

# *FIELD STUDY IN MIYAKO ISLAND*

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**JDS Program**

**Graduate School of Life and Environmental Sciences**

**University of Tsukuba**

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### ❖ Group information

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- Topic: Sub-tropical Ecosystem Biomass
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### ❖ Report structure

It will be divided into 3 parts:

- Part I: General information about Miyako Island
- Part II: Interesting points following the visited schedule
- Part III: Sub-tropical Ecosystem Biomass in Miyako Island

# Chapter-I

## Eco-Design Island

### I. Overview of eco-model city in Miyako island

#### 1. General information

Miyakojima is the largest and the most populous island among the islands of Okinawa Prefecture, Japan. It lies approximately 400 kilometers east of Taiwan, China and 303 km southwest from the city of Naha on the Okinawa mainland. The local Miyako language, one of several Ryukyuan languages, is spoken here. The land is mostly flat; having no high mountains or rivers, and the island consists of exposed coral reef and Ryūkyū limestone filled by sandstone and clay. The climate of Miyakojima island is that of a subtropical zone with an annual average temperature of 23.3°C, annual average rainfall of 2000 mm, annual average humidity of 79% and during the summer season (particularly the rainy season it is almost 100%).

*Figure 1: Map of Miyako island*



*Figure 2: Maehama beach*



Source: <http://www.okinawa-information.com/>

The population of Miyako island is about 55000, but the latest data shows that it has been decreasing and now has a population of 52000. The island area is about 205 km<sup>2</sup>, but the coastal line of this island is almost 100 km. It is suitable for sporting events such as marathons, cycling races, and triathlons etc.

The major industries of this island are agriculture and tourism. The main crops are sugar cane, tobacco, and mangoes. The sugar cane is the main product of Miyako's agriculture. 40% of Okinawa's sugar products come from Miyako Island. They also cultivate some other crops for the greenhouse system. Miyakojima is well-known for its beauty which attracts a great number of visitors to the island every year to visit the white sandy beaches, emerald green and cobalt blue sea, wonderful nature, and top rated SCUBA diving spots with many coral reefs. Miyakojima welcomes as many as 400,000 tourists annually. However, this year, the number of tourists decreased due to earthquake of March 11<sup>th</sup>.

*Figure 3: A cycling race around Miyako island*



Source: <http://www.kantei.go.jp>

## **2. Some limitations of the island**

Miyakojima is a sub-tropical, low and flat island surrounded by the sea and evolved from ancient coral reefs. The island exists in harsh natural conditions, and is very vulnerable to typhoons and droughts. The islander's lifestyle and economic activities must change to adapt to the impacts caused by natural disasters like typhoons. Typhoons are also the reason why the sugarcane is the main plant grown in the island.

Moreover, Miyakojima is very remote from the main island Okinawa. Therefore, the island depends much upon supplies of food and energy from the outside.

The local economy is stagnating due to a decrease in population. One of the biggest reasons is that the city has no university. After age eighteen, all young people have no choice but to leave the island for further education. Although, some young people want to come back, there are few job opportunities on the island.

### **3. Process to become an eco-island**

Miyakojima has been designated as one of the future generation Energy Parks by the Japanese government. "Next-Generation Energy Parks" aim to promote public understanding of next-generation energy being used in harmony with the global environment. For that purpose, solar power and other new-energy consuming facilities will be set up in the Next-Generation Energy Parks to increase opportunities for the public to have first-hand experience of next-generation energy, including new energy.

In 2008, the Miyakojima city declared the "Eco-island Miyakojima Declaration" regarding the island which will state their intentions to stay permanently. After the Eco Island declaration in 2009, Miyakojima city was designated as one of the Environmental Model Cities. The target is to reduce CO<sub>2</sub> emissions compared with the 2003 guideline of 30% in 2030 and 70% in 2050. The plans for emission reduction focus on an energy policy implemented mainly in the sectors of transportation and households, because they recorded the highest emissions. As a result, one of the main targets of the environmental model city is to establish a low carbon type eco-island which consists of three main components: Self sufficient energy using sugarcane, CO<sub>2</sub>-free projects in the transportation sector, and other Eco-actions.

## **II. Miyako- an eco island**

### **1. Concept of eco-island and declaration of eco-island city**

"Eco Island is a broad based strategy for improving the social, economic and environmental sustainability of the island. The strategy will build stronger, healthier communities with more opportunities for people to be involved in the local life" (Isle of Wight Council, 2008).

To limit the increase of material affluence on the island' soil, groundwater, and marine resources, the island made the "Declaration of an Eco-island Miyakojima" in 2008 to preserve its nature and environment.

