

TO APPLY CIRCULAR ECONOMY ON POLLUTION REMEDIATION AND INTEGRATED MANAGEMENT IN DONGGANG RIVER BASIN, TAIWAN

Lu, Tai-Ying¹, Ting, Cheh-Shyh²

ABSTRACT

Donggang River has a total in length of ca.44 kilometers at Pingtung Plain, Taiwan. It is a typical water-flowing river with an average daily flow of 2.06 million m³. It provides water for daily supply of 300,000 to 350,000 m³ of Kaohsiung City. In the past ten years, nearly 74% of the animal husbandry pollution in the basin has caused serious water quality problems. Over the years, there has been no departmental integration mechanism and effective governance policies.

This study concerned about Kaoshiung- Pingtung water resources from the role of civil NGO and started to make progress over the governance with further analysis of Donggang River through several public and private meetings and discussions. After the discussion, a so called Circular economy model– an innovative multi-diverse solution have been formulated that converts pollution sources into resources and energy. In addition, lots of efforts were made efforts to enter to the six-year Forward-looking infrastructure water environment construction, starting in mid-2017. The project has been upgraded to the key management level of the Executive Yuan, and the case is to expected to solve the practical examples of sustainable development of water resources through technical, policy and social aspects.

From the perspective of policy-driven, this forum will demonstrate the Circular Economy Model solutions that have been proposed for many years of technological innovation, meanwhile to develop the governance of the integration of various departments. A model case for Taiwan's river pollution remediation was eventually established that simultaneously solves river pollution, creates renewable energy and resources. .

Keywords : watershed integration management , circular economy , river pollution remediation , renewable energy

1. INTRODUCTION

Pingtung County in Taiwan is a city dominated by traditional agriculture. Moreover, agricultural production relies mainly on animal husbandry, and there are a large number of farmers in the county who raise pigs, raise cattle and raise poultry. According to the "Number of Pigs Survey Report (2017.11)" issued by the Agricultural Committee of the Taiwan Executive Yuan, there are 1,710 pig farms in Pingtung County with 1,233,642 pigs, making it the second largest pig and animal husbandry county in Taiwan. For a long time, Pingtung animal husbandry is an important source of income for farmers. However, the smell of animal husbandry and the pollution of rivers have caused people's living environment to be very troubled and dissatisfied. The main reason is that livestock farmers use traditional simple sewage treatment and government regulations. The emission standards are very lenient (in the case of COD, the standard is 600ppm). Even so, the livestock and livestock households are

¹ Doctoral candidate of Civil Engineering Institute, National Pingtung University of Science and Technology, Taiwan. (no.3, Ln140, Tzu-li 2nd Rd, Kaohsiung, 80046 Taiwan(R.O.C)); E-mail: luty1961@gmail.com

² Dean of the College of Engineering, National Pingtung University of Science and Technology, Taiwan. (1, Shuefu Road, Neipu, Pingtung 91201, Taiwan (R.O.C)); E-mail: csting@mail.npust.edu.tw

still not operating due to the fact that most of the sewage treatment equipment has not been updated for 30 years or even to save electricity. Of course, the discharge of wastewater is unqualified and causes environmental damage. Pollution!

Donggang River is the most important river in Pingtung Plain. It has a total length of about 44 kilometers. The drainage area covers 17 townships in Pingtung County. Its drainage area is about 436 square kilometers. Because the river formation is very special, according to the Ministry of Economic Affairs, South of the Water Resources Department. District Water Resources Bureau "Discussion on the Development of Donggangxi Public Water Supply Source (2011)", Donggang River belongs to the river where the groundwater (including the undulating water) is filled with springs (such water sources account for nearly 90% of all water sources in the river), The water resources are abundant and the average daily flow is 2.06 million m³. Several decades ago, in order to solve the problem of industrial water use in the south, it was convenient to set up a river to collect water from the downstream of Donggang River to supply 300,000 to 350,000 m³ of industrial water per day in Kaohsiung City. However, nearly 74% of the animal husbandry pollution in the basin has caused the water quality pollution index (RPI) of the water quality in the past five years. The index between the downstream port west pumping station and the Xingshe Bridge station is higher than 5.0, and even more than 6.0. The degree of pollution is such that the backwater purification field must spend a lot of money and energy to treat the ammonia nitrogen in the raw water. However, it still often fails to meet the water quality standards.

