhua Reservoir, which provides household water use in Tainan and Kaohsiung, accumulated 17 million cubic meters of sedimentation, which is 1/5 the storage capacity of the original 110 million cubic meters. [26]

Sedimentation in Major southern Taiwan Reservoirs						
Reservoir	**Designed Capacity (Cubic Meter)**	**Current Capacity**	**Sedimentation Rate**	**Amount Cleaned in 2014 (Cubic Meter)**	**Cleaning Budget after Typhoon Morakot**	**Water Provided Area**
Zengwen	748.4 million	473.3 million	36.8 percent	1.6 million	1094 million	Tainan City/ Area North to Zengwen River
Nanhua	158.1 million	97.9 million	38 percent	0.3 million	360 million	Tainan City/ Area South to Zengwen River
Wushantou	154.2 million	79.8 million	48.2 percent	0.03 million	95 million	Jianan Plain

▲ Southern Taiwan Reservoir Sedimentation

Data Source: Liberty Times[27]

The Desilting Tunnel of Zengwen Reservoir is currently under construction and approaching its finishing stages. According to Lai Chien-Hsin, Director General of Water Resources Agency, the tunnel will be complete by October 2017. The estimated disposal rate would be 1.04 million cubic

[26] http://www.epochtimes.com/b5/9/12/2/n2741303.htm
[27] http://news.ltn.com.tw/news/life/paper/869403

meters of sedimentation annually, which is a 995 cubic meters/second increase in disposal rate. This construction will stabilize the water supply in Tainan, and save roughly US $23.25 million in sedimentation disposal. [28] Desilting Tunnels for Nanhua Reservoir and Baihe Reservoir are scheduled to be completed in 2018.

Underground Water

Underground water is a large contributing source of fresh water in Taiwan, especially in lowland areas. Southern Taiwan utilizes underground water due to the lack of surface water in extreme dry seasons. Specifically, agricultural and fish farming industries among coastal areas use large amounts of underground water to supply their large water demands. However, excessive use of underground water has resulted in severe consequences including non-reversible land subsidence, saltwater intrusion, and flooding. Subsidence occurs in 1/10 of the plains in Taiwan [29]and is most severe in Yilan, Changhua, Yunlin, Chiayi, Tainan, Kaohsiung, and Pingtung. For example, pumping in the coastal areas of Pingtung may have resulted in land subsidence. Reports of subsidence up to approximately 2 stories high have been in the press. There are significant opportunities in southern Taiwan due to its high reliance on underground water. In order to stimulate economic growth while simultaneously ensuring environmental safety, authorities are in search for effective management methods to balance the amount of underground water drawn out.

[28] http://www.chinatimes.com/newspapers/20170401000531-260106
[29] http://www.wcdr.ntu.edu.tw/223202365219979385192879723475332873845028797.html

Water Opportunities

Smart Water Management

"Taiwan is now going through a 'dry period' – their perspective is changing quickly, and awareness is growing as to the need to manage water effectively, Taiwan's water system is outdated, and they are advancing a very large effort to revamp the country's water system, at an estimated investment of $9 billion" – (Ran Yehezkel, April 9 2017)[30]

Central and local authorities alongside industries are actively seeking solutions to improve the current water system with smart technologies. The objective is to sustain water supply by increasing the amount of water obtained, simultaneously, ensuring efficient usage of current resources. The implementation of smart water management can optimize resources and integrate quantity and quality management through ICT/IoT and big data technology. In addition to establishing various practices and policies, the real challenge and goal is to create a total solution that integrates all solutions to work together. Therefore, IoT PaaS should be at the core to build an integrated ERP control system dedicated to water.

Flood Prevention presents a great opportunity in southern Taiwan especially during the rainy seasons in the summer. As discussed in previous sections, southern Taiwan experiences extreme rainfall distribution during the year with a ratio of 9: 1 between rainy and dry seasons. In addition, typhoon season overlaps with the rainy season; thus, chances are high that during these times the current water system cannot fully collect, store, and manage the heavy rainfall. This also may result in natural disasters that harm populations living downstream. Possible incorporation of smart water management can effectively monitor rainfall with relevant information such as reservoir flood control capacity.