#### Declaration of the Eco-Island Miyakojima (March 31, 2008)

- ☐ We will protect our precious ground water which supports the island's life.
- ☐ We will protect our beautiful coral reefs and the sea.
- ☐ We will conserve our limited resources and energy by using our wisdom and creativity.
- ☐ We will act individually, aiming to make Miyakojima beautiful, tidy, and earth friendly.
- ☐ We will think and act together with the peoples of the world to preserve and protect our environment and pass it on to future generations.
- ☐ We will protect our forests, sea, and air and act to make an environment in which all living things can co-exist.

(Situation of Miyakojima city, 2008)

## **2. Self-sufficient energy supply with the use of sugar canes**

The natural resources on this small island are limited. Therefore, to meet the power demands, it is required to utilize other alternative renewable energies.

The most important crop on the island is sugar cane which is the source of material for power generation and fuel from bagasse and bio-ethanol, by making much of it from the remnants after the process of sugar manufacturing.

Ethanol produced from sugarcane provides energy that is renewable and less carbon intensive than oil. Bioethanol reduces air pollution thanks to its cleaner emissions, and also contributes to mitigate global warming by reducing greenhouse gas emissions. The byproduct of sugarcane production (bagasse) is used to produce heat and power and at a very competitive price. Power generation facilities on the island, which are dependent on fossil fuels are being converted into a biomass generation system that uses bagasse, which reduces emissions and guarantees a steady energy supply. Bagasse is one of the untapped biomass sources. Bagasse is sugarcane trash, which is converted into energy and fertilizer using a carbonization plant and gasification plant and a high-speed composting plant. It helps to reduce the volume of CO<sub>2</sub> emissions, and improve soil fertility and preserve the quality of the underground water and soil.



The Miyakojima “Bio-ethanol Island” project is planned through the cooperation of the Cabinet Office, the Ministry of Agriculture, Forestry and Fisheries, the Ministry of Economy, Trade and Industry, the Ministry of land, Infrastructure and Transport, the Ministry of the Environment, and the Fire and Disaster Management Agency. The project aims to form a low carbon social system of recycled sugar cane to make the island’s industry more active and by transforming sugar cane used in sugar making into a value-added product.

*Figure 4: A sugarcane field in Miyako island*



Currently, E3 and E10 (a 3% and 10% ethanol mixture) are being produced and they are planning to produce E100 for a new generation vehicle. E3 is mainly sold on Miyako Island, but the production of E10 is less popular. There are about 25-26 eco-taxi on Miyako island. The expansion of “eco-cars” use in the near future can contribute to reducing carbon dioxide emissions. They are planning to introduce electric vehicles and charging devices widely. However, at present, only one charging station for eco-cars has been built in Miyakojima city. Further infrastructure required for eco-cars, including bio-ethanol-powered vehicles and plug-in hybrids, is very necessary.

*Figure 5: Eco-taxi in the city*



In addition, waste edible oils are used for producing biodiesel fuel and the city is also working to develop a system for collecting used cooking oil and expand its use as a fuel for garbage trucks and other vehicles. Biodiesel is a clean, renewable fuel made from used cooking oil. Benefits of biodiesel fuels are the effective utilization of waste oil, along with being environmentally friendly. It is harmless not only to the air, also to the soil, water, and the human body.

### **3. CO<sub>2</sub>-free project, depending upon clean energies**

The electric power of most small islands rely on diesel engine generators. However, Miyako Island is currently running test installations using wind mills and solar panel generators. In order to establish a CO<sub>2</sub> –free system with clean energy, they have cooperated with the Okinawa Electric power Co.,Inc and Okinawa New Energy Development Co.Inc to develop large-scale renewable energy power plants, and to combine those facilities with storage batteries to facilitate a stable supply of renewable energy. Solar and wind powers are also renewable energies. Renewable energy is not subject to sharp price changes because it comes from sources such as sunshine, flowing water, wind, and biological waste, all of which are freely available. This gives people a greater certainty about the cost of energy, which is good for both society and the economy. Additionally, they prevent global warming as a clean, safe source of electricity.



Within Okinawa EPCO's Miyako Island Micro-grid demonstration project, solar power generation facilities are introduced on a large scale as an independent system on the remote island. The Toshiba group was the overall EPC (Engineering Procurement Construction) contractor for this project and completed this project in October 2010. The objectives of the project are to utilize renewable energy sources such as PV power (photovoltaic) and wind power, to evaluate the influence on the electricity grid from renewable energy sources and to demonstrate the stabilization methods on the electricity grid using renewable energy sources to charge and discharge the batteries.