In terms of pollution prevention, only the environmental protection department is deterred by inspection. However, there are many livestock and cattle (bovine) livestock and livestock households in the basin. According to the Taiwan Environmental Protection Agency's "Water Pollution Source Control Data Management System Data", the livestock industry information will be listed in November 2018. Pingtung There are 401 animal husbandry in the upstream of Gangxi water intake station in Donggangxi River Basin (there are 371 pig farmers and 30 cattle farmers), and the approved number of breeding heads is 430,085 (426,641 pigs and 3,444 cattle), plus There are 1,914 pigs and cattle breeding herds in the county, and less than 30 inspection personnel in environmental protection units. Even the annual total fine of animal husbandry is nearly 30 million, which is almost the highest in Taiwan. If there is no other such as the agricultural management department to counsel and By subsidizing animal husbandry and households, improving the equipment for sewage treatment and breeding of livestock houses from the source, in fact, it is impossible to achieve the pollution behavior of deterring the animal husbandry by inspection alone.

In December 2014, the author served as the environmental protection director of Pingtung County, and the former county magistrate actively promoted the change of livestock waste and excrement from energy-consuming treatment of pollutants into energy (biogas) and resources (fertilizer). Policies to improve animal husbandry pollution from the source, and Pingtung County has a large number of agricultural tree-cutting and rice-harvesting agricultural raw wastes that have not been properly utilized. Farmers have solved such agricultural uses in open burning. Tobacco causes a lot of air pollution and road driving dangers. At the same time, it is necessary to solve the problem of land acidification and food safety caused by the extensive use of chemical fertilizers and pesticides by Taiwan farmers. Therefore, it is promoted by policy research and is also an executive. It is proposed to change agriculture by agricultural circular economy model. The strategy of waste pollution; in addition, due to the complexity of the above-mentioned pollution control units, the non-EPA bureau can solve a single department. For many years, there is a lack of departmental integration mechanism and effective governance policies, and the integration of various departments is very important and trend. Trends, so this study also further proposes the departmental integration governance structure and division of labor. The Secretary-General of Pingtung County Government will promote the leadership. The

following will present research results on the implementation of various policies and results and follow-up review.

2. INNOVATIVE APPROACHES

This policy uses the concept of circular economy to transform the cycle of multiple pollution problems into a new sustainable green cycle.

This paper uses the innovative way promoted by circular economy, which is the dilemma caused by various pollution problems in Pingtung. It is transformed into a new sustainable green economy cycle as shown in the following figure.



Figure 1. Schematic diagram of the strategy of transforming agricultural problems and dilemmas into sustainable agriculture

2.1 Promote animal husbandry, urine, excreta energy (biogas) and resources (fertilizer)

Thirty years ago, Taiwan's animal husbandry and urine were all used as resources (pig excrement as farmland fertilizer). There is another saying in Taiwan: "If fertilizer does not enter the field, it means that the literati do not study." In 1991, Taiwan began to regulate livestock waste water, requiring more than 200 heads. The pig farm must be used as a wastewater treatment facility. However, this policy has been promoted for nearly 30 years. Although the livestock farmers have traditional simple sewage treatment and the government regulations are very relaxed (in the case of COD, the standard is 600ppm), the current situation of Taiwan's animal husbandry is mostly The three-stage treatment wastewater mode with solid-liquid separation, anaerobic (gas-to-gas) fermentation and aerobic treatment, the livestock and livestock households have not been updated for nearly 30 years due to the old sewage treatment equipment, and most of the equipment cannot effectively treat the sewage. Water meets emission standards, and the electricity cost is often higher due to aeration and aerobic treatment procedures. In order to save costs, the pollution of rivers is not properly treated, and it is difficult to completely improve the river water pollution. On the other hand, for the livestock industry, the application process for processing is too complicated, and it is difficult to encourage the industry to actively cooperate, resulting in the river water body still being seriously affected by its pollution.

