(WC) Pursuit of Authentic Water Efficiency by Investigating Regional Waterworks and Historical Backgrounds

THAP WATER

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Abstract

Our group (1) researched about the pros and cons associated with Japan's water supply, and (2) we suggest ways to use water efficiently.

From this, we discuss the good and bad points of using tap water as a drinking supply. Moreover, the efficiency of the water supply infrastructure is talked about based on the history of waterworks. Points are made regarding the waterworks facilities and the people's health from drinking tap water, and then are used to show the importance of using water effectively.

Further research is done by conducting several experiments to clarify the pros and cons of tap water and by researching about Mannou Lake in Kagawa prefecture. Moreover, using data from The Bureau of Waterworks, we propose some solutions to increase water efficiency and to maintain the current infrastructure.

In conclusion, we are focusing on problems regarding the water supply in Japan, and we are presenting solutions not only to developed countries, but to also developing countries lacking in sufficient infrastructure. We are confident that our research will increase awareness on how important it is to use water effectively.

Keywords

Water efficiency, community, relationship, globalization

1. The Purpose of the Research

Water is vital for our living.

In Japan, where people can access water easily, we tend to overlook the fact that a single drop of water obtained by simply turning on the tap, is actually provided with the latest and innovative technologies which involve a number of people's efforts and struggles. We take it for so granted that it is almost impossible for us to imagine a life without having access to tap water. Most of us have never experienced water shortages or droughts in our lives.

However, just a few decades ago, our ancestors were suffering from water-related

disasters. And today, there are people around the world not being able to receive the sufficient amount of water in their daily lives, especially in developing countries. We realized that there was a divergence of consciousness between developing nations and developed countries regarding this issue.

Through this conference, we would like to raise awareness of the importance of tap water and convey to cherish the limited water resources.

Moreover, by investigating our home country's history of water-related disasters, we are firmly convinced that we are able to propose effective solutions for both developed and developing countries.

2. Method of the Research

This research paper consists of three parts:

1. Investigating today's waterworks systems
2. Researching about water-related disasters in the past and what we can learn from them
3. Suggesting and encouraging people to raise awareness about the idea of "water efficiency"

For 1 and 2, we carried out a filed survey, visiting Hokkaido, Chiba, Tokyo, Kanagawa and Kagawa. We also went to Chiba Prefectural Waterworks Bureau to conduct an interview with the staff members. Other than that, we researched using books and internet.

3. Results of the Experiment/Research

1.Water Supply and Sanitation System in Japan

a. Water Treatment Process in Japan

i. Background Research

We visited 5 places in Japan for our background research.

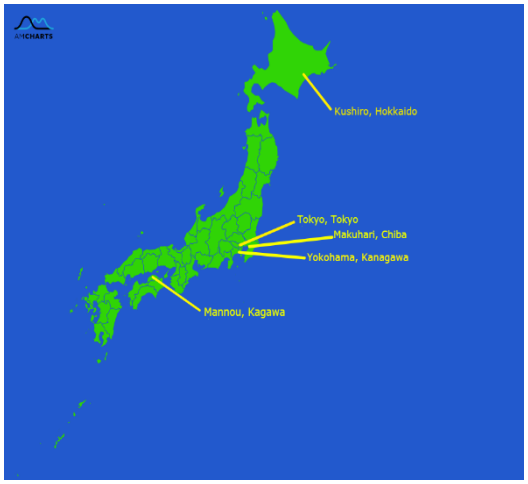


Diagram. 1

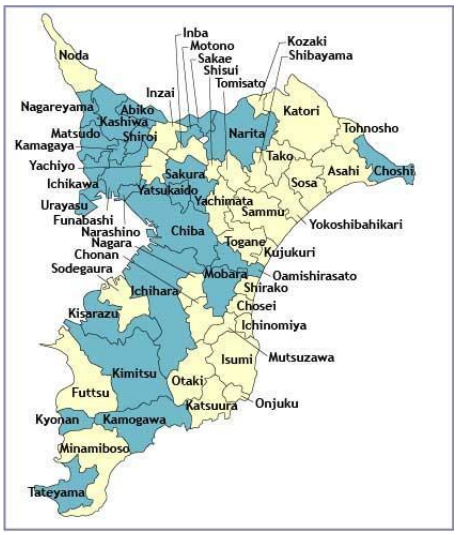


Fig.1

ii. Water Purification Systems in Japan

1. Places

a. Makuhari, Chiba Prefecture

1. Overview

Chiba Prefectural Waterworks Bureau has been supplying water since 1936. Currently, the water-supply district of Chiba Prefectural Waterworks Bureau has spread around to 11 cities in Chiba Prefecture, which accounts to 566 ㎢ in total. Waterworks in other places in Chiba are managed by different firms and organizations.

~List of 11 Cities~

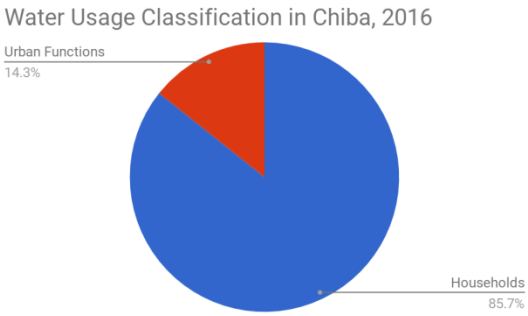
- Chiba
- Ichikawa
- Funabashi
- Matsudo
- Narashino
- Ichihara
- Kamagaya
- Urayasu
- Narita
- Inzai
- Shiraishi

Current situation of waterworks in 11 cities listed above (March 2016)

- Water supplied population: 2,993,421 (Around 48% of population in Chiba Prefecture)
- Dissemination rate of water: 96.4%
- Daily water consumption (average): 871,660 ㎥
- Maximum daily water consumption: 1,010,789 ㎥

(2016 Chiba Prefectural Waterworks Bureau)

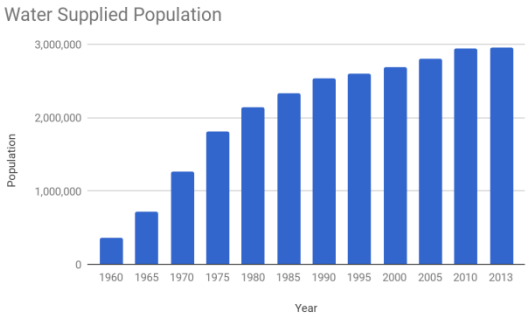
Water usage classification



→ Urban functions include the following:

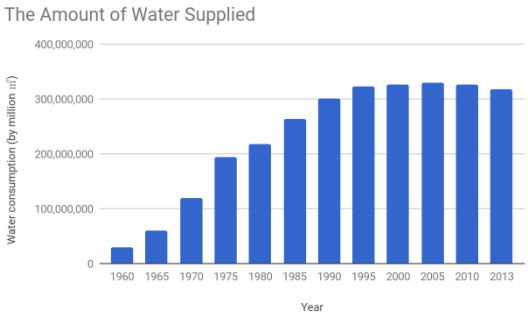
- Water fountains in shopping malls and office districts
- Office buildings in Makuhari New City Center
- Narita airport
- Tokyo Disney Resort
- Makuhari Messe

Transition over water supplied population (2017 Chiba Waterworks Bureau Brochure)



As can be seen from the graph above, the water supplied population is increasing. Although the pace of population growth is declining, it is still expected to rise for next twenty years. Possible reasons/factors are: 1. Expansion of office district in Makuhari and 2. Urban development (E.g. building large-scale housing complexes).

Transition over water consumption (2017 Chiba Waterworks Bureau Brochure)



As can be inferred from the graph above, the water supplied population is directly proportional to the amount of water provided. However, water consumption starts to slowly decline from 2005, and this trend is likely to continue. One of the possible reasons is that water-saving household appliances have become a lot more common and popular in Japan.

2. Water Sources

Chiba Prefectural Waterworks Bureau hold three major water sources as the table 1 presents. Tone River (Including Lake Inba-numa and Edo River), Yoro River, and Obitsu River. Chiba's Water source is heavily relied on Tone River, consisting 88% of the total water sources. (2017 Chiba Waterworks Bureau Brochure) This is not really a favorable situation as depending on only one water source is precarious and insecure. If something happens to Tone River, like water pollution or drought, the whole prefecture's waterworks can be damaged greatly.

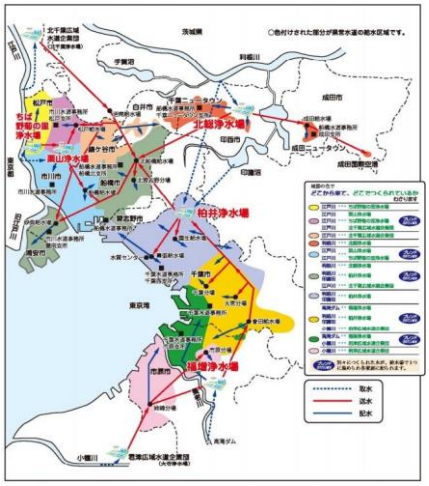


Fig.2

→ Chiba's map (Japanese) showing where the water sources and purification plants are.

3. Water Purification Plants in Chiba

(2017 Chiba Waterworks Bureau Brochure)

- Kashiwai Water Purification Plant

Fig.3

Site area: 259,856 ㎡

Water providing districts: Chiba, Ichihara, Funabashi, Ichikawa, Urayasu, Narashino

Supply capacity: 530,000 ㎥/day

- Western facility

Water source: Tone River

Water intake station: Kinoshita water intake station

- Eastern facility

Water source: Lake Inba-numa

Water intake station: Inba water intake station

This water purification plant was built in July 1986, in order to response to the exponential increase in demand for water. At that time, Keiyo industrial area (between Tokyo and Chiba) was developing rapidly, and the population of Chiba increased correspondingly. When this plant was built, its supply capacity was 270,000 ㎥/day, but because the population continued to grow, in 1971, they constructed one more plant adjacent to the original one.

Presently, together with Eastern facility and Western facility, this water purification is capable of providing 530,000 ㎥/day, which is the largest water supply in Chiba prefecture.

Because the water from Lake Inba-numa is heavily polluted, Eastern facility uses the advanced water treatment system, which involved ozone and activated charcoal to remove the color and odor of the water.

- Kuriyama Water Purification Plant

Fig.4

Site area: 43,663 ㎡

Water providing districts: Matsudo, Ichikawa, Funabashi

Supply capacity: 186,000 ㎥/day

Water source: Edo River (Tone River)

Water intake station: Yagiri water intake station

This water purification plant has been used since 1958. It was constructed to meet needs for water after the WWII. It was expanded in 1961 and 1966, in order to response the rise in demand for water, as more people were moving in Chiba.

As the space available for this building is limited, it uses the place effectively and efficiently. For instance, they built the water reservoir under the water filtration pond. Moreover, this purification plant is known for its long history.

- Hokusou Water Purification Plant

Fig. 5

Site area: 129,519 ㎡

Water providing districts: Urayasu, Ichikawa, Funabashi, Narashino, Shirai, Inzai, Narita

Supply capacity: 126,700 ㎥/day

Water source: Tone River

Water intake station: Kinoshita water intake station

Constructed in 1975, the purpose of this water purification plant is to supply water for Chiba New Town, Narita New Town and Narita airport.

Similar to Kashiwai Water Purification Plant, it uses the advanced water treatment system. In addition, starting from 2011, as a part of a PFI project, they began to recycle the wastes collected from raw water.

*PFI

Stands for private finance initiative. It is a method of providing funds for investments where private organizations are contracted to carry out public business.

- Fukumashi Water Purification Plant

Fig. 6

Site area: 82,362 ㎡

Water providing districts: Chiba, Ichihara

Supply capacity:90,000 ㎥/day

Water source: Yoro River

Water intake station: Takataki dam

(Takataki dam is a multi-purpose dam built for river system improvement in Yoro River and stable supply of agricultural water)

It was built in 1993 to provide water for Chiba and Ichihara, where the population growth was prominent in Chiba Prefecture. It was the first water purification plant in Chiba to introduce the advanced water treatment system.

- Chibanogikunosato Water Purification Plant

Fig.7

Site area: 125,021 ㎡

Water providing districts: Matsudo, Ichikawa, Funabashi

Supply capacity:60,000 ㎥/day

Water source: Edo River (Tone River)

Water intake station: Yagiri water intake station

It was planned in a project called “Chiba21 New Waterworks” and constructed in 2007.

It has the advanced water treatment system as well as the water supplying facility in times of emergency. Moreover, it has installed solar panels. Therefore, this water purification plant uses renewable energy in the process of water purification.

4. Preparing for Emergencies

- From the Great East Japan Earthquake (in 2011)

Due to the earthquake that occurred on March 11, 2011, the waterworks was damaged in Urayasu, Chiba, Narashino and Ichikawa. The water supply was cut off in a total of more than a thousand places, affecting around 178,000 households (2017 Chiba Waterworks Bureau

Brochure). From this experience, Chiba Prefectural Waterworks Bureau is working on the following:

- Inspections on temporary water supply system in case of emergencies
- Making an operating manual in order to share the same information among the waterworks bureau personnel
- Increasing the amount of stocks
- Cooperation with other waterworks bureaus
- Promoting earthquake-resistance water pipes

- Water shortages

As the water sources of Chiba Prefecture are heavily depended on Tone River, Chiba Prefectural Waterworks Bureau would face a serious water shortage if a severe drought occurs in Tone River.

Nevertheless, it is unlikely to happen in the near future, as Japan is rich in precipitation, it is vital for Chiba Prefectural Waterworks Bureau to consider expanding their water sources to different and a variety of places.