*Figure 6: Wind-powered turbine, Karimata Wind Power Demonstration Facility*

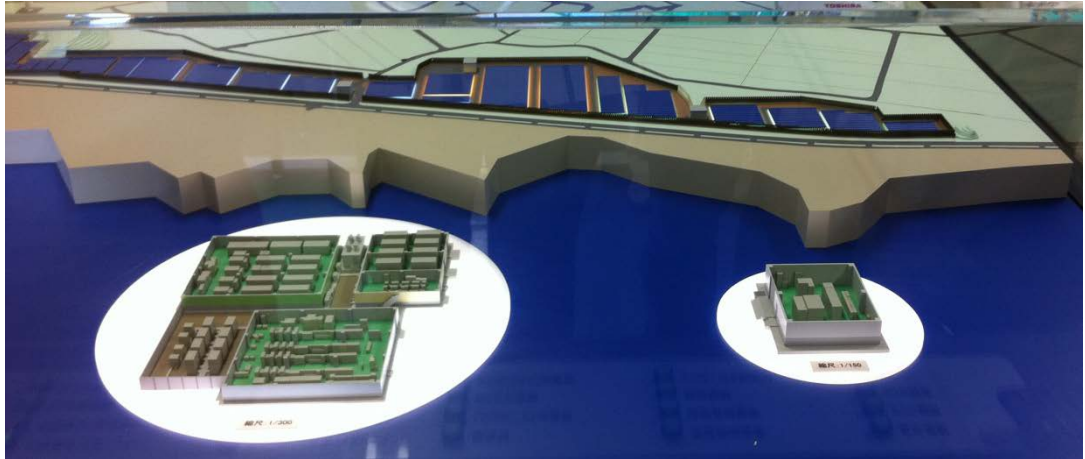
Solar and wind power stations are concentrated in the Karimata and Fukusato areas on Miyako Island. There are a total of 5 wind-powered turbines on the remote island. Three of them are located at the Karimata Wind power station in the Karimata area. Two others exist at the Sadefune wind power station in the Fukusata area. The Miyako Island Mega-Solar Demonstration Research Facility is also located in the Fukusato area.

The total electrical demand of the island is 50MW (50,000kW). The capacity of existing solar and wind power generation facilities on Miyakojima are 4000kW and 4200kW, respectively. The storage batteries are (NAS- sodium-sulfur battery) 4000kW, (LiB) 200kW for wind power generation and (NAS) 4000kW, (LiB- lithium-ion battery) 100kW for solar power generation.

*Figure 7: Solar panels in Fukusata area*



*Figure 8: Miyako Island Mega-Solar Demonstration Research Facility*



The island has natural gas resources that are also a cheap and clean source of power compared with fossil fuels. Nowadays, due to climate change, humanity has started to pay attention to producing and selecting cheap and clean power supplies. The city is, therefore, seeking to improve its energy self-sufficiency by developing natural gas as well as tidal and wave power generation facilities.

#### **4. Eco-actions in Miyako Island**

Miyakojima city pledges to build a concrete image of a low-carbon society. With its attractive blue ocean, the city has become a sight-seeing location visited by around 400 thousand people per year, while the city population is only 50 thousand. Like many other

cities in the inevitable development trend, Miyako faces an increasing consumption demand and dependence on resources outside the city. Thus, the city announced the “Eco-island Miyakojima Declaration” in 2008 for the island, which will provide its residents a convenient and sustainable life. One important component in developing a low carbon type eco-island is implementation of eco-actions including awareness raising for all island residents, design of sub-tropical eco-houses, and the continuous development of eco-tourism which is the biggest industry of Miyako island.

There are around 20 Eco-model houses established in 20 municipalities in Japan, which is consider the specific local situations such as weather and the terrain of each city in the Eco-house model project by the Ministry of Environment. Miyako has introduced sub-tropical eco-houses with air-conditioning and hot water systems that take advantage of the natural conditions of the island. In particular, eco-houses in Miyakojima are designed with grid doors to protect them from typhoons and to avoid flying objects from them. These houses save energy because they receive natural energies at a maximum level. Moreover, the eco-house is also designed to reduce humidity and reduce heat through walls and thick roofs. It can be said that Eco-houses are a combination of the traditional house designs in Miyako and modern technology to take advantage of natural energies. Tourists, who have opportunities to stay in an eco-house, will get to experience an energy saving and environmentally friendly house.

*Figure 9: Two Eco-house types in Miyako*



Environmental education and awareness raising for island residents are also of great importance to the sustainable development of the island. Therefore, the island authorities decided to focus on awareness raising activities for all the island’s citizens ranging from school children to old people. Special lectures on environmental protection and a green lifestyle have been given to kids and school students who will



educate their own parents and relatives. This will help to increase the consciousness and knowledge of all citizens about clean energy, environmental responsibility, and energy savings...etc. Moreover, not only the residents, but also the tourists who visit the island for sight-seeing or sports activities are also the objects of environmental education through the integration of environmental communication into cultural and sport activities. Apart from issuing leaflets and posters about the island's environmental protection activities, Miyako develops eco-networks that enhances the cooperation between local residents and visitors to facilitate eco-activities. For example, planting mangroves by both local people and baseball players. The Miyako Island Strongman Triathlon, a marathon and a bicycle race are very famous sporting events that provide a good opportunity for players and tourists to directly join environmental protection activities on the island. There are also musical events intergrating the environmental protection idea into music. The "Kagisuma donation box" is also an idea to ensure funding for environmental protection and the forestation program on the island through which local people and visitors can understand the need to protect the island's environment. In fact, the whole island has become an energy park where tourists can visit and learn about new energy facilities such as mega solar panels and wind mills.