Irrigation Management is a large segment to tap into because the majority of current water resources are provided for agricultural uses. Currently, Chia-Nan Plain relies on farmers that are hired to manually control and allocate water resources for irrigation.[31] Although current results are positive, improvements can be made to allow better management on such a vast plain. In accordance with the Forward-looking Infrastructure Development Program, the Southern Region Water Resources Office will cooperate with the Taiwan Chia-Nan Irrigation Association to develop a system that leverages big data to more effectively irrigate Chia-Nan Plain. The system will include long distance data transmitting devices that bring data from the front-end sensors to the back-end

[30] http://israelnewtech.com/2017/04/09/israeli-water-seminar-taiwan-promising-new-market/
[31] http://www.wra.gov.tw/ct.asp?xItem=99689&ctNode=9598

analysis platform for decision making. This year, this system will be tested on one irrigated area as a demonstration for future implementations elsewhere. [32]

Underground Water Management is also an opportunity for southern Taiwan, especially in Kaohsiung where water supply is dependent on underground water resources. Over drawing underground water has resulted in non-reversible land subsidence. To effectively resolve this problem, underground water management and recharging analysis systems could be utilized. Through enhanced observation well systems that include smart water sensing devices, both public and private sectors are able to gather important information through low cost long range transmission regarding water quantity and water quality. This valuable data can be used to construct dynamic 3D underground water models where underground water drawing and recharging mechanisms can be simulated for reference. At the same time, the dynamic model can support the design of water drawing policies to prevent overdrawing in any situation. A strong monitoring mechanism would help the successful implementation of this policy. Most importantly, the information collected and generated can be leveraged to optimize the amount of city water, underground water, and ground water used.

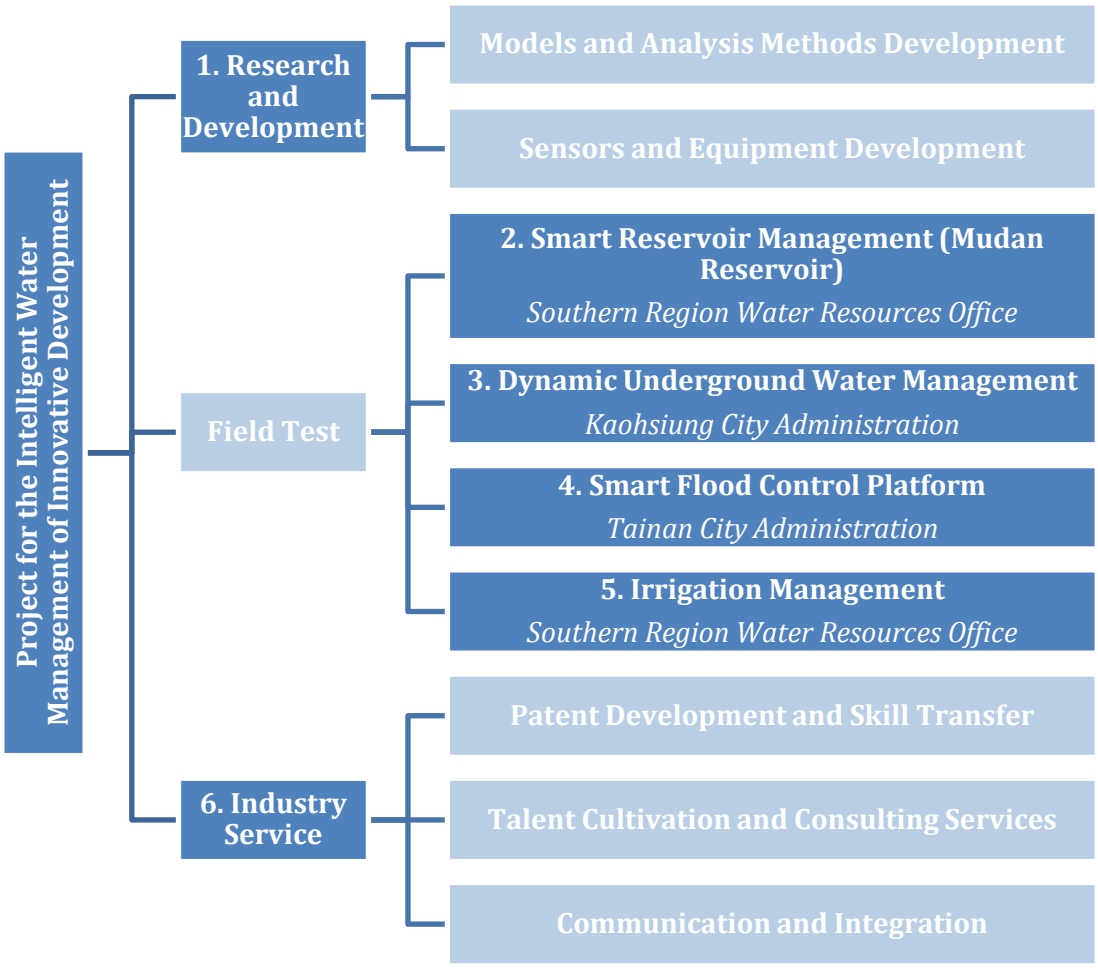
Leak Prevention Management also poses opportunities for American companies wanting to enter southern Taiwan, particularly for cities like Kaohsiung where leakage rates are elevated. Smart water management may be leveraged to monitor and collect real-time data regarding water quality, volume, and pressure in every pipe. The data should also incorporate geographical features and climate information, such as typhoon data and precipitation calculations. Water management offices can then effectively analyze these numbers and gather insights regarding the most urgent leakage problems. At the same time, these insights can also be used to forecast future needs. This may systemizes accurate and efficient projections as opposed to detecting leakages by using the current human detection model. The margin for human error is decreased.