Also, in order to protect water reservoirs and water purifications plants from antisocial behavior, the security for these significant areas is maintained strong and stable.

Emergency drills are carried out every year to ensure that things will go smoothly and promptly in case of emergencies.

Fig. 8

5. Promoting and Supplying “Safe and Delicious” Water

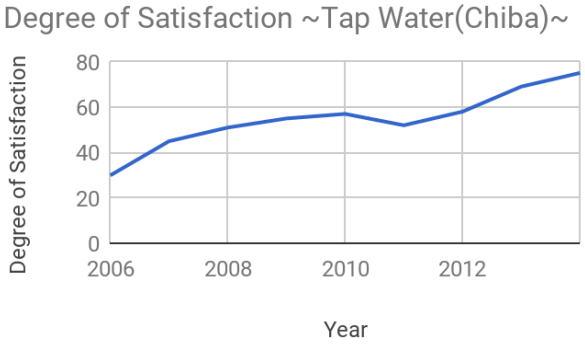
Because Chiba Prefecture is located at the lower reaches of Tone River, the quality of the raw water is not satisfying when compared with other prefectures. Moreover, the water pollution in Lake Inba-numa is an urgent matter to solve yet there are no effective solutions for this issue.

Therefore, Chiba Prefectural Waterworks Bureau plans to introduce the advanced water treatment system to every water purification plant.

Improvement in the degree of satisfaction

According to Chiba Prefectural Waterworks Bureau, the degree of satisfaction in tap water has improved enormously sue to a decrease the amount of chlorine included in the water provided. In addition to this, Chiba Prefectural Waterworks Bureau began to distribute a monthly PR brochure to the households in its water distribution area.

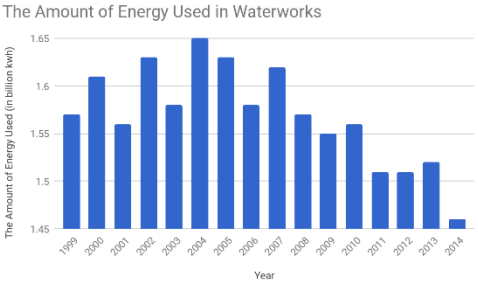
Successfully, the degree of satisfaction has risen from 30% in 2016 to 75% in 2014 as the graph below present (2017 Chiba Waterworks Bureau Brochure). Moreover, as the customers' feedback table (table 2) shows, the number of complaints regarding to tap water has decreased from 338 in 2010 to 188 in 2014 (2017 Chiba Waterworks Bureau Brochure).



6. Future Management

Chiba Prefectural Waterworks Bureau aims to decrease the amount of carbon dioxide emitted by generating electricity. Therefore, it encourages power saving in the waterworks system as well as using renewable energy.

Chiba Prefectural Waterworks Bureau successfully decreased the amount of energy used in the process of waterworks.



Chiba Prefectural Waterworks Bureau is and will be striving towards one goal, which is "to

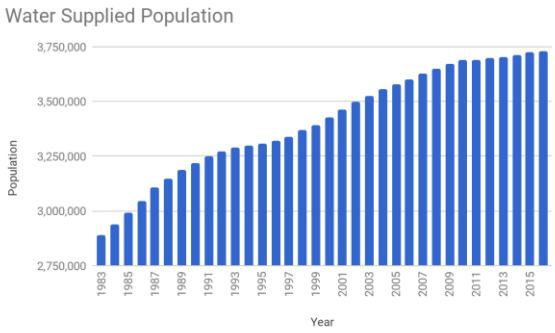
stably provide safe, delicious and trustworthy water to our customers".

b. Yokohama, Kanagawa Prefecture

1. Overview

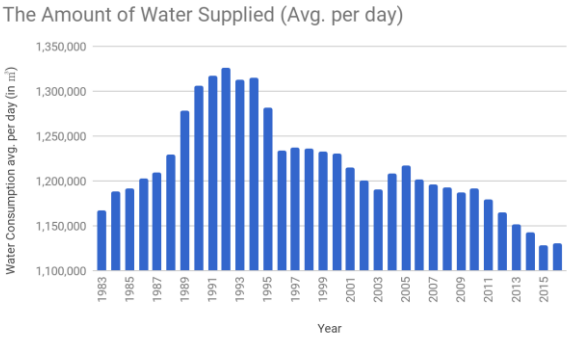
Water supplied districts involve the entire city of Yokohama, and currently, the dissemination rate of water has reached up to 100%. The city's population exponentially increased during the rapid economic growth in Japan (1970's). In today, although the population is rising constantly, it is predicted to decline over time. (2016 Yokohama Waterworks Bureau)

Transition over water supplied population (2016 Yokohama Waterworks Bureau)



Despite the fact that population is at its rise, water consumption is decreasing as the graph below presents. (Further discussion of this problem is done in the next section.)

Transition over water consumption (2016 Yokohama Waterworks Bureau)



~ Water charges (in 2015) ~

Revenue: 975 billion yen

Details:

- Water bills → 702 billion yen
- Loan for the future investments → 273 billion yen

Expenditure: 1,135 billion yen

Details:

- Water meter inspections → 12 billion yen
- Water leakage investigations → 15.3 billion yen

- Replacement earthquake-resistant water pipes → 201 billion yen
- Water purification system and maintaining water quality → 41 billion yen
- Preservation of upstream forests → 2.6 billion yen

*A reserve fund in Yokohama Waterworks Bureau is expended in order to balance the shortage of the revenue.

2. Water Sources

As the table 3 shows, most of the water sources in Yokohama are consisted of Doshi River, Sagami River and Sakawa River. All of the three rivers originate in other prefectures such as Shizuoka and Yamanashi. The headspring of Sagami River is Mt. Fuji, and therefore Yokohama is famous for its distinguished water quality in Japan.

3. Water Purification Plants in Yokohama (2016 Yokohama Waterworks Bureau)

- Kawai Water Purification Plant

Fig. 9

Supply capacity: 172,800 ㎥/day

Water source: Doshi River

It was constructed in 1901 and has the longest history among all of the water purification plants in Yokohama. After more than 100 years of operation, its reconstruction project began in 2009.

Currently, the facility owns filtration system with a ceramic membrane. It is a new, innovative technology in Japan that has been introduced recently. This new system enables water purification plants to conduct the process more

efficiently and effectively. Moreover, it is space-saving.

Although it is costly to introduce this new system, more and more water purification plants in Japan are considering replacing the old technology with the ceramic membrane filtration system.

Fig. 10

→ Ceramic membrane filtration system in Kawai Water Purification Plant

- Nishiya Water Purification Plant

Fig. 11

Supply capacity: 480,000 ㎥/day

(394,000 ㎥/day for tap water, 86,000 ㎥/day for industrial use)

Water source: Sagami lake

- Kosuzume Water Purification Plant

Fig. 12

Supply capacity: 530,700 ㎥/day

(284,700 ㎥/day for tap water, 246,000 ㎥/day for industrial use)

Water source: Banyu River

4. Preparing for Emergencies

- Water pipes

1961: Replacement of the old and decaying water pipes to new water pipes began

1981: Earthquake-resistant water pipes were introduced

2006: Yokohama Waterworks Bureau started using earthquake-resistant water pipes in all constructions

No damage of earthquake-resistant water pipes was reported in Great Hanshin Earthquake (1995) and Tohoku Earthquake (2011), two of the largest and most devastating earthquakes in modern Japanese history.

Presently, Yokohama Waterworks Bureau aims to replace 110km of water pipes in a year. (2016 Yokohama Waterworks Bureau)

- Water supplying points

Yokohama Waterworks Bureau has set up places to provide water to the public in case of emergency.

Fig. 13

- Reservoir (22 reservoirs in the city)

Fig. 14

- Water wagon

Fig. 15

- Underground water supply tank for emergency (134 tanks in the city)

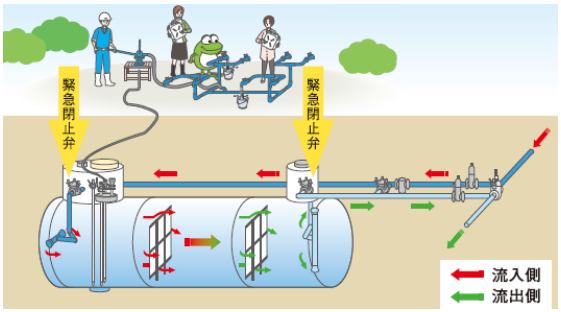


Fig. 16

(The red arrow shows the water flowing in, and the green arrow shows the water discharged)

- Emergency temporary faucet (358 in the city)

Fig. 17

In addition to the points listed above, Yokohama Waterworks Bureau conduct emergency drills with residents annually to share the information.

5. Supplying Safe Water

Yokohama's water quality standard is greatly higher than the standard set by Japanese government. For instance, the maximum amount of benzene in Japan's tap water is 0.01mg/L, whereas Yokohama's standard is 0.001mg/L.

6. Future Management

- Preservation of water conservation forests

There are three major roles of water conservation forests.

1. To store water

Thick layers of forest floor is capable of storing rainwater.

2. To purify water

Thick layers of decayed leaves and branches are slowly absorbing rainwater, eventually filtering contaminants out of it.

3. To prevent floods

Thick canopy of forest and layers of humus ground are responsible for low runoff, preventing floods.

Staff members from Yokohama Waterworks Bureau regularly visit the Doshi forest to protect and cultivate natural vegetation, which plays a vital role in maintaining the quality of water.

Fig. 18

They also offer activities in the forest which children can enjoy, such as hiking and study sessions about water conservation forest. Through these activities, they aim to convey the significance of protecting the forest to the next generation.

c. Kushiro, Hokkaido Prefecture

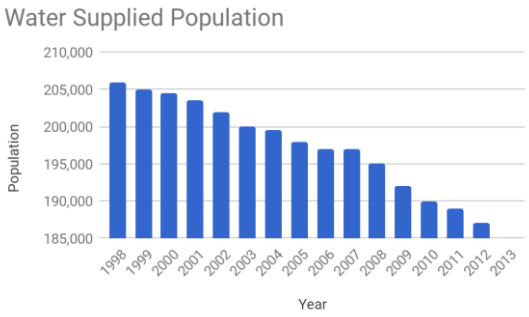
1. Overview

In 1922, when Kushiro was reorganized as a municipality, the only water source available for the residents was a well. It is estimated that there used to be around 1000 wells in total in the city. However, more than two-thirds of them were not suitable for drinking water.

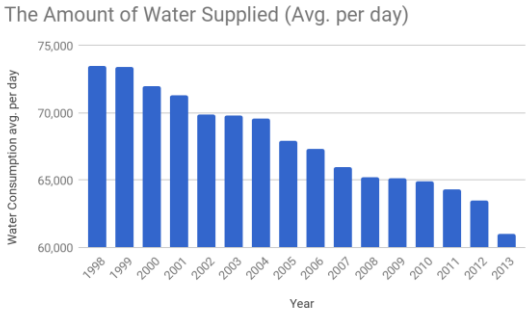
In order to meet the demands of safe and drinkable water, the waterworks system in Kushiro was established 1927. Expansion projects were carried out in 1959, 1961 and 1971 as the population increased.

However, in today, Kushiro has been losing population as younger generations are likely to move out to bigger and urban cities like Sapporo (Hokkaido prefectural capital) and Tokyo. (2015 Kushiro Waterworks Bureau)

Transition over water supplied population (2015 Kushiro Waterworks Bureau)



Transition over water consumption (2015 Kushiro Waterworks Bureau)



→ Water supplied population is declining so as the amount of water supplied.

2. Water Sources

Kushiro's water source is Kushiro River, which originates from Lake Kussharo and flows across the southern part of Kushiro Plain, forming broad wetlands.

Fig. 19

Lake Kussharo

Fig. 20

Kushiro River

Characteristics

- Volcanic geographical features (contains volcanic substances)
- Contains organic matter from Kushiro Plain (wetlands)
- Includes substances of pasture from the upper stream
- Domestic wastewater from Kushiro city
- Meltwater contains a large amount of ammonia

Due to the features listed above, the quality of water in Kushiro is not really favorable. Before the purification process, the raw water has a brownish color and a 'grassy' odor.

3. Water Purification Plants in Kushiro

Aikoku Water Purification Plant

Fig. 21

Water providing districts: Kushiro

Supply capacity: 61,000 ㎥/day

Water source: Kushiro River

Water intake station: Iwabokki water intake station

4. Preparing for Emergencies

As Kushiro is located on Chishima volcanic belt, the chance of occurrence of large earthquakes is high. Therefore, appropriate preparation for the earthquake has to be conducted.

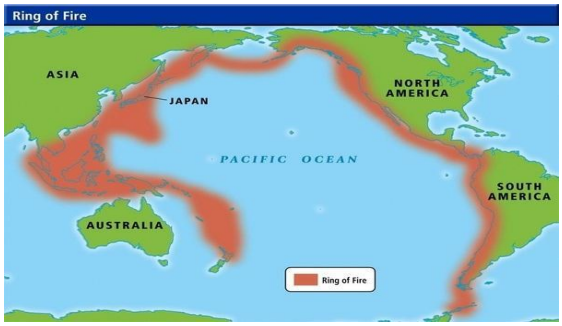


Fig. 22

Kushiro Waterworks Bureau is working on improving facilities and water pipes, making them quake-proof.

5. Providing “Safe and Delicious” Water to consumers

Unique methods are used in order to remove the color and smell from the raw water.