The trend toward eco-tourism is global. Miyako has a high potential for developing sub-tropical eco-tours. Eco-tours are a popular program among tourists especially, with fixed-point observations of coral reefs as well as mangrove planting. The island is surrounded by beautiful coral reefs which are homes for small fish and protect many of them from their predators. There are many beautiful and colorful corals. Particularly, Yabiji, located near Ikema Island, is the largest coral reef group in Japan, consisting of more than 100 coral reefs.

*Figure 10: Coral reef in Miyako island*



Source: [www.miyakojima-kids.net](http://www.miyakojima-kids.net)

Moreover, what makes the mangroves in Miyako (Shimajiri Mangrove Forest) special is that they grow in an area without rivers. Therefore, they attract various visitors ranging from scientists to average tourists. Convenient walking trails built through the mangroves allow tourists to experience the beauty of the well-protected mangrove forests and understand the importance of these forests for the natural and environmental protection of the island. Moreover, visitors can enjoy bird watching interests in a convenient bird watching tower on the tour. In the Ikema wetlands, visitors can see another mangrove forests. These activities have helped Miyako become one of the best eco-tourism destinations in Japan.

### **III. CONCLUSION**

The study tour to Miyako island was extremely successful for the JDS students. We were given a great opportunity to visit many different and beautiful places in the islands, city where we could understand clearly about an eco-model city through an orientation explaining how to develop self-sufficient green energy from wind mills and mega solar panels, and power generation from bagasse and bio-ethanol (biomass energy) from sugarcane. The CO<sub>2</sub>-free project, in implementing eco-cars for transportation in Miyako, as well as applying eco- actions including the design of sub-tropical eco-houses, eco-tours, and awareness raising activities about environmental issues on the island for local residents and tourists were all very interesting. With proper awareness of the local citizens regarding energy issues for the existence and sustainable development of Miyako island, self sufficient energy has become the key to establish an eco-model city. With a target of a 30% to 40% reduction in greenhouse gases by 2030, and a 70% to 80% reduction by 2050 (compared with 2003), the city authorities and citizens who live in the “Environment Model City” have made every effort to obtain the ambitious targets. In the declaration of the Eco-island Miyakojima (March 31, 2008), the local authorities and residents on the island have pledged to “cherish the limited resources and energy by knowledge and contrivance”.

Energy is vital for development. At present, Miyakojima city is using energy from the wind and the sun as well as biomass energy from sugarcane. However, in the future, with the quick development of tourism and other industries, the demand for energy on the island may increase. Therefore, R&D for future energies such as wave and marine energies are also important. Moreover, replicating eco-house models, energy saving buildings, visualization of energy consumption, increasing the applicability of bagasse power generation, increasing the number of bio-ethanol charging systems, and a zero carbonization farming system are all necessary activities for the sustainable and prosperous future of the beautiful island – Miyako.

In the future, a university or college should be established on Miyako to educate the local youth to help keep them staying long term and to contribute to the development of the island. This is a realistic measure to solve the problem of population decrease on the island. The city is now in the process of establishing an island type, low-carbon society system through the initiatives of locally produced energy and resources, utilizing the forces of nature, such as the widespread sugarcane fields, sunlight, and the wind. With the joint efforts by both the local authorities and citizens, Miyako promises to be a most attractive and green island in terms of both its natural landscape and energy consumption. Eco actions are also very dependent on citizens' initiatives. Therefore, the participation of local residents in policy making should be taken into more serious consideration.

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## **Chapter-II**

### **The Water Management of Miyako Islands**

#### **I. The Nature of the Miyako Islands**

The Miyako Islands are located just about in the middle of the 80 or so large and small islands that make up the Ryukyu Archipelago. They lie approximately 850 km from Kyushu's Osumi Peninsula and about 450 km from Taiwan. The latitude ranges from 24 degrees 30' to 50' North and longitude ranges 125 degrees 10' to 30' East.

The ground stratification consists, for the most part, of a covering of Ryukyu Limestone from the 4th Cenozoic Period (approximately 1.5 million years ago.) Underneath that layer is an accumulation of Shimajiri Clay from the Pliocene Period that is approximately 5 million years old.



Picture 1: Miyako Islands

#### **1. Biological Life on the Miyako Islands**

The biological life on the Miyako Islands is specific to the Islands' geographical position, geological age, regional characteristics, as well as climate. To date, there have

been 740 varieties of plant life, 650 species of insects, 23 kinds of reptilian and amphibian life, 254 types of birds and 8 varieties of mammals recorded.