Animal husbandry and feces are essentially high organic and nitrogenous substances. The water-soluble substances produced by anaerobic digestion of animal husbandry and urine are biogas slurry, and the solid products are biogas residue. Biogas slurry and biogas residue are rich in nutrients and fertilizers, which can improve the ability of plants to resist pests and diseases, and help crops absorb and increase yield. Farmers use biogas slurry and biogas residue as farmland fertilizers,

which can reduce the use of chemical fertilizers, promote organic agriculture, and save considerable fertilizer costs. There are many implementation cases abroad:

1. European and American countries such as the Netherlands, Sweden and other countries have used animal husbandry and urine for anaerobic fermentation and then applied it to farmland as a fertilizer. It has been used for decades, and pig farmers signed contracts with farmers.
2. The EU has to return to farmland for all livestock waste regulations.
3. The United Kingdom directly identifies anaerobic fermentation biogas slurry as a biological fertilizer, which can be commercially traded and become a valuable fertilizer.

This Council recommends to the Environmental Protection Agency (EPA) of the Executive Yuan to refer to foreign experience and promote the situation, the current situation of the animal husbandry industry, and consult experts and scholars and pig associations, cattle raising (stock farmers) association, and the EPA and the Agricultural Council of the Executive Yuan. As a result of the consultation, on November 24, 2015, the "Water Pollution Prevention Measures and Inspection Report Management Measures" was revised and issued, and 10 chapters of the "Biogas Slurry Farmland Fertilizer Use" chapter were set up to promote management. In addition, on October 28, 2016, the "Water Pollution Prevention Measures and Inspection Report Management Measures" will be re-established to expand the use of biogas slurry and biogas residue farmland fertilizers, simplify testing items and increase management flexibility, and expand participation. In the beginning of 2016, with the assistance of EPA funds, a three-year promotion plan began in Pingtung.

After 3-year promotion, besides conducting the publicity conference and giving advices to livestock farmers, Pingtung county government figures out some strategies, which are never carried out in Taiwan, to convince people join the policy and break through the predicament. Details as following contents.

A. Set up county counseling group for livestock farms

Pingtung county government set up a county counseling group consist of department of agriculture, environment protection bureau and environment consultants in 2017. The counseling group has give advices for 44 livestock farms by exploration on site including Sinpi Township, Wandan Township, Chaozhou Township, and there were 17 livestock farms had agree to join "Piggery Waste and Digestate as Farmland Fertilizer". The county counseling group will keep working in 2018 to help other livestock farms.

B. Exemplary Piggery Waste and Digestate irrigation

We have assisted to transport over 5,000 ton of Piggery Waste and Digestate for farmers in Pingtung county. Most of them said Piggery Waste and Digestate is good for crops and no other bad effect so far.

C. Cooperate with agricultural technology experts to conduct field trials

Due to the farmers had no confidence about the policy, Pingtung county government invited Y. H. Lin who is an associate professor in National Pingtung University of Science and Technology to conduct piggery waste and digestate as farmland fertilizer field trials like mango, guava, lotus, date, lemon, coffee, dragon fruit, betel nut, banana and so on.

The test results show that:

1. There is no obvious odor in the Piggery Waste and Digestate application process.
2. Continuously applied Piggery Waste and Digestate to crop, the nitrogen content of soil was increased significantly.

Professor Lin reminded farmers that the application of piggery waste and digestate has positive effects on both the plants and the soil, and no need to worry about Cu, Zn remain in plants and the soil.