Here are some examples:

- Biosensor

Fig. 23

- Water quality monitoring device (By observing the movements of fish)

Fig. 24

- Ammonia meter

Fig. 25

- Water oil level monitor

Fig. 26

Due to the geographical and climate features of Hokkaido, precautions must be taken during the severe winter season in order to ensure stable and secure water supply. In Kushiro, freezing of water occurs from November to April, and so, following things are done in Kushiro Waterworks Bureau.

Water Purification Plant

→ Every facility is constructed indoors

→ Heater is used during the winter season

Water pipes

→ Water pipes are built underground, deeper than 1.6m

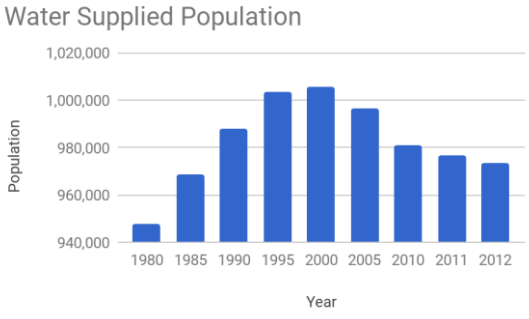
→ The underground as well as the surface of ground is heated

d. Mannou, Kagawa Prefecture

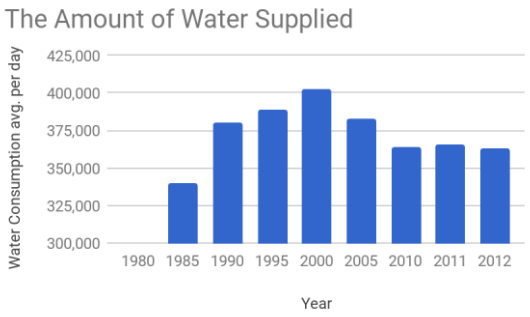
1. Overview

Water provided in Kagawa Prefecture is collected from Kagawa irrigation system. Located in the southern part of Japan, Kagawa Prefecture is easily damaged by the drought. Despite the difficulty of obtaining sustainable access to water sources, currently, Kagawa Prefectural Waterworks Bureau is conducting three projects: 1. Providing tap water, 2. Industrial water and 3. Goshikidai waterworks project (supplying water to remote villages which are now popular for sightseeing)

Transition over water supplied population (2012 Kagawa Waterworks Bureau)



Transition over water consumption (2012 Kagawa Waterworks Bureau)



Both graphs above present the same trend; the maximum point is at year 2000, and it shows a gradual decline after that.

2. Water Sources

Major water source used in the prefecture is Kagawa irrigation system, which collects water from Yoshino River.

Fig. 27

Yoshino River

More than 50% of water sources in Kagawa Prefecture originate in other prefectures, including Yoshino River. (2012 Kagawa Waterworks Bureau)

3. Purification Plants in Kagawa Prefecture (Mannou Town) (2012 Kagawa Waterworks Bureau)

- Takayahara Water Purification Plant

Supply capacity: 4,400 ㎥/day

- Shijyou Water Purification Plant

Supply capacity: 1,450 ㎥/day

4. Preparing for Emergencies

- Using Lake Hozan as a large reservoir

Fig. 28

Lake Hozan

This lake was artificially constructed in 2009 in order to avoid Kagawa Prefecture suffering from water shortage during the summer. It also

can be used as a water providing station when an earthquake occurs, and water supply is cut off.

5. Future Management

As the population is predicted to decrease over time, Kagawa Prefectural Waterworks Bureau proposed a plan called “Expanding Water Networks in Kagawa Prefecture”.

Shrinking population directly means a decrease in the revenue of Waterworks Bureau. Before facing financial crisis, it is vital for Kagawa Prefecture to consider ways to continue providing water. The purpose of this project is to improve efficiency of waterworks and maintain the system of waterworks to the next generations.

2. Water Purification Plants

Potential problems and solutions regarding to today’s waterworks in Japan

i. Potential problems

1. Decreasing population & Aging society

Nowadays, Japan’s population has begun to decline and the proportion of people that are capable of work and revitalize the nation’s economy is gradually decreasing. The fertility rate is at decline whereas the life expectancy continues to increase.

In addition to this issue, the young people in Japan tend to abandon rural villages and live in big, urban cities such as Tokyo and Osaka. As a consequence, the majority of the population is centered in urban cities, creating a city-state. Therefore, cities, towns and villages that are outside of the city-state are likely to eventually fade away. Rural areas must adapt to this situation.

As explained in the previous section of this report, cities such as Yokohama and Makuhari have the opportunity to introduce a new, advanced technology and maintain the current waterworks system because they are able to earn sufficient amount of profit from their citizens. On the other hand, remote areas such as Kushiro and Mannou are suffering from financial difficulties. If they cannot handle the situation well, it is

possible that in the near future, water supply will be cut off from rural areas even though there are people who require water.

Water is vital for our living so everyone should have the right to have access to safe, clean water. Therefore, this problem cannot be overlooked.

2. Decline in the waterworks' revenue earned

Not only due to the population decrease, but there is also a possible reason why the profit is decreasing. As the graphs presented before explain, the water consumption rate is falling both in urban cities (Yokohama and Makuhari) and rural areas (Kushiro and Mannou). Although it is not proved scientifically, the possible factor affecting this trend is spreading concept of "Water-saving". After the economic recession that occurred in 2009, Japanese people began to save money and cut down on expenses. This was when the idea of "Water-saving" became very popular. In today, almost all household appliances found in Japanese stores are "Water-saving".

Moreover, this concept is considered environmentally friendly as waterworks system require a large amount of electricity. Japanese people are not really aware of the financial situations that waterworks bureaus are confronting today - they simply consider "Water-saving" as a good thing.

3. Decrepit facilities & need for quake-proof construction

Most of the water purification plants and water pipes that are used today were constructed in around 1980's. Expected durable life (designed by law) of water pipes is 40 years. Although it is possible to use the water pipes that exceed 40 years, it is undeniable that they have to be replaced over time. In addition, the needs and demands for quake-resistant water pipes and facilities are rising due to the Tohoku earthquake in 2011.

Constructing new facilities and installing quake-resistant water pipes are necessary in the near future. However, in order to carry out these projects, a considerable amount of money is

necessary, which is unlikely to be achievable in today's financial situation.

4. Lack of human resources

As the population decreases, the number of human resources available would be limited. Skills and technique that have been developed and inherited from the past may vanish as a result of this.

Nowadays, young people are eager to obtain a high-paid, stable job. The technical jobs in waterworks bureau take efforts to acquire, but the salaries are not good compared to private firms and companies. Therefore, young people avoid choosing this kind of job which is only worsening the issue.

ii. Possible solutions

1. Using state/government subsidy

Although this sounds like a temporal solution, it prevents worsening the current situation and is actually effective.

2. Reconsideration of the significance of tap water

In order to solve all four problems listed above, it is important to discover and change the very root of these problems. It takes a long time to see its effects, but it is firmly convinced that the situation would improve eventually.

People should really realize the importance of tap water and appreciate to the current circumstances. This can be said not only to Japan, but also to the other developed countries that have a sustainable access to water sources. People in developed nations usually take it for granted that they are always able to gain fresh tap water without knowing the efforts behind the scene.

Through activities and conferences like Water Is Life, people should be able to realize that they have been overlooked a vital aspect of their lives.

iii. Water Tasting Experiment

Tap Water or Bottled Water

Introduction: Nowadays, most of the people in developed countries have access to safe, drinkable

tap water. However, they tend to purchase bottled water, considering it to be “healthier” and “more palatable” than tap water. In fact, the bottled water market in Japan is constantly expanding as shown in the figure 29 below.

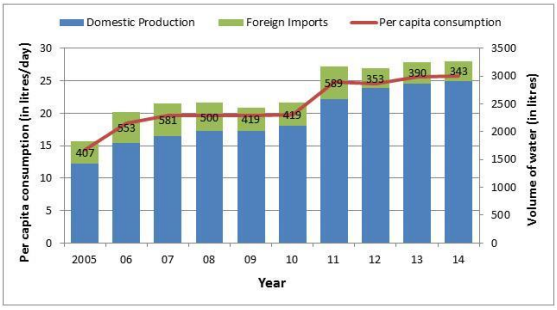


Fig. 29

According to an online website, statista, it is estimated that the annual revenue of the bottled water segment in Japan amounts to US$2,740m in 2018.

Tap water in Japan is cleansed through a number of process in water purification plant before being delivered to consumers. Despite the fact that tap water in Japan is one of the safest water around the world, many students and teachers in Shibuya Makuhari high school purchase bottled water in cafeteria.

Aim: In order to investigate people’s preference over tap water and bottled water and raise awareness that we should not have biased perspective towards tap water.

Hypothesis: We hypothesize more than 50 % of the research participants prefer water A (tap water).

Materials/Equipment:

Bottled water (Suntory’s Mineral Water)

→ 2.0L × 3 bottles

Tap water from Makuhari Senior High School (Chiba prefecture)

→ 4.0L

Paper cups

→ 400 cups (2 cups/person, mark 200 cups as A and other 200 as B)

Containers

→ 4 containers (0.9L container × 2, 2.0L container × 2)

Stickers

→ 150 stickers (1 sticker/person)

Table

→ 1 table

Paper

→ 3 papers (2 for instruction of the experiment, 1 for voting)

Method:

1. Pour tap water and bottled water into 4 containers (2 containers each) and leave them in the same place for three hours in order to keep the temperature same. Organize papers and stickers as shown in the diagram above.

2. When the containers are left for three hours, prepare 40 paper cups on the table (20 are marked as A and other 20 are marked as B). Pour tap water into cup A and bottled water into cup B.

3. Conduct the experiment by asking the people passing by to drink both water A and B and put a sticker on the paper to vote for their preferences.

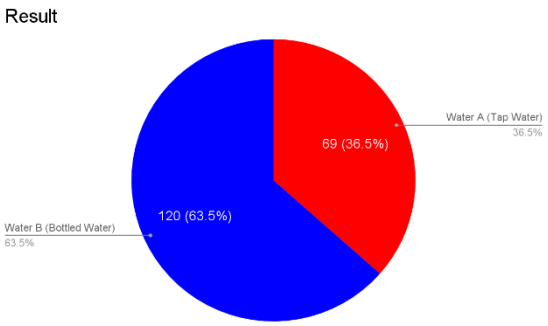
4. Repeat step 2 and 3.

Safety & Precautions:

- As the experiment is conducted in front of the school's cafeteria where a number of people walk through, one has to be careful when handling water.
- In order to maintain hygiene throughout the experiment, all the paper cups should be used only once. Also, the containers should be washed before and after the experiment.

Result:

Out of 189 research participants, 69 preferred water A (tap water) and 120 preferred water B (bottled water).



Conclusion:

Can be seen from the result, 36.5 % participants preferred tap water over bottled water, which was different from our hypothesis. However, the result revealed that some people that favored tap water do purchase bottled water. 500 mL bottled water in Japan costs 100 to 120 yen, whereas tap water costs 0.33 yen/1 L in average. Comparing these two prices, it is obvious that tap water is a lot more cost-effective and convenient than bottled water. Moreover, bottled water is contained in plastic bottles, and this increases the plastic waste being produced. Although there are some ways to recycle plastic bottles, it is undeniable that consuming bottled water contributes polluting the environment.

During the experiment, some people commented that they dislike the taste/smell of chlorine which is used to sterilize tap water. Actually, there are numerous effective methods to discard chlorine from tap water. Therefore, in the next experiment, we would like to compare the taste difference between tap water without chlorine and bottled water.

Evaluation of the Method:

Overall, the procedure of the experiment was not a failure. However, the amount of water we have prepared prior to the experiment was not enough so we had to add more water during the experiment. In the consequence, we could not maintain the same temperature, resulting in unreliable data. In addition to this, although we prepared papers explaining this experiment, but some people did not seem to understand it well. They considered this experiment is about guessing which water has better quality, not about choosing which water they prefer. Therefore, by looking at the voting paper, some people chose the one which had more votes, thinking it to be the “correct” answer.

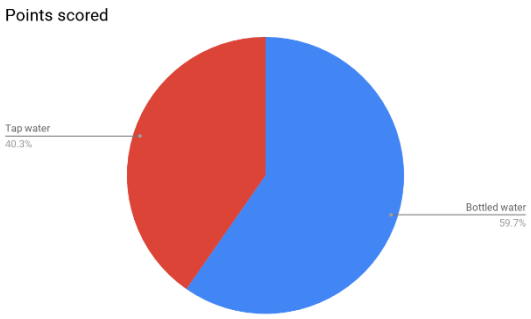
A possible further experiment can be conducted using bottled water and tap water which does not contain chlorine. More amount of water should be arranged before the experiment, and voting should not be shown visually to participants.

Water Tasting Experiment 2

We conducted the experiment again but changing one factor - using tap water without chlorine instead of normal tap water. We changed the voting system as it says in the evaluation of the method from the first experiment. Moreover, this time, we were able to maintain the temperature of two waters the same, by measuring it.

The result:

Out of 62 research participants, 25 people chose tap water (without chlorine) and 37 people chose bottled water.



Conclusion:

Although the number of research participants was smaller this time, it was more accurate and reliable than last time. The result shows that if chlorine is filtered out from tap water, more people are tend to favor it.

From the two experiments conducted, around 30% people prefer raw tap water and 40% people prefer tap water when filtered. People should not be wasting money on bottled waters with their biased thoughts that bottled water is more delicious and healthy. Drinking tap water is cost-effective, and by filtering it, people can enjoy tap water even more.

In this section of the report, the waterworks system in Japan is investigated. To summarize, the most prominent thing is to change people's awareness and attitude towards tap water. However, most people in developed countries do not really have the experience of water-related disasters, and therefore, it is not easy for them to imagine what they are like specifically. So, from the next chapter, this issue is conveyed from the historical aspect.