## **2. The Ave Fauna of the Miyako Islands**

Although the main type of genus of tree found in the Miyako Islands is the Tabunoki, unlike other prefectures, there are the varieties specific only to tropical regions such as the Adanki, Gunbaihirugao, Kusatobera, and the Gajumaru, which are varieties that can be found anywhere on the islands. There are 132 species, 450 genus, 592 varieties and 6 subgenus categorized within the wild fauna of the region, once you include the immigrant plant life then the numbers increase to 134 species, 513 genus, 707 varieties and 6 subgenus.

Compared to other islands in Okinawa Prefecture, the varieties of fauna are not so numerous nor particularly characteristic. Varieties of Maple, Oak, Shiinoki and Mochinoki found on the island are not indigenous. The following varieties, however, are distributed around the island: Sakishimaenoki (*Celtis biondii* Pampanini var. *insularis*), Miyakojimaso, Oonukakibi (*Panicum paludosum*), Tenjikunasubi, Taiwanchitosegasura (*Gardenia shimadae*.) These have come across from the Yaeyama Islands and spread across this region as well. The species found at the northern limit consist of 9 genus and 24 varieties such as Indohimokazura (*Deeringa polysperma*), Fujibogusa, Hirugidamashi (*Avicennia marina*), Ketanuki mana etc. There is no southern limit but if one stops at the Yaeyama region then, of 25 genuses, there are five distributed throughout the region. Examples of such are Isunoki, Masaki, Taranoki, etc.

## **3. Miyako's Climate**

Miyako has a sub-tropical climate that includes high temperatures and high humidity. Including a yearly temperature average of 23 degrees Celsius and a humidity of 80%, the year-round climate is fairly temperate.

The climate is sub-tropical and strongly influenced by the Japanese Black Stream currents.

The typhoon season lasts from summer until about October and strong typhoons tend to come around September. Typhoons wreak havoc on agriculture but the good news is that they bring much needed rain as well.

**Water resources** consist of sources of [water](#) that are useful. People use water for [agricultural](#), [industrial](#), [household](#), [recreational](#) and [environmental](#) activities. In fact, all of these elements require [fresh water](#). According to the survey, only three percent of the water on the Earth is fresh water; over two thirds of it is frozen water. The unfrozen freshwater is found mainly as groundwater. Generally, sources of fresh water are surface water, under river flow, groundwater, desalination and frozen water. In the case of the Miyakojima Island, wells with groundwater were used as drinking water resources until the modern water supply system was established. The modern water supply system has been developed by water facilities such as dams. Wetlands are very important to protect water resources and the ecosystem.

**Surface water** is water in a river, lake or fresh water wetland. Surface water is naturally resupplied by precipitation and naturally lost through discharge to the oceans, evaporation, evapotranspiration and sub-surface seepage.

Although the only natural input to any surface water system is precipitation within its watershed, the total quantity of water in that system depends on many other factors. These factors include storage capacity in lakes, wetlands and reservoirs, the permeability of the soil beneath these the storage bodies, the runoff characteristics of the land in the watershed, the timing of the precipitation and local evaporation rates. All of these factors affect the proportions of water lost.

Humans often increase storage capacity by constructing reservoirs and decrease it by draining wetlands. Humans often increase runoff quantities.

**Under river flow:** The total volume of water transported downstream will often be a combination of the visible free water flow together with a substantial contribution flowing through sub-surface rock and gravel that underlie the river and its floodplain called the hyporheic zone. For many rivers in large valleys, this unseen component of flow may greatly exceed the visible flow. The hyporheic zone often forms a dynamic interface between the surface water and the true ground-water, receiving water from the ground water when aquifers are fully charged and contributing water to ground-water when ground water is depleted.

**Groundwater** /Sub-surface water/ is fresh water located in the pores found in soil and rock. It is also water that is flowing within aquifers below the water table. The natural input to sub-surface water is the seepage from surface water. The natural outputs from sub-surface water are springs and the seepage to the oceans.

If the surface water source is also subject to substantial evaporation, the sub-surface water source may become saline. This situation can occur naturally under endorheic bodies of water, or artificially, under irrigated farmland. In coastal areas, human use of a sub-surface water source may cause the direction of seepage to the ocean to reverse which can also cause soil salinization. Humans can also cause sub-surface water to be "lost" through pollution. People can increase the input to a sub-surface water source by building reservoirs or detention ponds.

**Desalination** is an artificial process by which saline water (generally sea water) is converted to fresh water. The most common desalination processes are distillation and reverse osmosis. Desalination is currently expensive compared to most other alternative treatments for water, and only a very small fraction of total human use is satisfied by

desalination. It is only economically practical for high-valued uses (such as household and industrial uses) in arid areas.

**Frozen water:** Humans have made several schemes to use [icebergs](#) as a water source, but it is considered a very high cost process. Glacier runoff, on the other hand, is considered to be surface water.