However, piggery waste and digestate as farmland fertilizer may cause the problem about lack of phosphorus and potassium fertilizer during flowering and fruiting period, farmers should add properly.

D. Integrate government resources to increase allowance for livestock farmers
Pingtung county government has set up plenty of allowance for livestock and herdsmen to improve their wastewater treatment facilities every year.

Since 2017, water pollution fees imposition begins, we have integrated various resources, including EPA subsidies, water pollution funds and air pollution funds, to further increase the amount and number of allowances, to assist livestock farmers to improve and encourage them join "Piggery Waste and Digestate as Farmland Fertilizer" policy.

E. Combine On-site Wastewater treatment projects to promote "Piggery Waste and Digestate as Farmland Fertilizer"

Since the seriously pollution of Donggang River, Pingtung county government has designed several On-site Wastewater treatment Plants along the river. One of them was located in Long Ching river drain system, and we are planning to plant grasses on the high riverbank. It's another innovative idea to recycle livestock sewage.

2.2 Promote the conversion of agricultural raw waste after planting fruit tree pruning and rice harvesting into a biomass fuel plan

For a long time, farmers have planted fruit trees and harvested rice. The biomass branches and rice straws are used as waste and burned in the open air. Of course, the burned ash is rich in carbon and potassium fertilizer, which can be used as farmland base fertilizer. However, farmers will also mix other agricultural materials such as plastic sheets and other wastes into the open burning, which will cause very large environmental problems. In addition to seriously affecting air quality, smoke will also affect the driving of vehicles on the road. Safety. The Environmental Protection Agency plays the role of air pollution inspection. Because of the open burning, the annual fines are dozens of times higher than other counties and cities. Although the fines will cause deterrence, this is a poor economic peasant that has been developed for decades. Habits are difficult to change at one time but fines create a heavy burden of living. The Pingtung County government began to coach farmers ten years ago to smash agricultural waste leaves and waste straw stalks into small farms and then rot them as organic fertilizer for farmland. However, rice stalks that have been implemented in the past few years are more likely to be rotted and then enter the soil and become organic fertilizers. However, the branches of the fruit trees, even the huge branches that are destroyed by the typhoon and rain, are more difficult to treat. In addition, although the county government assisted in the formation of farmer cooperatives and fully subsidized small crushing machinery, the wages for the replacement of handling were also a burden for farmers.

The agricultural area of Pingtung County accounts for 1/4 of the total area, which is relatively large amount of agricultural waste. It is estimated by the species of fruit trees abundant in Pingtung County. The amount of discarded branches and leaves is as high as 120,000 metric tons, and the wooden branches produced by street tree pruning also exceed 3,000 tons. In order to solve the pollution problem related to wood waste in Pingtung, and at the same time transform waste into renewable resources and create economic value, Pingtung County Environmental Protection Bureau began to use this waste wood as a material at the end of 2015, and integrate and recycle resources, and divide it into two. At the same stage, the cycle of "resources→pollution products→renewable resources→economics" is achieved to realize the development of circular economy.

A. The first stage: firstly, the Pingtung County Environmental Protection Bureau will firstly dismantle the abandoned plant after the typhoon has been crushed, and re-activate the plant rental by private investment and the introduction of newer

equipment, and free of charge by subsidizing the township resources. For the farmers, the pruned waste branches of the fruit trees that cannot be broken in place are transported to the centralized plant for treatment. After screening, drying and crushing, they are pressed into biomass pellet fuel rods (RDF-5), which are provided near the industrial area. The factory that used heavy oil as fuel was used as a boiler alternative fuel, and actively set up the next stage to generate electricity by cogeneration.