Water sources in Chiba Prefecture (Table 1)

Water sources	Water Purification Plant/Water Supply Plant	Supply capacity (㎥/day)	Percentage (%)	
Tone River (Including Lake Inba-numa and Edo river)	Kashiwai Water Purification Plant	530,000	42.3	88.0
	Hokuso Water Purification Plant	126,700	10.1	
	Kuriyama Water Purification Plant	186,000	14.8	
	Chibanogikunosato Water Purification Plant	60,000	4.8	
	Shonan Water Supply Plant	201,300	16.0	
Yoro River	Fukumasu Water Purification Plant	90,000	7.2	7.2
Obitsu River	Anezaki Water Supply Plant	60,000	4.8	4.8

Customer's feedback (Table 2)

Year	Consultations	Complains	Requests	Others	Total
2010	122,985	338	209	10	123,542
2011	118,682	514	187	25	119,408

2012	108,394	291	195	85	108,965
2013	105,232	381	284	57	105,954
2014	109,026	188	299	51	109,564

Water sources in Yokohama (Table 3)

Water sources	Water Purification Plant	Supply capacity (㎥/day)	
		Tap Water	Industrial Water
Doshi River (Owned by Yokohama)	Kawai Water Purification Plant	172,800	
Sagami Lake (Shared by Yokohama, Kawasaki and Kanagawa Prefecture)	Nishiya Water Purification Plant	394,000	86,000
Banyu River (Shared by Yokohama, Yokosuka, Kanagawa Prefecture)	Kosuzume Water Purification Plant	284,700	246,000
Sakawa River	Isehara, Sagamihara, Nishinagazawa Water Purification	605,200	

	Plants (Owned by Kanagawa Water Supply Authority)		
Sagami River	Ayase, Sagamihara (Owned by Kanagawa Water Supply Authority)	499,000	

2.Water-Related Natural Disasters and Preventative Measures

The Objectives

Based on the research on how much water was valued in the past, the aims for this report will be to (1) point out how much developed countries are unconscious about the water crisis today, and (2) to suggest to developing countries on how to use water effectively with methods used in the past.

1.1 To Propose Ideas for Developed Countries

In order to propose a change for the developed countries, research on the worshipping of water in Japan will be done among with finding data to reveal how much water is being wasted in these countries.

1.2 To Propose Ideas for Developing Countries

As for suggesting ideas for the developing countries, Japan's various geography and its individual ways of taking measures against water-related damage will be introduced. From this,

The Research

Considering the fact that many of the natural disasters in the world are caused by water, this section will be divided into two: droughts and floods.

Due to the fact that (1) droughts mainly affect only the Seto Inlands and (2) floods affect almost every area in Japan, research will be done by comparing each area affected by flooding. This is

predicted to have close ties with the geography and climate of the area.

2.0 The Objectives of the Research

Located in the Seto Inland Area, Lake Manno is the largest reservoir in Japan. To obtain further information on this area, individual interviews were done on the Department of Waterworks and on the customs associated with water supply. The Department of Waterworks is known for controlling the water supply in regions of Manno Land Improvement Ward and Manno Ward itself. (The Manno Land Improvement Ward is an organization that manages the water supply in the Manno area.)

Due to the fact that floods have relatively similar characteristics throughout Japan, information was obtained by an overall study using books and other sources, instead of fieldwork. For this, a majority of this report consists of research based on Lake Manno.

2.1 Droughts in Lake Manno

The Seto Inland Area is composed of prefectures in the Chugoku Shikoku Area, specifically the ones along the Seto Inland Sea.

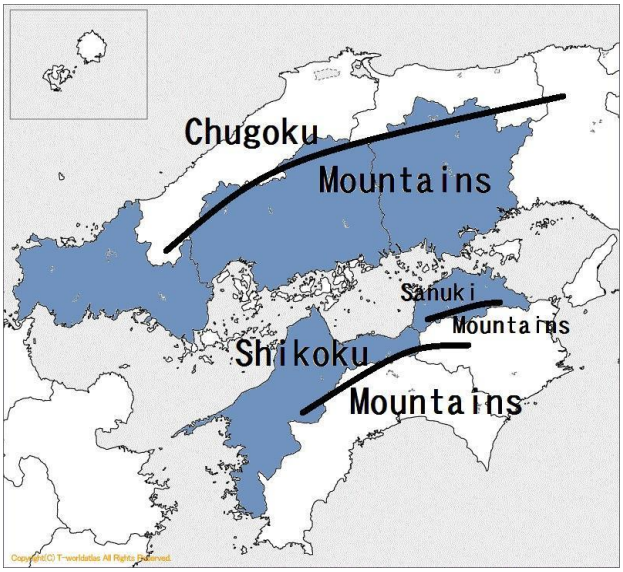


Fig. 30

In the winter and summer seasons, seasonal winds blow throughout Japan. The summer winds are high pressure winds that blow southeast, and in contrast the winter winds are high pressure winds that blow northwest from Siberia. The problem with this, however, is that it creates an environment where droughts can easily occur. The Chugoku Mountains block the southeast winds from blowing, causing the precipitation rate to be low compared to other areas.

【1981～2010】

month	average temperature (℃)	pre-cipitation mm
Jan.	5.5	38.2
Feb.	5.9	47.7
Mar.	8.9	82.5
Apr.	14.4	76.4
May	19.1	107.7
Jun.	23.0	150.6
Jul.	27.0	144.1
Aug.	28.1	85.8
Sep.	24.3	147.6
Oct.	18.4	104.2
Nov.	12.8	60.3
Dec.	7.9	37.3
annual	16.3	1082.3

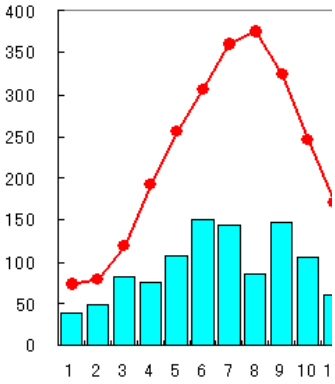


Fig. 31

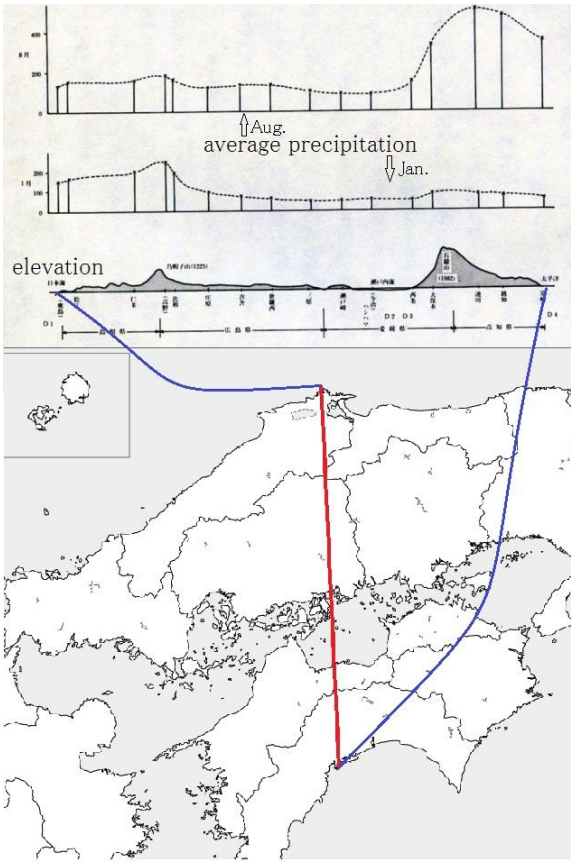


Fig. 32

As seen in the map below, it can be seen that Kagawa Prefecture has hardly any rivers, and thus has an environment that makes it easy for a drought to come.

Today there are 14,600 reservoirs in Kagawa prefecture. 52 percent of the water used for agricultural purposes is dependent on these reservoirs.

Fig. 33

As seen on this map, Lake Manno is located on the southwestern area of Kagawa prefecture.

Fig. 34

The amount of usable water stored in Lake Manno is 15,400,000 tons, at the maximum depth of 28 meters, maximum capacity area of 138.5 hectares, and irrigational area of 3239 hectares. Its beneficiary area covers 2 cities and 3 towns at 2634 hectares, and has an association consisting of 7,468 people. These factors make Lake Manno one of Japan's most greatest agricultural reservoirs.

Moreover, as a dirt-based dam, Lake Manno's structure allows it to have a height of 32 meters, length of 155.8 meters, and width of 20 meters.

Fig. 35

2.1.1 Climatic Characteristics and Traditions of Manno Area.

The following information is based on Hiroyuki Kanou's research.

As mentioned earlier, the Seto Inland Area lacks in precipitation, causing constant droughts in the area.

"Water comes from the heavens, and is given by God"

This is a translated phrase said by the people of ancient Kagawa (known as *Sanuki*), and was especially said during the drought (which came every 6 years). This saying was highly believed at the times of *Sanuki*. Water back then was believed to be given by the Gods, so at times of scarcity, the praying for water took place.

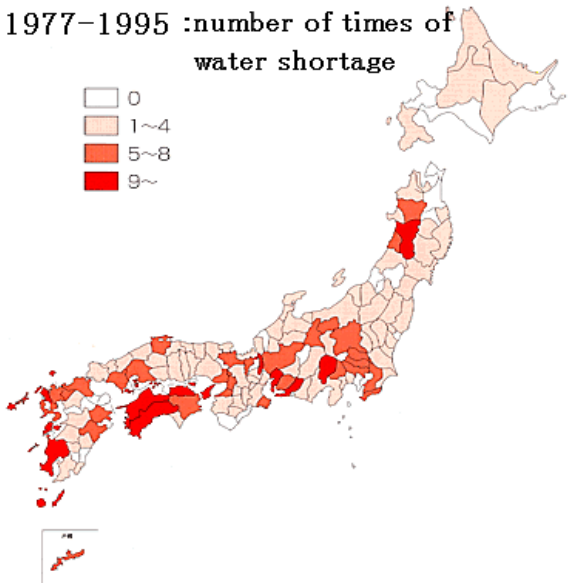


Fig. 36

However, Kuukai, a well known Japanese Buddhist saint, changed the circumstances by allowing more water to be accessed. Not only did he hold a praying for rain at Kotonami City, but he also restored Lake Manno as a lake “builder” in 818. As mentioned earlier, this is what allowed Lake Manno to become the largest reservoir in Japan.

Additionally, Michizane of the Sugawaras, the governor of Sanuki, has made efforts to improve the water conditions in the Manno Area. In 888, he said the words “In exchange of my subject’s life, please save the 200,000 lives of Sanuki,” and took part in a 7-day praying for rain. This was for the gods in Shiro Mountain of Kanagawa, and was continued even during the Hansei Period. These practices were done by both the government and the people, and consisted of (Shinto) rituals such as “getting water from the neighbors” and “waiting for the rapid streams”.

There were also records of fighting over the water supply, and the belief of the Dragon God that has spread throughout Japan.

However, the slogan “Shikoku as one” stimulated the planning of “The Yoshino River Total Exploitation Project”. As a result, “Kagawa Water was created in 1981 after 12 years of creation. It flows through the Sanuki Mountains, and brings water to throughout Kagawa Prefecture.

2.1.1.1. Traditions

Below will be listed the translation for The Konjyaku Stories (11th Century, Unknown), which mentions Lake Manno. (Note that this was translated from ancient to modern Japanese, and then to English. The original text will come before the translation.)

Chapter 20 Story 11

竜王為天狗被取語 第十一

(Original Version)

今昔、讃岐の国□□の郡に、万能の池と言ふ、極て大きなる池有り。其の池は、弘法大師の、其の国の衆生を哀はれがり哀レガリ一本哀バムガニ作ル為に、築き給へる池也。池の廻り遥に広くして、堤を高く築き廻したり。池などは見えずして、海とぞ見えける。池の内、底井(そこひ)無く深ければ、大小の魚共量無し。亦、竜の栖(すみか)としてぞ有ける。

而る間、其の池に住ける竜、「日に当らむ」と思けるにや、池より出て、人離れたる堤の辺に、小蛇の形にて蟠り居たりけり。

其の時に、近江の国比良の山に住ける天狗、鵄(とび)の形として、其の池の上を飛び廻るに、堤に小蛇の蟠て有るを見て、□鵄、反下(そりくだつ)て、俄に掻き抓(つかみ)て、遥に空に昇ぬ。竜、力強(こは)き者也と云へども、思懸けぬ程に俄に抓まれぬれば、更に術尽て、只抓まれて行くに、天狗、小蛇を抓砕て食せむとすと云へども、竜の用力強きに依て、心に任せて抓み砕き噉む事能はずして、繚(わづらひ)て、遥に本の栖の比良の山に持持一本将ニ作ル行ぬ。狭き峒(ほら)の動くべくも非ぬ所に打籠置つれば、竜、狭く□□狭クノ下一本ツヅマリテトアリ下同ジ、破(わり)無くして居たり。一滴(しづく)の水も無ければ、空を翔る事も無し。只死なむ事を待て、四五日有り。

而る間、此の天狗、比叡の山に行て、短(ひま)を伺て、「貴き僧を取らむ」と思て、夜る、東塔の北谷に有ける高き木に居て伺ふ程に、其の向に造り懸けたる房有り。其の坊坊一本房に作ル下同ジに有る僧、延に出て小便をして、手を洗はむが為に水瓶を持て手を洗て入るを、此の天狗、木より飛来て、僧を掻き抓て、遥に比良の山の峒に将て、竜の有る所に打置つ。僧、水瓶を持ち乍ら、我れにも非で居たり。「我れ今は限りぞ」と思ふ程に、天狗は僧を置くままに去ぬ。