The Miyako islands consist of eight separate islands and are considered a part of Okinawa. Miyakojima is a flat island of up-lifted coral reef which is encircled by ocean, and has no huge mountains or rivers. This island exists in harsh natural conditions, susceptible to typhoons and droughts. Miyakojima is located in a subtropical zone. The annual average temperature is 23.3°C and annual average precipitation is 2,000 mm. The main industries of this island are agriculture and tourism. Sugar cane, tobacco and mangoes are key items of farming.

During the field study, we were shown many wells, which are called “ga” by the local people. They are the main drinking water sources for the local people. Some wells have a very interesting history. For example: The Yamatoga Well is an excellent example of the high level of stonecutting skills that existed in the Ryukyu kingdom around 1720. Surrounding the wells are stone walls, and on the other side of the walls there is a set of stairs carved into the Ryukyu limestone which lead down to a natural spring. Local history tells a tale of two guarded gates that once stood in front of the Yamatoga well. The general public living on Miyakojima Island was not allowed to enter the well area. Admittance was reserved only to a select group of officials from Shuri castle, the former capital of the Ryukyu kingdom.

Another historical and interesting well which we saw was the Sabautsuga. It has a 1.5m diameter and a 4.5m depth, which was created by stacking stones on top of each

other. The well was used by the people of Sarahama for more than 240 years until the modern water supply system was put in place in 1966. There are 124 simple stone steps leading to Sabautsuga. The water in the well occasionally mixed with sea water, however depending upon the tides, thus making it unsuitable for drinking.



Part of the 124 simple stone steps to Sabautsuga





Surrounding area of the Sabautsuga Well, which is close to the coastline



The Sabautsuga Well

Because of the severe natural environment, Miyakojima has suffered serious drought damages. To liberate the island's farming from water shortages, the city has launched a project of constructing, as part of water source development, a water sealing dam which would be situated in the highly permeable underground in the stratum of the Ryukyu limestone, and which was constructed over 14 years from 1987 to 2000.



Tank of the water sealing dam, 2011.12.25

## **II. The Irrigation Facilities on Miyakojima Island**

To address drought and to modernize agricultural management, a comprehensive irrigation facilities has been implemented since 1987. These facilities cover half of the total surface area of the islands and about 90 per cent of the arable land. We visited the underground dam with the officials of these facilities.

We observed the irrigation facilities are divided into the following three parts:

1. The construction of two underground dams, named Sunagawa and Fukuzato, and intake facilities (a number of wells with submersible motor pumps) installed in the storage area of those dams.

2. The construction of farm ponds and the main pipelines

3. The construction of irrigation facilities on the farm and the field consolidation.

### **1. Concept of the Underground Dam**

The ground water level of Miyakojima Island fluctuates heavily due to rain flashes and at the same time, salt-water infiltration along the coastline makes the use of ground water difficult. The Govt. thinks if they can control groundwater at a constant level, the use of available groundwater resources will increase remarkably. Based on this idea, Govt. has started to construct an underground dam that can help to use ground water which is refilled by rain flashes for irrigation and can protect to flow up rain water to the ocean. On the other hand, an ideal situation of constructing an underground dam is located in the Miyakojima Island. We knew that the following appropriate conditions at Miyako helped to build such dams:

- An aquifer with high effective porosity, sufficient thickness needs and great areal extent;
- An impermeable bedrock layer under the aquifer;
- Sufficient groundwater inflow to the underground area;
- An underground valley where an underground barrier can be built;
- Land-use practices that do not contribute to groundwater contamination.

An underground dam is a facility that stores groundwater in the pores of the strata to enable sustainable use. These dams have many advantages, e.g., unlike a surface dam, land is not submerged to store water and there is no danger of breaching due to natural or manmade disasters. The surface area can be used in the same way both before and after construction of the underground dam. An underground dam allows the development of water resources in regions where the construction of surface dams is difficult due to geological conditions, and where groundwater cannot be used in its current state.



Underground dams are composed of a cut-off wall to dam the groundwater flow and prevent the intrusion of seawater, as well as facilities (wells, intake shaft, and pumps) that draw up the stored groundwater. Since the utilization of the stored groundwater in an underground dam requires pumping, the operating costs are higher than those of a surface dam.



Fig.: Fukuzato dam

Underground dams that store a few hundred to several million m<sup>3</sup> of ground water have been previously constructed using available technology, such as the mix-in-place construction method, and put to practical use in dry regions.

In southwestern Japan, MAFF constructed the first mega-subsurface dams, the Sunagawa subsurface dam and Fukuzato subsurface dam, on Miyako island in 1988. Construction was completed in 1993, and the groundwater reservoir became fully recharged in 1995. After that, five subsurface dams were completed and six subsurface dams are still under construction by the MAFF for irrigation using the mixed-in-place slurry-wall method.