B. The second stage: since the first stage of the production of agricultural waste fuel rods is cheaper than the original use of heavy oil and effectively reduce air pollution, the cost of transportation is higher, which offsets its economic benefits. In the second phase, the development of biogas fuel is generated by gasification and cracking. The remaining products of biochar and wood vinegar are used for commercial value. The EPA counseling manufacturers began to invest in the first stage. The plant uses a gasification cracking method to treat the biomass waste facility, which also processes the cattle dung that is plagued by farmers. After one year of preparation time. In December 2018, a gas-fired power plant capable of processing 6-8 tons of agricultural waste per day, continuous operation gasification cracking furnace and 100KW operation for 24 hours was completed.

2.3 Integrated Management Plan with Donggang Creek Governance as the Target

The above strategy of the agricultural circular economy model involves multiple departments at the central and local levels, and there is a real need for integration in governance. After all, the proposed project is the local county and city environmental protection bureau, but many of the rights involved in agriculture, land management, urban and rural development and even water conservancy units.

In mid-2015, the Department proposed the "2030 Donggang River Vision Project", which takes into account the overall consideration of river water quality, water volume and waterfront living environment, and the above-mentioned circular economy model. And can establish a policy communication platform with the Donggangxi authorities, the Central Water Resources Department (WRA) Seven Rivers Bureau.

In May 2016, the central government changed. The new government proposed the "National Prospective Basic Plan" including major transportation, green energy, digital, water conservancy and environment in early 2017. The Pingtung County Government will "the vision of Donggang River in 2030". The plan was submitted for approval by the central government after half a year of review. As a demonstration project for water and environment, it was led by the Administrative Council of the Executive Yuan to establish a platform for promotion, including the Agriculture Committee, the Water Resources Department, the Construction Department, the Environmental Protection Agency and the Taiwan Sugar Company. For many units, every 1~2 months of the platform meeting is reviewed and managed in a "rolling-style" manner. This management model is more special and rare in today's government system.

3. RESULTS AND DISCUSSION

3.1 Promote animal husbandry, urine, excreta energy (biogas) and resources (fertilizer)

A. Winning deeds in these years

In 2017, we reported "Promotion of Piggery Waste and Digestate as Farmland Fertilizer in Pingtung County" to participate the "Standard Learning program" handled by the Executive Office of the Personnel Administration of the Executive Yuan and finally get a Honorable Mention (only 3 places).

Additionally, the yearly assessment about water, soil and groundwater pollutant by EPA, we also win the ranking of excellent in recent years.

B. Promotion results so far

As of May, 2018, Pingtung has promoted 123 livestock farms to participate "Piggery Waste and Digestate as Farmland Fertilizer" policy.

We can reduce more than 600,000 tons of livestock excrement (about 82,000 pig manure and urine) go into the river each year.

The improvement of water quality has gradually yielded results. For example, Donggang River, its proportion of serious pollution decreased from 15.6% (104 years) to 5.3% (106 years); the proportion of unsightly (slightly) pollution increased from 16.8% (104 years) to 42.0% (106 years).

Additionally, gang-shi pumping station, one of the EPA's key monitoring station, was also decommissioned in 2018 due to improved water quality (from severe to moderate).

The Pingtung County Government will continue to cooperate with the central government policy to promote "Piggery Waste and Digestate as Farmland Fertilizer" policy, which will contribute to the policy goal of reducing water pollution.

3.2 Promote the conversion of agricultural raw waste after planting fruit tree pruning and rice harvesting into a biomass fuel plan

A. After using the RDF in the Pingtung Plant, the largest soy sauce company in Taiwan, near the EPA, compared with the original heavy oil fuel reduction benefit analysis, one metric ton of heavy oil fuel can generate 10,000 tons of combustion heat for about 435 US dollars, compared with RDF. RDF sells about US\$75 a ton, which can produce about 4,500 tons of combustion heat. If you need to achieve the same combustion heat, you need about 2 tons of RDF, which can save 170 US dollars compared with the original cost. Wanjiayang Sauce Co., Ltd. In the second quarter of 2016, the East Plant switched to RDF as fuel, and the reductions compared with the plant's second season 2015 air pollution fee declaration are as follows:

SOx is reduced by about 1404 kg and is estimated to be reduced by 5.617 metric tons per year.

year	SOx emission factor (kg/m ³ , metric tonnes)	Sulphur content of fuel	SOx emission concentration (ppm)	SOx emission standards (ppm)	SOx emissions (Kg)
2015 Q2	14.284	0.5	186	300	1406.97
2016 Q2	0.018	0	2	300	2.82

NOx reduced by approximately 748 kg, estimated to be reduced by 2.99 metric tons per year

year	NOx emission factor (kg/m ³ , metric tonnes)	Nox emission concentration (ppm)	Nox emission standards (ppm)	NOx emissions (Kg)
2015 Q2	4.447	159	250	876.06
2016 Q2	0.821	132	350	128.49

Granular contaminants are also reduced by about 222 kg in a single quarter, with an estimated reduction of 0.888 metric tons per year, due to the addition of cyclone and bag dust collector after 105 years of conversion to RDF.

year	Particulate matter emission factor (kg/m ³ , metric tonnes)	Concentration of granular emissions (mg/Nm ³)	Particulate matter emission standards (mg/Nm ³)	Particulate matter emissions (kg)
2015 Q2	1.129	83	100	222.41
2016 Q2	0.004	2	50	0.63

Table 1. RDF is fuel, compared with the reduction of air pollution fee declared by heavy oil in the original factory

B. Data analysis of 100kw gasifier power generation system: treated fuel rods, water content below 20%, one Kg compacted raw material can generate 1Kwh, produce about 2 m³ of gas, and the purified calorific value per cubic gas is about 1200 Kcal. The composition of the combustible gas is as large as CH₄, H₂, ethylene and CO. In terms of mass balance, the fuel is vaporized to produce about 0.15 Kg of biochar,

about 0.15 Kg of tar, and the combustible gas is condensed to produce a little low concentration of acetic acid. Water, the rest is a crude pyrolysis component. The pyrolysis gasification temperature is about 950~1000 °C, the NO_x is below 100ppm after cooling and purifying, the SO_x is below 15ppm, the particle size is about 2~3, and the system thermal efficiency is about 75%. The system can be used for power generation alone or simply docking. Tons of boilers, heat and power cogeneration equipment transfer energy utilization: about 1000 degrees of electricity per ton of compacted wood raw materials, 120 ~ 150 kg of carbon, and produce 5 to 6 tons of industrial steam.



Figure 2. 100KW biomass gas power generation equipment

3.3 Integrated Management Plan with Donggang Creek Governance as the Target

The integration of Donggangxi is not only established by the Central Administrative Council, but also by the Secretariat. The local government also has a platform for the integration of the bureaus. The meeting is held every two weeks and is also managed in a "rolling" manner. Through a unified advisory group that combines the folk think tanks with the "Donggang River Governance Project Office", we will strive for relevant supporting programs to achieve mutual governance goals.

In addition, through the meetings convened by the councillors, many of the restrictions of the laws and regulations were successfully resolved. For example, farmers changed to biogas slurry and slag irrigation. However, in addition to the EPA's amendments to the laws and regulations, the agricultural committee's decree did not even The Water Resources Department also imposed restrictions on the irrigation of biogas slurry and biogas residue in the high beaches of the river. Through this platform, the restrictions of the law are resolved smoothly and quickly. In addition, in the land use law, many equipments such as gasifier equipment and animal husbandry and excreta are restricted on agricultural land, and because of the communication and modification of this platform, the Agriculture Committee passed the relaxation of "Law of animal waste and agricultural waste recycling" in March 2018. A number of laws and regulations that hinder the recycling of the circular economy have been overcome.