其の時に、暗き所に音有て、僧に問て云く、「汝は此れ誰人ぞ。何くより来れるぞ」と。僧、答へて云く、「我れは比良の山の僧也。手を洗はむが為に、坊の延に出たりつるを、天狗の俄に抓み取て、将来れる也。然れば、水瓶を持ち乍ら来れる也。抑も、此く行は誰そ」と。竜、答て云く、「我れは讃岐の国万能の池に住む竜也。堤に這ひ出たりしを、此の天狗、空より飛来て、我を抓て此の峒に将来れり。狭く□□て為む方無しと云へども、一滴の水も無ければ、空をも翔らず」と。僧の云く、「此の持たる水瓶に、若し、一滴の水

や残たらむ」と。竜、来れを聞て、喜て云く、「我れ、此の所にして、日来を経て既に命終なむと為るに、幸に来会ひ給て、互に命を助くる事を得べし。若し、一涕の水有らば、必ず汝を本の栖に将至るべし」と。僧、又喜て、水瓶を傾けて竜に授くるに、一涕許の水を受つ。

竜、喜て、僧に教へて云く、「努々怖る事無して、目塞て、我れに負(おは)れ給ふべし。此の恩、更に世々にも忘難し」と云て、竜、忽に小童の形と現じて、僧を負て、嶋を蹴破て出る間、雷電霹靂し、空陰り、雨降る事甚だ怪し。僧、身振ひ、肝迷て、「怖し」と思ふと云へども、竜を睦び思ふが故に、念じて負はれて行く程に、須臾に比叡の山の本の坊に至ぬ。僧を延に置て、竜は去ぬ。

彼の房の人、「雷電霹靂して、房に落懸る」と思ふ程に、俄に坊の辺、暗(やみ)の夜の如く成ぬ。暫許有て晴たるに、見れば、一夜、俄に失にし僧、延に有り。坊の人々、奇異(あさまし)く思て問ふに、事の有様を委く語る。人、皆此れを聞て、驚き奇異がりけり。

其の後、竜、彼の天狗の怨を報ぜむが為に、天狗を求むるに、天狗、京に知識を催す荒法師の形と成て行けるを、竜、降て蹴殺してけり。然れば、翼折れたる屎鵄にてなむ、大路に踏まれける。彼の比叡山の僧は、彼の竜の恩を報ぜむが為に、常に経を誦し、善を修しけり。

実に此れ、竜は僧の徳に依て命を存し、僧は竜の力に依て山に返る。此れも皆、前生の機縁なるべし。此の事は、彼の僧の語り伝ふるを、聞継て語り伝へたるとや。

(Translated Version)

A long time ago, in the lands of *Sanuki*, was a quite large lake called Lake Mano. It was made by (dear) *Kou Bou Dai Shi* (later known as Kukai), as he felt pity for the people in Japan at that time.

The lake's surroundings continued far beyond the lake itself, and consisted of a tall bank. The surface of the water was so wide that it was often mistaken as an ocean, instead of a lake. This lake was home to countless species of fish, and also was the home of a dragon.

One day, the dragon sought to come out where the sun was, but did not have the opportunity to do so. There was a snake coiled up on a bank (isolated by humans), which blocked it from coming out.

Simultaneously, a tengu of the Hira Mountains had transformed into a kite (bird) and flew over the lake to find the same snake.The kite descended, curving its body, and scratched the dragon with its sharp nails at an instant. Then it flew high up in the sky.

Although the dragon is stronger than the kite by nature, it was unable to do anything, as the actions by the bird were done in such a short amount of time. The dragon remained caught by the tengu.

The tengu was planning to break up the dragon into pieces to eat its flesh, but feeling a sense of respect for the powerful dragon, it could not tear it up as its heart desired. Not knowing what to do, it brought the dragon to his home in the Hira Mountains. The dragon was then crammed inside a small cave, where there was not a single drop of water. There was absolutely no way of escape nor any hope for flying in the sky ever again. Four to five days passed as the dragon waited for his death to arrive.

Meanwhile, the tengu had been making plans to kidnap a sacred monk, and how to aim for the right moment.

And so it became nighttime. The tengu watched from a tall tree in the East Tower of *Kitagaya*, and spotted a monk doing his business on the porch. When he was washing his hands with a water jug he brought by himself, the tengu flew from the tree, snatched him up, and flew away. When it returned back to the Hira Mountains, the tengu dropped the monk next to where the dragon was.

In a stupor and unable to think, the monk lay with his water jug in his arms. *My life is over now*, he thought, but instead of getting attacked, the tengu simply left.

From the darkness could be heard a voice. “Who are you?” it asked. “From where do you come from?”

The monk replied. “I am a monk of the Hie Mountains,” he said. “I was going out on the porch to wash my hands when I got caught by that tengu. And who are *you*?”

“I am a dragon of Mano Lake in the Sanuki region. I was crawling out into the bank but instead got attacked by the tengu and here I am. It’s very cramped in here, with no water or the hope of getting out.”

After the dragon’s reply, the monk replied “Well, it seems like there is some water left in my jug if you want it.”

Hearing these words, the dragon excitedly said, “I have spent several days here, reaching the end of my life, but fortunately we were able to meet. If it is the two of us, we can help each other get out of here. Now, if there is a drop of water in that jug, I will promise you that I will bring you home to where you live.”

Happy to hear this, the monk gave his jug to the dragon

The dragon, pleased, opened its mouth again.

“Never, ever fear about this,” the Dragon said. “Close your eyes and lift yourself up onto my back. I will never forget about this favor I owe you.” In the split of a second, the dragon transformed into a child, threw the monk up his back, and tore down the cave.

Then suddenly, thunder rumbled and rain poured down. Such state is extremely rare to happen. The monk trembled in fear and was purely scared.

However, the monk decided to trust the dragon and the promise. In no time they arrived back in the Hie Mountains, where there was the monk’s home.

After bringing the monk back to the porch, the dragon left.

The people were scattering around, thinking that lightning had struck somewhere, only to find the monk who they thought had disappeared. A little suspicious, the people demanded explanation from him. So he said about it all; he explained about his experience from the very start to the very end. This ended up having the people intrigued by his story and shocked at the same time.’

Later the dragon sought to have revenge on the tengu. One day it was wandering through the streets of ___ disguised as a “rough monk”.

Finding this, the dragon swooped down and kicked the tengu so hard that it took away its life. The tengu turned back into the figure of a kite, this time with broken wings, and lifelessly remained on the street as it got stepped on by the people.

The monk in the Hie Mountains continued to chant a sutra dedicated to the dragon that had saved his life, and carried on with his good deeds.

The dragon too, was thankful of the monk's virtue to him, and how he was able to have a longer life because of him. Similarly, the monk was able to return to the Hie Mountains thanks to the dragon. This all may have been fate, planned from the previous life.

This story was passed down for generations, the monk being the first teller.

Chapter 31 Story 22

讃岐国満農池頽国司語 第廿二

(Original Version)

今昔、讃岐の国□□の郡に、満農の池とて大きなる池あり。高野の大師の、其の国の人を哀まむが為に、人を催て築給へる池也。

池の廻り遥に遠くて、堤高かりければ、更に池とは思えで、海などとぞ見えける。広さは彼方幽(かすか)なる程なれば、思ひ遣るべし。其の池築て後、頽(くづ)れずして久く有ければ、其の国の人、田を作るに旱魃する時なれども、多の田、此の池に助けられて有ければ、国の人、皆喜び合へる事限無し。上より数の川共懸りたれば、池の内に水湛(たたへ)て絶る事無かりけり。然れば、池の内に大きなる、小さき、多くの魚有けり。此れを国の内の人、自然ら構て取る事有れども、魚し多く有ければ、池に魚満て期も無かりけり。

而る間、□□の□□と云ふ人、其の国の司として国に有けるに、其の国の者共も館の人も集て、物語などしける次でに、「哀れ、満農の池には、限無く多かる魚かな。三尺の鯉なども有らむ」など語けるを、守、伝へ聞て、「欲(ほし)」と思ければ、「構て此の池の魚を取らばや」と思ふに、池遥かに深ければ、人下て網を置く事も能はず。然れば為ける様、池の堤に大なる穴を通して、其より水を出して、水の落つる所に魚の入るべき物を

構へ置て、水を出しければ、水、走り出るに随て、其の穴より多の魚共出ければ、期も無く取てけり。

然て、其の後、其の穴を塞けれども、水の出る勢強くて、更に否(え)塞ぎ得ざりけり。池には樋(ひ)と云ふ物を立て、打樋を構て水をば出せばこそ、池は持(たも)つ事にては有るに、此れは堤を捜(くじり)通してければ、暫く其の穴頽れて広く成ける程に、大きなる雨降て、池の上より流れ来る河共の水増(まさ)りて、水、池に多く満ける程に、其の穴本として、堤突頽されにけり。

然れば、池の水、皆出て、其の国の人の家共・田畠など、皆損じにけり。多の魚共は流れて出て、此彼(ここかしこ)にて皆人に取られにけり。

其の後は池けの水も少く有ける程に、漸く其の残たる池も皆失せて、今は其の池、跡形も無てぞ有なる。

此れを思ふに、此の守の欲心に依て失せたる池也けり。然れば、此の守、此れに依て、何に罪量無からむかし。然る止事無き権者の、「人を哀まむ」とて築給へる池を失ひたらむだに、量無き罪也。其れに、此の池の頽るに依て、多の人の家共を損じ、多の田畠を失ひたる罪も、只此の守こそは負ふらめ。何に況や、池の内に有る若干の魚共の取られたる罪も、誰人かは負はむと為る。極て益無き態したる守也かし。

然れば、人の強の欲心は止むべき也かし。亦、国の人共も、于今至まで、其の守をぞ忄悪み謗るなる。

其の池の堤などの形は、未だ失せで有なりとなむ、語り伝へたるとや。

(Translated Version)

A long time ago, there was a massive lake called Lake Manno in the lands of Sanuki.

This lake was made by Kuukai, who felt pity for the people of the area at the time.

Anyway, the lake was a large one. The opposite side of it was far beyond, and looked like an ocean rather than a lake due to its tall banks. In fact, the opposite side was so far away that it blurred in anyone’s vision, and ought to be known widely of its largeness.

The lake remained the same large one as time has past. It did not lose a bit of its shape, and continued to moisten the rice fields as it prevented drought. The people were delighted by this, as

this was a blessing that lasted forever. The Imperial Court gave them permission to connect the lake to various rivers, and thus allowed the water to never run out. For this, plentiful fish lived in the lake, and the people had an unrestricted supply of it.

One day, the administrator of the country opened a meeting with those from a high class.

"What a surprise," the people said. "There is so much fish in Lake Manno! There are even koi 3 shakus (≒90.3 cm) long!"

Hearing this, the administrator's hunger aroused. "Let us make a fortune from the fish here," he said, and sprang into action.

He prepared a net, but due to the lake's deep floor, it could not be set properly. For this, he opened a hole in the banks, controlled the water so that it would flow into the hole, and placed a container to catch the fish. The plan was a success; a large fish was caught.

However, no matter how much effort was done, the hole could not be closed up due to its powerful current. The only way to prevent the lake from having a washout was to use a gutter and drain it little by little. Although this was the best solution, the waters were flowing into the lake at such a massive force, causing the banks to collapse.

For this, all of the water in the lake flowed out, and homes and rices fields were destroyed. All that remained in Lake Manno was a small puddle; what used to be a lake with lots of fish was now washed out, the fish belonging in the stomachs of other people.

This is the story of how one administrator's greed caused the collapse of a lake, and its consequences following it. It crushed Kuukai's wish of supplying the people with abundant water. Such "crime" is most reprehensible. The collapse of the lake has caused countless houses and fields to wash away, all because of the administrator. What a waste his decisions were.

No one is aware of how to stop their desires from taking over them. The people of Sanuki continued to hold a grudge against the administrator, and disrespected him.

The traces of this lake still remain today.

2.1.1.2. Beliefs

Rituals such as the praying for rain are still practiced today in Kagawa. As an example of these practices, explanations on the *Ayako Dances* will be added. *Ayako Dances* are recognized as an Important Intangible Cultural Property, and have a significant meaning in Kagawa culture.

2.1.1.2.1. History

The *Ayako Dance* is a type of performing arts originated in Sabu Area of Zouzu Mountains. It focuses on the granting for rain and does so by performing a dance to the Buddhist gods. Though this is done irregularly and only at times of the annual drought, it usually takes place in mid to late August.

The dance is ultimately done in front of Kamo Shrine. The rest is performed using Japanese halberds and poles, and with a greeting at the center of the stage. After that come the groups of the *Shiyou*, *Daiyou*, and *Sokuyo*. They perform their specific dance in a line, according to the three styles. As for the music, there are approximately 12 songs in total, and the dances are choreographed to it accordingly. Some examples include the “Water Dance”, “Shikoku Dance”, “Ayako Dance” and “Hiding Dance”. These dances have forms similar to that of the original *Kabuki*.

The dance’s origin and tradition is as stated below.

In the old days, there lived a girl named Aya in a rich and powerful family known as the “*Samon Shichimei*”.

During the period of dry weather, plants were on the verge of death and the villagers were in deep suffering.

One day, however, Aya told a traveling monk about the pain the villagers were going through because of the environment. The monk, feeling sorry for the people, taught Aya how to make it rain. He guaranteed her that by praying to the King and performing a dance, there is an absolute guarantee that it will rain.