In 2014, Taipei was the first municipal in Taiwan to install Automatic Meter Readings (AMR) in some of the large water usage buildings, such as city council buildings and local schools.[33] Since water costs are rising, increases in water usage may result in large cost difference. With traditional meters, users will only realize over use when the bill arrives at the end of the month. With AMR, users can effectively monitor the water quantity and quality by minutes. It incorporates a software system that collects water usage data and informs users through an APP. When abnormal situations occur, such as possible leakages, the system will automatically alert the user. This system enables users to efficiently track and conserve water. As of this year, the number of AMR installed will reach 1,800 users. In addition, new public housing constructions in Taipei have also installed AMR. Xing Long (興隆) public housing became the first to install 272 AMR into their housing facilities. According to the Taipei Water Department, five other public housing constructions in Taipei will

[32] http://www.cna.com.tw/news/aloc/201705060048-1.aspx
[33] http://www.chinatimes.com/newspapers/20151202000515-260102

also begin installation within the next year. There is a total of 1.62 million meters in Taipei, and within the next 10 years, local authorities hope to slowly upgrade all meters to AMR. However, currently AMR prices are still considered high, and require more quantities to lower prices and enable mass upgrades.[34] With the successful implementation demonstrated by Taipei, there is also opportunity for southern Taiwan to implement similar measures and control the high leakage rates.

The Ministry of Economic Affairs and the Ministry of Science and Technology recently proposed a joint project, Project for the Intelligent Water Management of Innovative Development (智慧水管理創新產業發展計畫), to develop the smart water management industry in southern Taiwan. The plan aims to bring together academic organizations, local authorities, and industries to develop a solid foundation for the relatively new industry in southern Taiwan. Tainan, Kaohsiung, and Pingtung will be the focused demonstration areas for this project. After execution, methods will be reviewed and improved for further implementation in other counties and municipalities. The plan includes 6 main projects[35]:



[34] http://www.chinatimes.com/newspapers/20151202000515-260102
[35] http://epaper.wra.gov.tw/Article_Detail.aspx?s=85DD41356F82A29A

Important Technologies for Smart Water Management Development Plan (1/2):

Taiwan's Technology Readiness:
✓ **Developed technology/product**
▲ **Developing technology/product**
× **Undeveloped technology/product**

1. Research and Development	✓ Water and Geographical Research
	▲ Underground Water Pumping Evaluation
	▲ Ground Water and Underground Water Management
	× Underground Recharge System Research
	× Underground Water Treatment Techonology
	× Underground Reservoir Demonstration
	▲ Water Treatement Plant Demonstration
	× Underground Water Quality Monitoring Device
2. Smart Reservoir Management	▲ Automatic Monitoring Technology for Reservoir Water Quality
	▲ Monitoring Technology for Dam Safety
	✓ Data Transmission System within Collecting Area
	▲ Image Technology
	✓ Smart Reservoir Management System
	▲ Integrated Monitoring System for Hydroelectric and Solar Power
3. Dynamic Underground Water Management	✓ Pumping Well Check
	× Water Pumping Real-time Monitoring System
	✓ Underground Water Level Real-time Transmission System
	✓ Underground Water Rights Management System
	✓ Pumping Tube Well Project
	✓ Underground Water Observation Well Performance Evaluation

Important Technologies for Smart Water Management Development Plan (2/2):

Taiwan's Technology Readiness:
✓ **Developed technology/product**
▲ **Developing technology/product**
× **Undeveloped technology/product**

4. Smart Flood Control Platform	▲ Long-Distance Data Transmission Improvement
	▲ Water Pump Real-time Reporting System
	▲ Expansion and Upgrade for Flood Warning System
	▲ VR/AR Technologies for Data Integration
	× Integrated Transmission Technology for Water Monitoring Devices
	▲ Natual Disaster Information Service Platform
5. Irrigation Management	× Water Monitoring Technology for Fields
	× Smart Water Conservation Management
	▲ Water Conservation Technology for Irrigation
	× Monitoring Techonology for Water Flow in Canals
	▲ Evaluation Technology for Irrigation Conservation Efforts
6. Industry Service	✓ Check Smart Management Sensor Demands
	✓ Check Smart Managment Anaytical Model Demands
	✓ Check Smart Management Database Demands
	✓ Check Smart Manaement Talent Demands
	▲ Promote Water Industry and Establish Information Exchange Platform
	▲ Promote Trade Show Events Abroad
	▲ Establish Platform for Domestic and International Communications
	▲ Match-make Domestic and International Technologies
	✓ Host Conferences and Seminars for Water Technology Industry
	▲ Cultivate Professional Talent