4. CONCLUSION and VISION

After three years of promotion to solve the pollution of rivers with circular economy, and combined with the platform of integrated management, we have successfully achieved the goal of recycling pollutants to convert raw pollutants into resources and energy, and the policy of reusing natural biogas slurry, from Pingtung. At the beginning, it has been promoted in various counties and cities in Taiwan. However, although Pingtung has promoted 123 livestock farms to participate in the policy of "pig waste and digestive juice as farmland fertilizer", it can reduce more than 600,000 tons of livestock waste per year (about 82,000). Head pig manure and urine) enter the river, and it also reduces the problem of farmers extracting groundwater and river pollution. However, 123 livestock farms are only less than 1/10 of Pingtung pigs. Therefore, the Pingtung County Government is still working with the Central Environmental Protection Agency to promote the simplified application process, and the Agricultural Committee has included biogas slurry and biogas into the organic fertilizer subsidy program to increase incentives!

In 2016, the inauguration speech of Taiwan's new president specifically stated that the goal of its administration is to actively promote the transformation of waste into a recycling economy of resource and energy. However, in the past three years, the central government has not been in charge of the leading ministry of circular economy, and the circular economy is correct. The road still needs to continue to work hard to achieve the ultimate goal of "cradle to cradle" zero waste.

REFERENCES

1. e River Knowledge Service Network. (2018). Southern River - Donggang Stream. Captured from the Ministry of Economic Affairs: <https://e-river.wra.gov.tw/System/NewArticle/DealData.aspx?s=0DF149D4324492FC&index=0C264F9F23F430F0&sm=C5C02B9403FF0A61>
2. Pingtung County Government Environmental Protection Bureau. (2013). Survey and Analysis Report on "Dangerous Water Quality Survey and Interception Commissioning Feasibility Assessment and Planning and Design Technical Services of the Donggang River Basin". Pingtung County Government
3. Pingtung County Government Agriculture Department. (2017). Livestock Ranch Registered Farmers' Register. Pingtung County Government
4. Pingtung County Government Environmental Protection Bureau. (2018). Donggang Creek Sewage Information Statistics. Pingtung County Government
5. Pingtung County Government Environmental Protection Bureau. (2017). Linluoxi Drainage Water Environment Improvement Project. Pingtung County Government.
6. Pingtung County Government Environmental Protection Bureau. (2018). Donggang Xixing Huayu Drainage Water Purification Project. Pingtung County Government.
7. Pingtung County Government Environmental Protection Bureau. (2018). Longjingxi Wanyu Drainage Water Purification Project. Pingtung County Government.
8. Farmland Water Resources Department. (2016). Agricultural Water Resources Maintenance and Sustainable Use. Executive Yuan Agricultural Committee. Extracted from the Executive Yuan Agricultural Committee: <https://www.coa.gov.tw/ws.php?id=2505425>
9. The Seventh River Bureau of the Ministry of Economic Affairs of the Ministry of Economic Affairs. (2008). Donggang Creek Renovation Outline (Revision Plan)

Planning - Water Quality Improvement. Ministry of Economic Affairs Water Resources Department

10. The Seventh River Bureau of the Water Resources Department of the Ministry of Sports. (2018). Introduction to the Donggang River Water System. Extracted from the Seventh River Bureau of the Water Resources Department: <http://www.wra07.gov.tw/12594/12595/12602/12605/17105/>
11. Water Resources Department of the Ministry of Economic Affairs, Southern District Water Resources Bureau. (2016). Development of the overall water resources utilization strategy of the Donggang River Basin. Ministry of Economic Affairs Water Resources Department
12. Department of Water Resources, Ministry of Economic Affairs. (2018). Prospective Infrastructure Design and Planning – Water Environment Improvement National Water Environment Improvement Plan (Approved). Ministry of Economic Affairs Water Resources Department
13. The Environmental Protection Agency of the Executive Yuan. (2018). The 107-year Donggang River Basin River Pollution Index (RPI). Extracted from the National Water Quality Monitoring Information Network: <https://wq.epa.gov.tw/Code/AdvSearch.aspx?PageID=5&Water=River&Area=1740&Station=>