So the plan was set for action. The villagers gathered together, dancing to the drums and the Aya-couple’s gong. Moments later, the sky

clouded and started pouring like a waterfall.

Fig. 37

This eventually became an annual tradition done at times of dry weather.

As a result, these dances were named the "*Aya dances*", as they brought rain to its people.

Furthermore, it is said that the monk in this story is known to be Kou Bou Dai Shi.

Below is a brief summary of the dance.

2.1.1.2.2. Greetings from Ayako from the Praying of Rain (Japanese folk song)

The Water Dance

(Original Version)

一. 堺の町は、広いようで狭い

雨さえ降れば　蓑よ　竿よ　ヒヤ

雨が降ろうと　ままいのソレ

しっぽとぬうれて　ソレ

水か水か　サア

こうちござれ　こうちござれ

(Basic Summary)

This song basically shows how much water is important in the city of Sakai, and that the people are waiting for the day to come when it rains.

綾子踊

(Original Version)

一. 恋をして　恋をして　ヤア

わんわする　親の　ヤア　知らずして

あんあの子は　いんいつも　ソレ

夏やせをする　ウンウノヤ

あらんや　夏やせをする　ウンウノヤ

あんあじきなや　ヒヤ

ひうやに　ひうやに　ヤア

やらに　やりうろ　やりうろ

(Basic Summary)

In this song, one girl is illustrated as the main character. She is in love with another person, and is experiencing it on a hot summer day.

六蝶子

(Original Version)

一. 五嶋しぐれて雨降らば　千代が涙と思召せ

千代が涙と思召せ　ソレ　リンリンリン

リンリンリンリンリンリンリ

(Basic Summary)

This is another song calling for rain. It is ironic, as it says that tears will fall down if it does not rain, although that would solve the problem.

Fig. 38

2.1.1.3. Geographical Characteristics

As seen in the topographic map below, the Sanuki Plains have a relatively steep inclination.

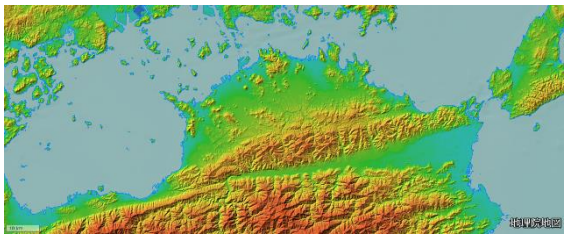


Fig. 39

This allows the drainage systems to be in fine condition.

Compared to other prefectures, however, this area does not have as much moisture in the lands. For this, it is almost like a dry agricultural field after being in the dry weather, where the water supply dries out.

Looking at the map below, it can be seen that the Manno Downstream Region (Marugame Plains) was covered with the stratum layer in the Holocene Epoch. There are some traces left of granite from 60 million to 90 million years ago as they protrude from the lands, and are inferred to be accumulated in the Cretaceous Period of the Mesozoic Era. However, these traces itself are actually the remains of the originally collapsed granite covered in andesite. Today they remain as small hills.

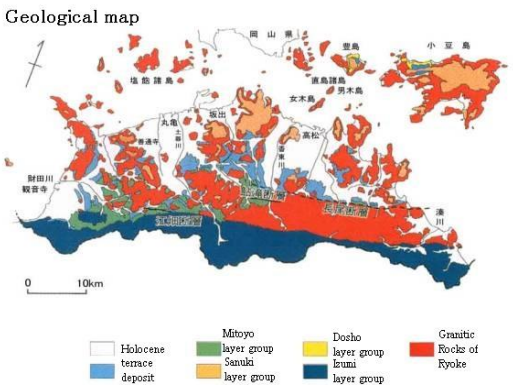


Fig. 40

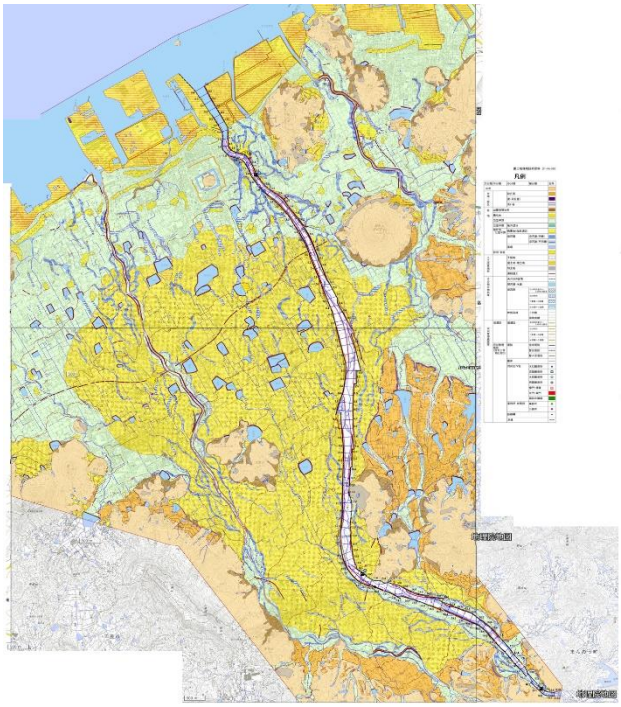


Fig. 41

Following this, an alluvium plain was made (Marugame Plains). The alluvial plains got formed by the concentration of sediments from the Kanakura River and the Doki River in the alluvial fan. Note that rivers such as the Kanakura

River and Doki River flow as underground rivers, and are not used as a water supply.

2.1.2 Droughts Taken Place Throughout History and Measures Taken

This page will focus on the droughts in the Marugame Plains among with Lake Manno's history.

2.1.2.1. History

Below is a brief historical outline of Lake Manno.

The beginning of the 8th century

701-704 The ruler of Sanuki, *Michimori-Ason* builds the banks (of Lake Manno).

808/9 Lake Manno's embankments break.

818 Lake Manno bursts.

821 Kuukai rebuilds the lake, after several failed attempts to restore it.

851 The embankments break again due to flooding.

852/8~853/3 The lake is restored after 7 months of effort.

1184/5/1 Lake Manno breaks again. It is told by the people that over the course of 330 years since year 851, Lake Manno had burst five times.

After 450, the lake had been abandoned for so long that it formed a village known as Ikeuchi Village.

1628~31 Lake Manno has been newly constructed by civil engineer Hachibe Nishijima of the Takamatsu domain.

1849~1853 Over the course of 220 years from the construction of Nishijima, equipment such as gutters and watchtowers were exchanged 18 times. Additionally, to make the lake last longer, Kiheiji Hasegawa changed the bottom gutter from wooden to stone.

1854/6/14~15 An earthquake strikes the area. A large opening is made in one of the gutters, and the stone walls have a water leakage.

1854/11/4~5 A large earthquake (Ansei Earthquake) worsens the damage of the gutters.

1854/11 Kiheiji Hasegawa dies of disease.

1866/8/7 Manno Lake collapses due to flooding. Houses that were built along the banks received damage as well as the bridge in Kotohara, that got washed away. The death toll was 18. This is also known as “The Massive Flood in the Year of the Tiger”.

1869~1820 Lake Manno gets restored again by Kiheiji Hasegawa with three other men. The stone hole was created after 6 months.

1821 The embankment is rebuilt.

1898 The gutters receive improvement from repair.

1905~1906 The first construction to raise the riverbanks takes place. At the height of 0.87 meters, weight of 6,670,000 tonnes, and financial cost of 16,751 Japanese yen, this was put into action. Moreover, a spillway was placed on the east side of *Gomadan* Rock, and dug drainage canals through tunnels.

1914 Kankou, the administrator of the Lake Manno Water Supply Association, suggested the use of Aichi Prefecture’s method of taking water from the lake. From this, a circular tower was built by the time the next administrator came.

1927~1930 The second construction began at the height of 1.5 meters, 7,800,000 tonnes, and financial cost of 428,000 Japanese yen. A tunnel is made from the Saita River, which is the sluice gate at the bottom of Noguchi Dam. An additional 1.5 meters was added to the tower. As an additional part to this construction, a “Lake Manno Road” was built.

1940~1959 The third construction to raise the riverbanks takes place. This time it was at the height of 6 meters, weight of 15,400,000 tonnes, and financial cost of 543,327,000 Japanese yen. The aqueduct in Ama River was constructed. A tunnel connecting the tower to Lake Manno was also built, at the length of 197 meters, height 1.5 meters, width 1.2 meters, and a rate of 4~5 tonnes flowing per second. This project continued for 16 years. During this, a sacred fire was lit along the bank to wish for the safety and completion of the construction. This

was based on Kuukai's actions, as he lit a sacred fire as well.

2.1.2.2. Specialties from the Past

Sanuki used to be well known for its sugar canes.

During the Edo period, Sanuki's sugar canes were a hit in the markets, as they were being experimented by Takamatsu feudal lord (5th generation) and Yoritaka Laikyou.

During the times of Yorihiro Laikyou, he promoted the cultivation of sugar canes after realizing that a third of the agricultural land being used is used for sugar canes.

However, the demand for sugar canes dropped when sugar from other countries started to get imported in large amounts.

This means that not a lot of sugar canes were being grown, and thus more of the land was used to grow rice. This also meant that more water was required, causing the demand for water to exponentially rise.

[*1] Sugar does not require as much water as rice does.

2.1.2.3 Droughts in the Past

The following will consist of factual information on the droughts that took place in the past and also the ways to take measure for any damages.

The years that drought came are below.

1870

1873

1876

1880

1883

1886

1890

1893

1894 Massive drought

1903 39-day dry weather from the end of July to the beginning of September

1904 35-day dry weather from the end of July to mid-August

The factors that caused the droughts during the Taisho age (1912~1926) were of

ruined trees and forests, decreased amount of stored water, and failure to restore the waters.

1913

1914

1917

1924 This drought causes massive damage in Manno Area, affecting 1,110 towns. The total loss in harvested rice was more than 2 million liters.

1940 As mentioned in the above, Kagawa prefecture had not been blessed with the ideal climate. All of the crops planted in the fields died, due to the lack of water supply. Farmers started to pump water from a well or hole dug out.

On July 23rd, the governor of Kagawa held a praying for water, and on August 3th, did another, this time with the entire prefecture participating for three days.

Damages that come from these droughts caused a 50 percent lower income in *Kami no Goh* Area, and 80 percent in Marugame City and South/Shirataka Village.

1973 “Takamatsu Desert”

The total amount of rain in June was only 83 millimeters. There was not rain from the 29th of June to the 30th of July, and clear skies dominated the weather of Kagawa for 31 days. The restriction fo water supply took place on July 13th, and another on the 21st from 9 A.M. to 5 P. M. As for the second one on July 13th, the people suffered from an 8-hour suspension of water. The worst one of all took place on August 1st, where water only flowed for 3 hours, from 5 A.M. to 8 A.M.

As a result, the plans for “Kagawa Water” were set into action quickly, resulting in the establishment of the drainage system. Kagawa water delivered water to the Sanuki Plains from Yoshino River (known as Shikoku Saburo). It ties the Tokushima Lake fields and the Kagawa Saita fields with an 8-kilometer aqueduct tunnel. This cuts through the Sanuki Mountains, however, due to the hard andesite in the mountain range, the construction was a difficult one. Furthermore, Ikeda Dam was constructed at the tip of the water intake region, its aim to efficiently draw water from the river.

The construction of Sameura Dam was also necessary, in order to raise the water levels of Yoshino River.

1994 Drought

As a result of water shortage affecting the people's lives and those of the agricultural society, farmers have come up with a way to use recycled agricultural water as usable water in households. It is known as the "Running Water" irrigation system, and was used in earlier times.

Along with this, the dredging of unused wells and the digging of one was done to increase the water supply. Actions like these and the purchasing of water lifting machinery lead to the debt of 1,287,600,000 Japanese yen in two months.

Rice growing, as a result of these farmers' efforts and blessings from Kagawa Water, has increased in production by 105 percent.

2005 Drought

Water shortage has become a serious problem only after rice planting was done. The bureau of waterworks has used the slogan "Taking countermeasures against water shortage without having to cut off any of the water supply". This was based on previous experience; water after being cut off becomes muddy, making it unusable and therefore wasted. Thus, the bureau promoted residents to take part in decompressing the water in their homes.

To (voluntarily) decompress, it means to adjust the water valve and to reduce the water supply by 10 to 20 percent of its normal value. Users will then be asked to close the water valve located in front of the water meter, and open it by rotating the knob twice. By doing this, users can conserve water without noticing the slight reduction of pressure in running water. If this is done, then 17 percent of the overall water supply will be saved. This equals to 22 thousand tonnes of precious water.

The plan was a success. This has allowed the 2005's water shortage to be overcomed without trouble, and was the reason for residents to feel no sense of crisis for water. When one of our team members went to Kagawa for homecoming, he

felt the same as well; there was no inconvenience as for the water supply.

However, the circumstances changed in the following year. The local media published an article with the heading “Decompression Continues, the Water Supply Does Not”. This means that the residents are still using running water with low pressure, even when it is not in a drought.

Consequently, the amount of water supplied to households continues to be reduced up to 10 percent, causing a low income for the workers in the bureau of waterworks.

In other words, the people had voluntarily took part of decompressing their water just for the sake of saving water during the drought. Since this did not make a change as much as it was thought to be, many started to believe that this should be how it is on a normal basis, causing the prevention of people turning on the valve again.

2.1.2.4. The objectives of the water supply

After the construction of Lake Manno by Hachibe Nishijima in 1631, the standards for managing the water supply were “___” and “precedents”.

Periodical water supply

Every year a *Hatsu-yuru-nuki* is done, 3 days before summer solstice (although today it is specified to June 13th). What this does is reconfirms that the water reaches the necessary areas needed in the agricultural fields.