Wastewater Treatment

"Taiwan industry uses 1.8 billion tons of water annually, and only 40 percent of this is reused. Compared with Japan's water reuse rate of about 70 percent, we have quite a bit of work to do." *(Dr. Teh-Ming Liang, Division Director of ITRI's Material and Chemical Research Laboratories)*

Due to the water shortages in Taiwan, central and local authorities are strongly promoting the concept that every drop of water should be used more than once. Taiwan aims to increase external supplies of reusable water and to fortify internal water usage efficiency. Taiwan's Ministry of Economic Affairs recently passed the "Reclaimed Water Resources Development Act" where the goals are focused on increasing the amount of reclaimed water used by industries. The targeted reusable water goal is 1.32 million CMD by 2031, which is 10 percent of the nation's public water supply.[36] The Water Resources Agency has announced its plan to invest US$503.8 million and construct 6 water treatment plants by 2020. The plan includes building three new plants and upgrading existing sewage plants to supply recycled water for nearby industrial parks. Once this project is completed, the six plants will be able to supply 280,000 metric tons of recycled water daily.[37] This is an opportunity for U.S. firms looking to enter the wastewater treatment industry in southern Taiwan as there are strong supporting policies and authorities.

From the six planned water treatment plants, four are located in southern Taiwan. The first construction will be the Fengshan River Plant, Kaohsiung which will be upgraded into a reclaimed water supplier for Kaohsiung Linhai Industrial Park Service Center as early as 2018. The plant is expected to recycle over 25,000 metric tons a day in 2018, with capacity increasing to 45,000 metric tons a day by 2019. U.S.

Planned Water Treatment Plants in Taiwan						
Location	**Kaohsiung Fengshan River**	**Taichung Futian**	**Kaohisiung Linhai**	**Tainan Yongkang**	**Tainan Anping**	**Taichung Fenyuan**
Current Status[38]	Upgrade	Upgrade	New	New	Upgrade	New
Area Providing Water To	Linhai Industrial Park Service Center	Taichung Harbor Related Industrial Parks Service Center	Linhai Industrial Park Service Center	southern Taiwan Science Park / Tree Valley Park	southern Taiwan Science Park / Tree Valley Park	Central Taiwan Science Park
Estimated Water	45,000	130,000	10,000	15,000	60,000	20,000

[36] http://www.wra.gov.tw/ct.asp?xItem=73761&ctNode=9598
[37] http://www.chinatimes.com/newspapers/20151124000150-260204
[38] http://www.chinapost.com.tw/taiwan/national/national-news/2015/11/25/451845/6-water.htm

Provision CMD						
Planned Completion	2018	2020	2020	2020	2020	2020

▲ Southern Taiwan Reservoir Sedimentation
Data Source: Water Resources Agency

Industry Challenges: Tender Regulations

Taiwan's Government Procurement Act (GPA), requires all government entities and state-owned companies to publicize any procurements with value over US$30,000 on the Taiwan authority's e-procurement website (http://web.pcc.gov.tw). Tenders are usually released in Chinese unless the tender is an international tender where summary procurement notice will be released in English. Foreign enterprises that bid on projects often acquire a local partner to bid on their behalf. Foreign companies then export equipment, technologies, and other related products. Some foreign companies that do not wish to partner with a local partner establish a Taiwan based subsidiary.

Conclusion

The water technology market in southern Taiwan offers many business opportunities for American enterprises looking to export. Taiwan's frequent water shortages have resulted in difficulties for local and central authorities' effort to stabilize water supply year round. Despite relevant measures being taken, ongoing climate changes and shifts within the population and industrial structure stress the urgency for immediate actions and improvements toward the current water infrastructure.

The Forward-looking Infrastructure Development Program (2017-2024) and Reclaimed Water Resources Development Act delineates the central authority's commitment to invest in the domestic water industry. Local authorities have also shown support towards this industry, developing projects to implement relevant measures.

To succeed in Taiwan, companies should focus not only on providing dedicated engineering solutions but also a complete and integrated system that provides solutions from front-end sensors, data mining know-hows, to wireless communications and decision-making analytical platforms. Smart management systems should build the foundation in order to fully benefit the process of optimization and efficiency. Such a system would solve current problems, at the same time, forecast future needs and provide a sustainable solution.

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