Miyakojima Island's drinking water source is groundwater, which is supported by the wetlands, such as freshwater marshes. Freshwater marshes are common wherever groundwater, surface springs, streams, or runoff causes frequent flooding or more or less permanent shallow water. Groundwater recharge occurs when water moves from the wetland down into the underground aquifer. By the time it reaches the aquifer, the water is usually cleaner than when it began to filter down from the wetland. Once in the aquifer, it may be drawn out for human consumption, or may flow laterally underground until it rises to the surface in another wetland as groundwater discharge. Thus, recharge in one wetland is linked to the discharge in another. Recharge is also beneficial for flood storage because runoff is temporarily stored underground, rather than moving swiftly downstream and overflowing.

Finally, Miyako Island's water resource consists of groundwater, which is related to the wetlands, which are well protected. The modern water supply is well designed. Wells, which used to be a main source of drinking water, are now tourist attractions.

## **2. Advantages of the Underground Dams**

Compared with conventional dams, underground dams have the following advantages:

- Since water is stored underground, submergence of houses and land can be avoided, and thus the land above the underground dam can be utilized as it was prior to the construction of the dam;
- Potential disasters caused by collapses of the barrier (cut-off wall) can be excluded;
- The construction cost of the cut-off wall can be lowered by thinning it, provided that it satisfies the necessary permeability requirement;
- The dam's life span can be semi-permanent because of the absence of the accumulation of sediments.

We visited the Shimajiri Mangrove Forest and the Ikema Wetland on the morning of the 25<sup>th</sup> of December. Okinawa, like many tropical and subtropical climates with coastal areas, has mangroves and the important eco-systems surrounding them. Okinawa has six mangrove species from four different families, five of which can be found on Miyakojima Island. The mangroves of Miyakojima Island at Batarazu-bay are the biggest colony on Miyakojima. At Shimajiri, grow all five domestic species are growing; Yaeyama Hirugi, Ohirugi, Mehirugi, Hirugimodoki and Hirugidamashi. What makes Miyakojima's mangroves special is that they developed in an area without any rivers. Mangroves are sites composed of plants of various sizes which grow in muddy areas near the coast. In these areas, sea water and fresh water mix creating a unique ecosystem.

### **III. Conclusion**

We are really impressed to observe ground water management and other infrastructural facilities of Miyakojima Island. We knew these mechanisms were started to apply even in the other parts of Okinawa and Kagoshima Prefecture. We thought that these kinds of facilities might be applied in arid or semi-arid areas to protect their people suffering from drought and encourage scientific water management.

#### **Source:**

1. [http:// archive.unu.edu/unupress/unupbooks/uuOZfe/uuOZfeOc.htm](http://archive.unu.edu/unupress/unupbooks/uuOZfe/uuOZfeOc.htm)
2. [http://wlcm.net/MarkWisniewsk/Natural %20Science%20Section.pdf](http://wlcm.net/MarkWisniewsk/Natural%20Science%20Section.pdf)



## Chapter-III

### Ecosystem Biomass

#### I. Miyako Island Information

##### 1. Geography condition

Miyako island (Japanese: 宮古島) or Miyakojima is the largest and the most populous island among the Miyako Islands of Okinawa Prefecture, Japan. It is located approximately 400 kilometres East of Taipei, Taiwan. With an area of 158.70 square kilometres, Miyako Island is the fourth-largest island in Okinawa Prefecture.

Miyako is a flat island of up-lifted coral reefs which is encircled by the ocean, where there are not so many mountains and rivers. Miyakojima is well-known for its beauty, particularly the Eastern Cape (東平安名岬), which is considered by many as one of the most beautiful spots in Japan, no matter how severe the weather conditions are.

The main industries of Miyako island are agriculture and tourism. Regarding the agriculture sector, sugar canes, tobaccos and mangoes are the 3 key products of farming. Places worth noting include Maehama beach, the German Cultural Center, Painagama Beach, and the sights on Irabu-jima. The tourism on this island also includes a variety of events, such as sporting event, a national triathlon meet and the Tour de Miyako island and a musical event to appreciate the environmental protection idea with music. With such kinds of events, Miyako island attracts around 400,000 tourists per year.

##### 2. Challenges

The prefecture of Okinawa is basically composed of many remote islands, among which Miyako island is positioned even further away. Because of the geography, this island depends upon food and energy supplies from outside, so it needs to create a resource circulation system based on local products and local consumption.

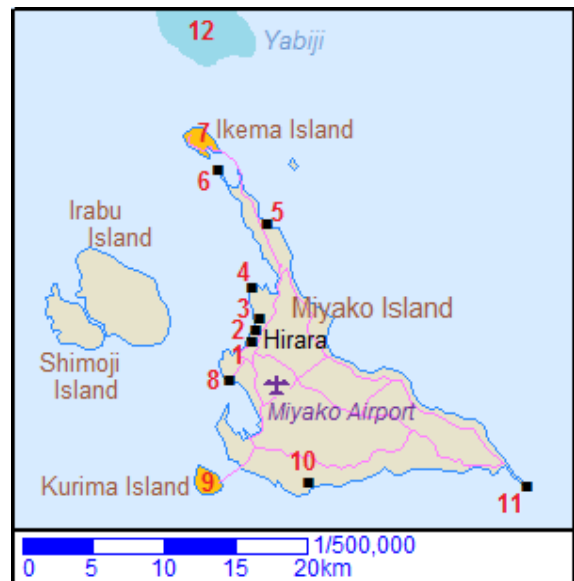


Figure 1: Miyako Island map

- Population: 55,000 (reality: 53,000)
- Area: 205 km<sup>2</sup> (main island: 80%)
- Climate: Subtropical
- Temperature: 23.3<sup>0</sup>C
- Precipitation: 2000mm