Practices of the water bonds

It can be confirmed that under the topic of “precedents”, Lake Manno’s water supply system split into two regions: *Kami no Gou*, that can receive drainage from all five gutters, and *Shimo no Gou*, that can receive the water supply from three gutters.

The type of water distributed to the *Kami no Gou* at times of natural disaster is called a “water bond”.

On the topic of the restoration in the *Kan-ei* Period (1624~1645), many reasons can be used to

explain the formation of two completely different regions in Manno Area, but it is certain that ___ (who discussed about the restoration of the lake beforehand) was aware of the fact that Lake Manno is a dry region.

Special Practices

There is an area that has a large portion of the water supply, and is called "___".

Two theories can be used to explain why this area earned "special" water supply: One is because it is known to be the place where the people of Ikeuchi Village migrated to. Ikeuchi village was part of Hachibe Nishijima's, and ___.

Irrigation and incense sticks

At times where there were no watches yet, the amount of time it took for an incense stick to burn out signalled when to irrigate each rice field.

The *Hashiri-tsuki* and *Kiri-nagashi* Methods

The *hashiri-tsuki* method was used at times of serious drought. It simply is the process of irrigating with reusable water or the leftover water used to irrigate another field.

If the *hashiri-tsuki* method is not enough, then the *kiri-nagashi* method is put into action. The borders between the fields will be taken out, allowing the water to move freely between the rice fields.

At such times of serious drought, the village mayors would stand near watersheds to make sure that no one would steal water.

[*1] The water bond areas are in Kamino, Yoshino, Kotohira, Enai, Yojyou, Takashino, Zougoh, and Tarumi. For every time a water bond receives water, the village headsman would write an official bond for the headsman of ___. This is how the term "water bond" was made.

2.1.3. Measures taken today

Although the methods of irrigation and supplying water used in the Edo era were mentioned up to this point, the focus will shift to (1) the structural characteristics of Lake Manno

and (2) the methods being used today (Meiji era and after).

2.1.3.1. The structure of Lake Manno

2.1.3.1.1. Location

The river in which Lake Manno draws water from is called Kanakura River. It is a very short river, making up only 6 kilometers in the lake's upper stream. The slope of the river is gentle at an inclination of 2 percent.

When focused on the topography, it could be seen that the banks are not evenly lined. Despite this, however, it is the most efficient way to construct an arc-shaped levee, making Lake Mannou have the ideal dimensions.

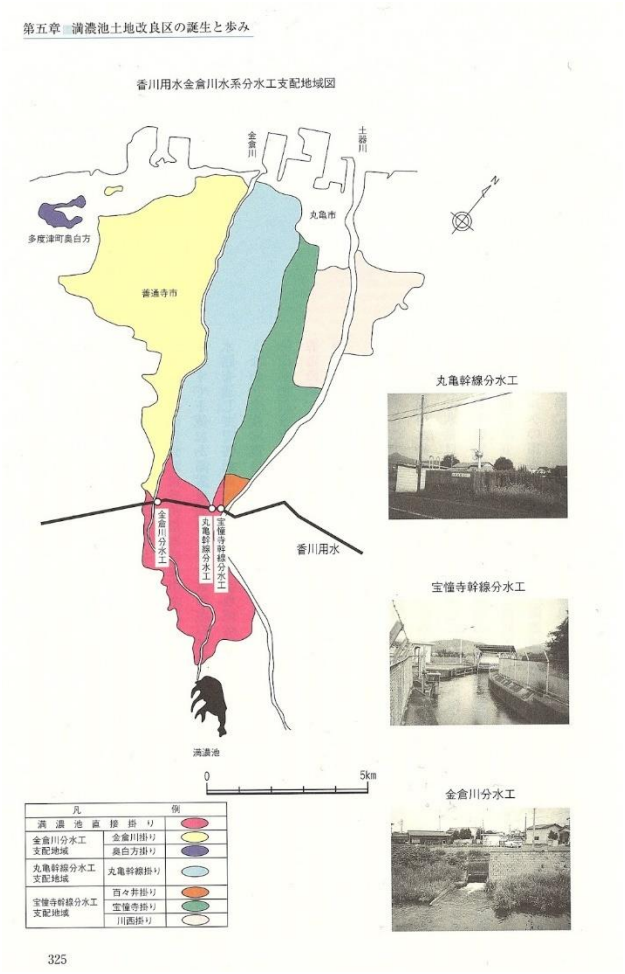


Fig. 42

The beneficiary area of Lake Manno can be seen below in this map.

2.1.3.1.2. Structure

In 821 Kuukai succeeded in creating a system where the water levels stayed at a constant value. By using the Tang's civil technology, he gave the arc-shaped banks the ability to equally split the water pressure, and made the walls sturdy enough to bear it.

Today, Lake Manno has a two layered bank; one is an old one and the other one was created during the second construction. The gutters were made by carving through the rock, and the pithead is in the shape of a pentagon.

It was inferred in 2012~2013 that despite its strong composition, an earthquake in Nankai Trough with a magnitude of 9 would sink the gutters by 40 centimeters.

2.1.3.2. Measures being taken today

Opened in 1974, Kagawa Water has enabled a steady distribution of water even at times of drought. This has allowed it to be safe to say that there is no more worries about having a shortage on water. Below are the details of the measures taken before the opening of Kagawa Water.

2.1.3.2.1. Lake Manno

Starting from the 1870s, water bonds created after the end of Meiji era (1912) did not consider the watchtowers as a source for determining water levels, but used an exact measurement of “6.97 meters above the bottom” to make sure that the water levels met the standards.

The areas of the water bonds were mentioned earlier (2.1.2.4. [*1]).

In order for the water bonds to start supplying water, a discussion with the Water Bond Distribution Committee must take place before doing so. The time and date for doing so will be discussed as well as the individual times for each village.

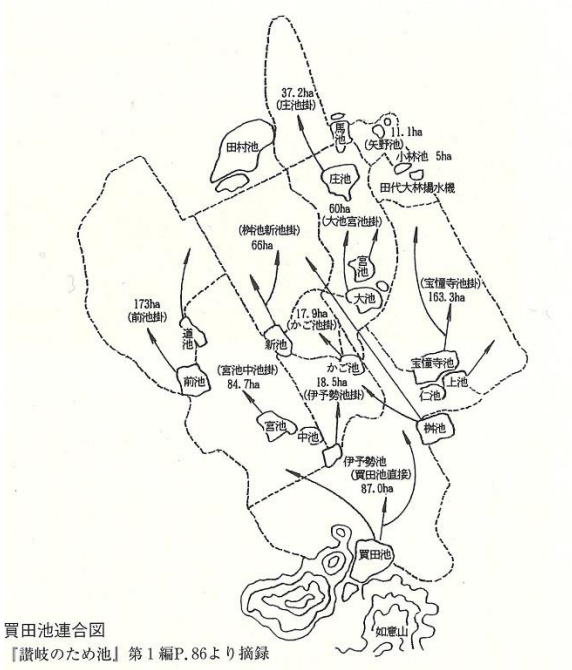
With the different irrigation systems being the standard for each village, the duration of water being supplied in each village will be decided, through sleepless days and nights. An additional hour to an hour and a half will be added to these times to allow a smooth shift between turning on and off the supply system. After this, the time frame for supplying water will be decoded. In this case, it will not be the standard amount of water being referred to in this decision, but the amount based on proportion and taxes. As for the cost of the water supply, it will be distributed according to the taxed-based proportions of each village.

If some water does not get used, it will be discussed in the committee on how to use it.

2.1.3.2.2. Lake Manno and its surrounding water systems

Under the umbrella of Lake Manno alone, there are 59 reservoirs, most of which are growing around the fan-shaped area in the Marugame Plains.

Out of the beneficiary areas of Lake Manno, there is one single reservoir in *Taremi* City that fits the criteria of being located in either *Kami no Gou* or the seven water bond areas.



買田池連合図
『讃岐のため池』第1編P.86より摘録

Fig. 43

However, there is a noticeable difference between the north and south side, as the northern side has more reservoirs than the southern side.

Although there is a “parent” lake, a “child” lake, and a “grandchild lake in the Kotohira Plains, the “child” lake is split up into 3: a lake that can (1) cover the loss for the irrigation water ahead of time, (2) finishes rice planting and (3) relies on everything.

Water purification practices

This is to preserve the amount of stored water, and is decided among those in the upper stream area and of the Water Supply Organization.

Watershed practices

This will include practices in each beneficiary area, and practices formed between “parent” and “child” lakes.

Water Supplying Practices

Following the word “program”, these practices supply water in the beneficiary areas until there is

confirmation that all of the water has been distributed.

2.2 Floods

2.2.1. Japan's geographical characteristics

As seen in the figure below, Japan is a region of high moisture content and high precipitation. The average amount of rain in a year (from 1976 to 2005) is 807 millimeters for the world average and 1,690 millimeters for Japan, which is nearly twice the amount.

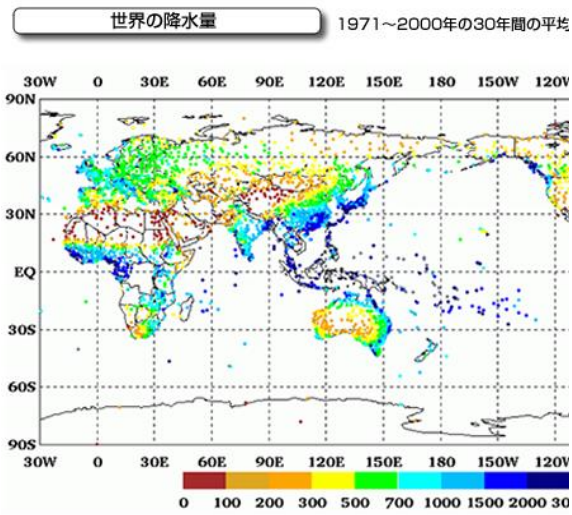


Fig. 44

However, due to the fact that 72.8 percent of Japanese land is mountains and that it reaches a height of 2000 meters to 3000 meters, the rivers run on a steep slope and are short in length. The size of the river basins are small as well.

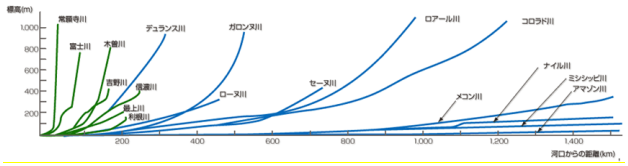


Fig. 45

For this, it is easy for a river to overflow at times of intense precipitation, causing floods. As a result, there is only a small amount of usable water sources.

Due to this, attention needs to be gained by the people so that they can help think of ways to save "unwanted water".

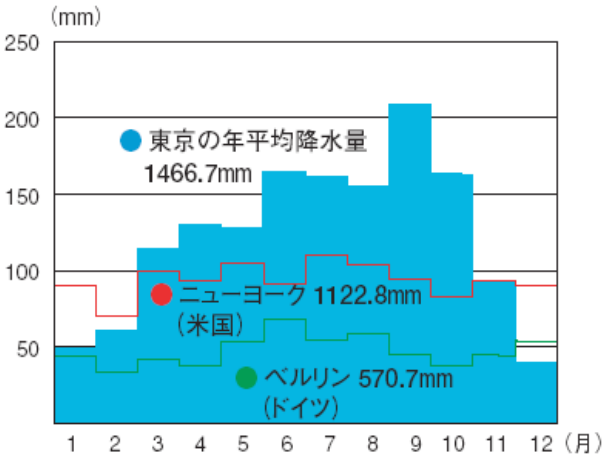


Fig. 46

In Japan, the “flood zones” make up 10 percent of the Japanese land, but is home to 50 percent of the population and an has 75 percent of property concentrated in the region. A majority of cities have a low elevation, making it vulnerable to natural disasters such as floods.

In addition, although the river system management has reduced the area of the “flood zones”, Japan has a larger amount of water at the times of flooding compared to other countries, and is severely affected by the financial and economic damage from these natural disasters.

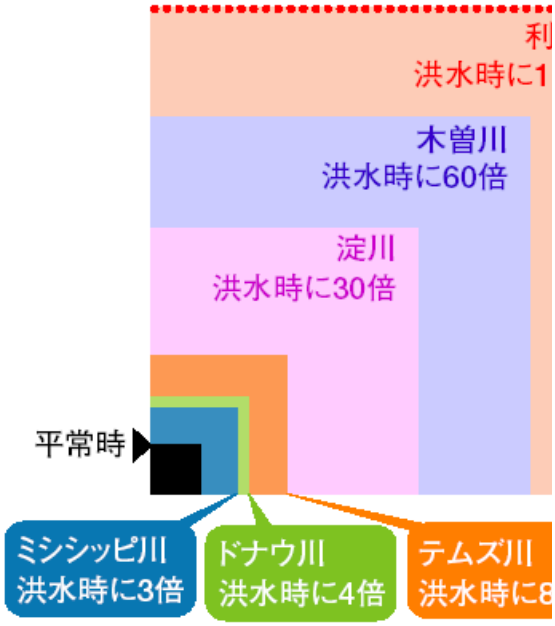


Fig. 47

In recent years, not only external flooding is affecting people, but so is internal flooding. External flooding is when water overflows from a river, while internal flooding is when it rains heavily on the streets that the city cannot take in it all due to its concrete streets.

Rivers rise at the times of heavy rain, and the middle/lower basins’ water levels rise. Due to this, the main river swells with water and flows into the city, the smaller rivers unable to stop it from flowing.

Below is a pie chart showing how much financial damage both internal and external floods cost.

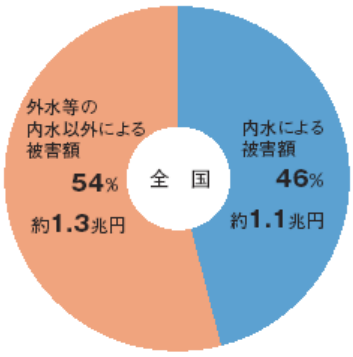


Fig. 48

2.2.2. Effective measures taken in the past

1742 The dog's flood: 2,800 dead

This was a massive flood that took place in the Chikuma and Sai Rivers. The cause of the heavy rain was a typhoon.

1885 Yodo River Flood: Flooded 71,000 homes, destroyed 15,000 homes, washed away 1,600 homes, and created 270,000 victims.

This flood took place from mid June to July, in Yodo River. Another name for this is the "Meiji Massive Flood". The banks were destroyed on purpose to allow more water to flow.

3. Proposals to Countries

3.1 Measures taken by geographical and climatic features (Developing countries)

Water-related disasters are happening all over the globe. Due to the fact that Japan is a vertically narrow strip of land, different countries will be able to find an area in Japan similar to that of their country, and find ways to take measures the same way.

3.1.1. Japan's climate

According to Köppen's Climate Classification, a majority is in either the warm continental climate or the warm oceanic climate. In places such as the summit of Mount Fuji, it is considered as a tundra climate. Moreover, according to the average from 1979 to 2000, Aomori Prefecture, the coastal side of Iwate Prefecture, and the coastal side of southern Hokkaido all have the West Coast Oceanic Climate distributed in their climate.

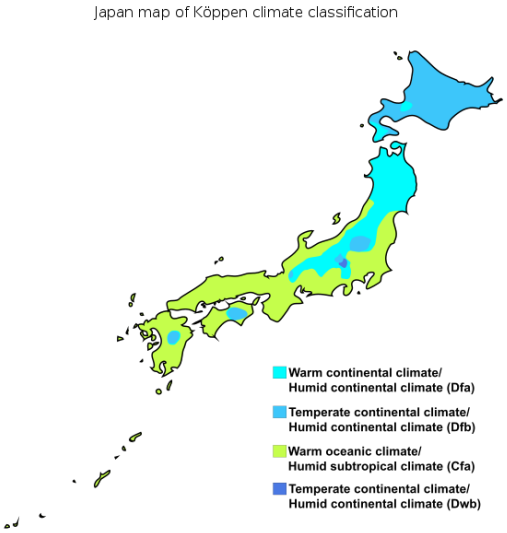


Fig. 49

However, these areas are somewhat too wide in area, and some areas may have inaccurate characteristics of their climate. To prevent this from happening, general information on the climate of Hokkaido, the Pacific, the Sea of Japan, the Central Highlands, the Seto Inland Area, and the Southwestern Islands, a total of six.

As for the climate in Hokkaido, it receives little precipitation and rarely experiences the typical rainy season in Japan. Summers are cool and winters are extremely cold.

The Pacific Area are vulnerable from typhoons, and thus can be considered as a highly precipitated area.

The Sea of Japan has a lot of rain in the winter, and as mentioned before, the Seto Inland Area does not.

The Central Highlands have a noticeable gap in the weather between summer and winter, and also between day and night.

In the islands of the southwest, there is a lot of precipitation.

Where the research was done in Lake Manno had a climate and geography that made it easy for a drought to occur.

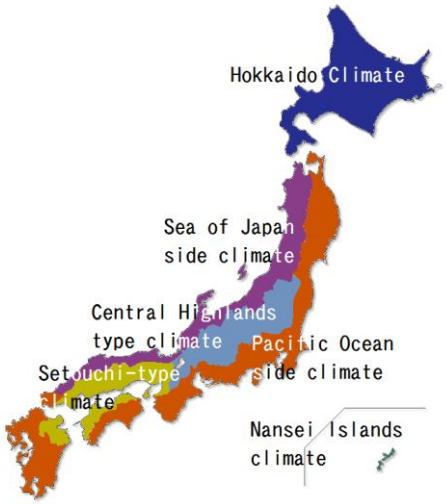


Fig. 50

3.1.2. World Climate

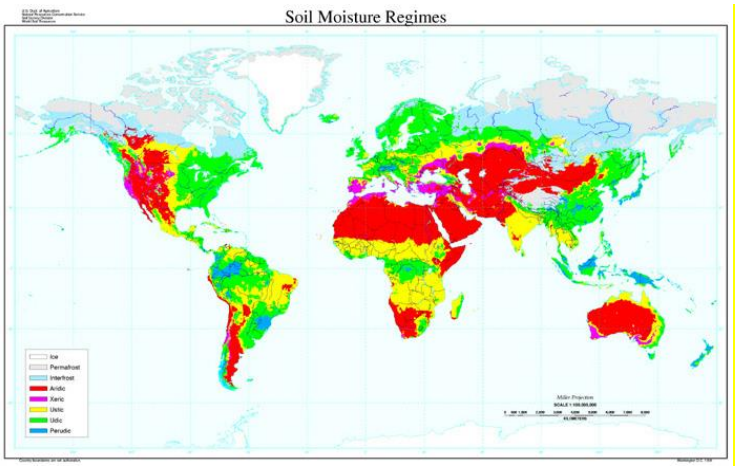


Fig. 51

The world's wet and dry regions are shown in the map above.

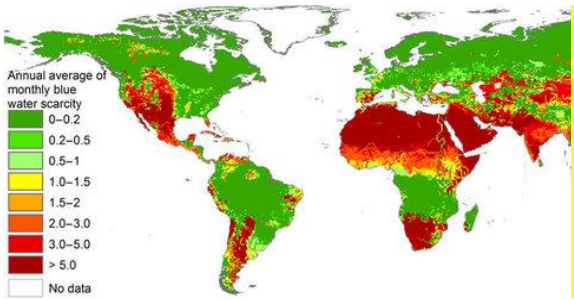


Fig. 52

When focused on both the regions with water shortages and with a dry climate, it can be seen that the two overlap.

However, in regions of dense population such as The People's Republic of China and India, it is in a state of water shortage although it does not have a dry climate.

Looking at the major rivers, it is normal to see no trouble in places with a source of water.

(Please turn over to see the map.)

Fig. 53

As one can interpret from the last section, dry climates are a result of the lack in rivers and precipitation. Therefore, a general suggestion for taking measures against it will be stated.

The reservoir itself is not something to be comprehended with the understanding of a dam. The main purpose of maintaining water with reservoirs is to combine with other water systems to create one unified system. As shown in the map below, Lake Manno has several reservoirs linked together. It allows the smaller ones to easily combine with each other by maintaining a "parent" "child" "grandchild" structure. Furthermore, by subdividing the areas of beneficiary needs, the ideal methods of transporting water can be put into reality.

Another point worth to think about is that there barely any reservoirs in the upper stream area, and that tools for pumping up water are not used. This means that the water is being supplied by using only the slope, making this process an efficient one as it does not use any electricity.

3.1.2.1. Dry Regions

The people who live in the Marugame Plains have a simple water storage facility in their homes.

Although the amount of rainfall may be constant year-round, it is recommended to introduce this system to other regions in the world that struggle from the shortage of water.

Sharing water from the main river: This is an applicable system to introduce to areas that have a large river nearby by lack in rainfall. Places such as Northern India, Los Angeles (U.S.), Yucatan Peninsula (Mexico), and the Republic of South Africa are too name a few.

Due to the fact that no more droughts occurred after the installation of Kagawa Water, not much about it was talked about during the interview.

Areas that are located in between the mountains often are affected by the shortage of water and floods (floods because depending on the mountain range, the rain clouds may be interfered with).

From these reasons, it can be said that the sharing of water from one main river is an effective method.

Since the main theme is the use paddy fields and how to supply them, the applicable countries are India, Myanmar, Vietnam, Thailand, and California State of the U.S. These countries all have paddy fields, but suffer from water-related natural disasters such as drought.

3.2. Solutions

With the similarity of having paddy fields but suffering from water shortages, countries such as India, Myanmar, Vietnam, Thailand, and California State of the U.S. can be given as an example.

Just like Lake Mannou, reservoirs can bring a lot of water into the region, because the system is intertwined with a network of rivers and streams.

However, there are disadvantages to this as well. Having too many networks increases the risk of being affected by a drought or a flood, because that reservoir itself is dependent on other sources.

3.2. To Preserve Water and Culture (Towards Developed Countries)

It is difficult to wrap the one's head around the idea of natural disasters that seem far away. Perhaps it is due to the fact that there was not an experience where such inconvenience has occurred.

However, now that the world is growing into one massive society, it is important to be able to sympathize with those who are suffering. It is also important to be able to lend a helping hand to them, for action is the next step towards a united world.

3.Using Water Efficiently

State of Developed Countries

The Idea of "Conserving Water" Being Misunderstood

Today, there are many home appliances that advertise their products as "water saving". This means that the machine/product will function without requiring as much water it usually needs. Air conditioners, toilets, and washing machines are to name a few. Many companies pursue the efficiency of their products with the fewest resources to create the ideal products for consumers, and thus more and more machines are created in this way today.

Conserving water may sound pleasant for both the consumers and companies. The price of water bills will get cheaper, which is appreciated by many people.

However, this will also mean that consumers will be able to use more of the machine without having to pay as much. This will cause the overuse of it, which is counterproductive to "saving water". These consumers may think that they are "saving water" when they actually are using more. They tend to be relieved that they are using less water than those who do not use these "water-saving" machines. But using water is still using water, so it makes the situation still the same or even worse.

As an effort to make environmental changes regarding water and water sources, a

number of prefectures in Japan have officially introduced home appliances that are "water-saving".

Disadvantages of Going Conservative

"Water-saving" may sound promising to consumers, because it will save them dollars from the expensive water bills. On the other hand though, this only is a start of a financial and economic crisis for the bureau of waterworks,.

As mentioned earlier, water saving machines will reduce the amount of water used in each household. This will cut the water bill to a lower price. However, this leads to a lower income for the bureau of waterworks, because not as much money will be paid from the people anymore. According to a worker at The Aikoku Water Purification Plant, this will make the bureau have no choice but to raise the price of the water bills, so it comes back to the citizens in the end.

This cause-and-effect situation has no end to it, because one factor causes the other. It is important to think in the shoes of those in each position for a unified solution.

What Developed Countries can do for Developing Countries, and What They are not Doing at the Moment

As mentioned earlier, there are many consequences to the use of water saving machines, as it causes many problems, mainly financial and economic. Clearly the developed countries are behind this. They believe that they are contributing to saving water by these "water-saving" technologies, but it may be counterproductive and cause the opposite effects.

What developed countries need is more knowledge on using water as minimum as possible. Not enough people realize that "water-saving" still uses a massive amount of water.

State of Developing Countries Public Health in Developing Countries

It may be rare for a normal citizen in a developed country to think about the status of those in developing countries. The truth is, there

are millions of people who are not as lucky as they are. Some have to walk several kilometers a day just to get a bucket full of water, but there is no guarantee that it is even safe to drink in the first place.

However, Japan, as it is a developed country, has a secure water system. According to a worker at Chiba Waterworks Bureau, the workers make sure that their water supply clearly meets and exceeds the water standards set by the government.

Suggestions on How to Use Water Efficiently and Effectively

Water is an indispensable resource for every single human being, which is purely the reason why there is a need to use it efficiently.

One way to use water efficiently is by using it for multiple purposes. For example, one can use used water from bathing for the laundry.

4. Conclusion

In addition to introducing the water facility equipment from Japan, it must be pointed out that the increasing awareness of conserving water is what is causing flammation in the waterworks systems of Japan. This is due to the decrease in the utilization of the bureau's services, the aging of the facility itself and the difficulty in the inheritance of skills by the next generation of works in the bureau.

There is a need to utilize the tax system and improve in raising awareness about such problems in order to solve it.

Hoping that there was an example in the past where improvements in raising awareness were present, research was done on the history of waterworks, specifically speaking of Lake Mannou.

Although only the historical events of Japan were mentioned, examination of the people's consciousness itself was done in order to present Japan's past and present as a case study.

In other words, confirmation of being conscious about the state of consciousness of the people was required in order to suggest change.

Below are the main suggestions for using water efficiently and effectively.

In order to use water efficiently, the construction of a network for supply water is needed, regardless of what country.

A mutual relationship between developed and developing countries needs to be established, in order for developed countries to donate usable equipment, and for developing countries to increase the number of human resources and to improve in their performances.

Here will be introduced the means and ends of the ODA, whose purpose is to share the same goals.

However, the true goal of taking part in development cooperation is not to fulfill one's individual desires, but to "invest in the future." The meaning of this consists of highly noble spirits.

However, in the real world, the amount one invests in depends on how much return they received in return. Even if there was no desire for a return in the first place, it would remind readers of the white supremacists and slavery being repeated again.

This was what made us interested in taking part in business affairs as reliable human resources, and we seek to establish it in the future as the water supply networks become connected and intertwining each other.

From the offering of usable equipment by developed countries, not only will it lead to a growth in human growth in developing countries, but it will benefit the developed countries' economy as well.

Such community is known as "The International Waterworks Network System / IWNS", and we highly suggest the construction of one, as there are high hopes of it leading to a brighter future for all.

5. Acknowledgements

We would like to show our deepest appreciation for having the opportunity to complete this paper on a topic we truly had interest in.

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We would also like to thank the Tokyo Waterworks Historical Museum for allowing us to expand our knowledge on the depths of waterworks.

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Last but not least, we would like to send our special thanks to Ms. Hosono, who has supported us in the making of this report, no matter how tough some of her days were.

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