The negative impacts on the environment are increasing because of many reasons caused by the changes in life style and industrial and economic activities. The water supply plays an important role in both agricultural activity and tourism, but currently Miyako island is facing drought and water contamination. In addition, the local economy, which needs a fixed numbers of employees every year for the local industries, is stagnating due to a decrease of population.

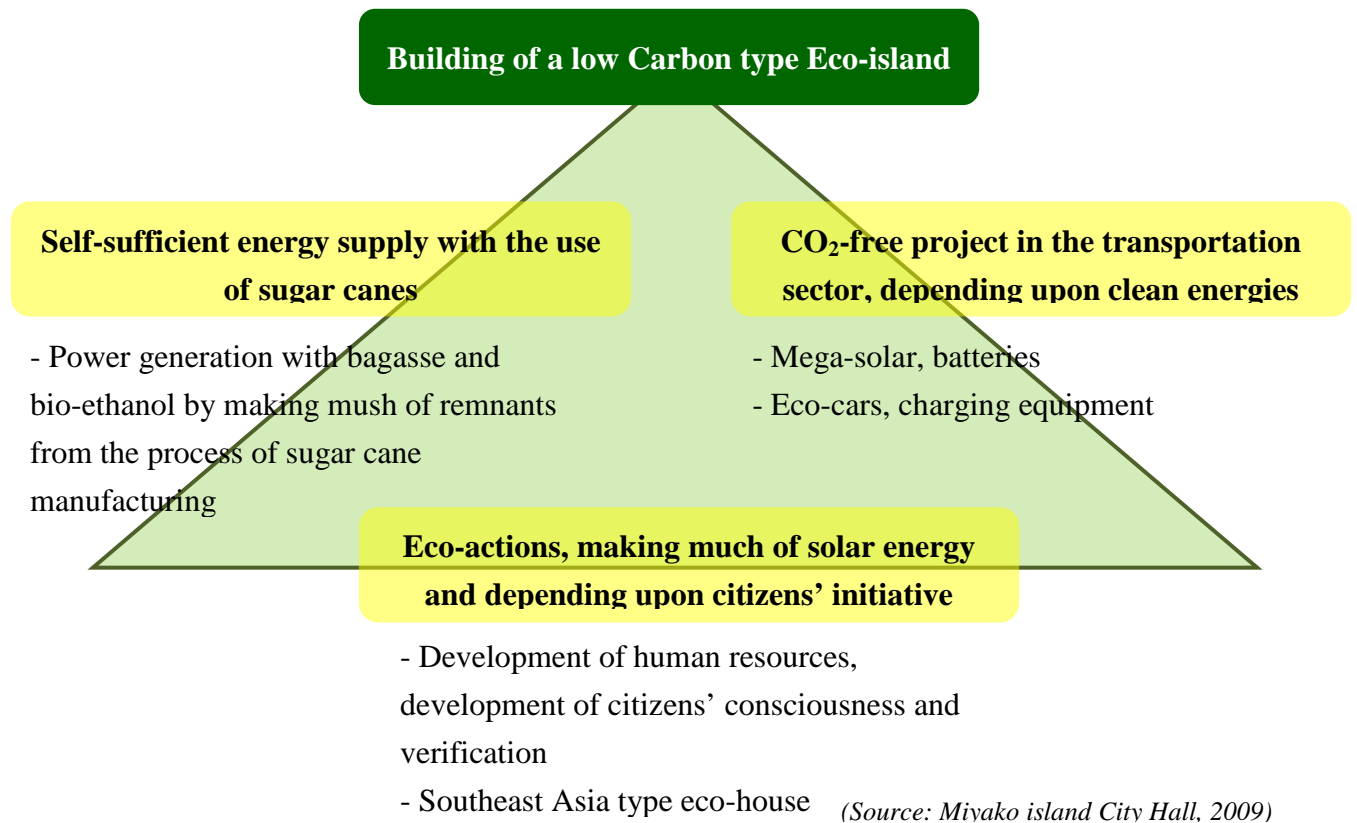
### **3. Policy**

In order to solve the above challenges, it is very important to develop efforts for an eco-island in Miyako with a principle of “sustainable development” and the *Declaration of an Eco-island Miyakojima* is one such effort.

According to the “*Declaration of the Eco-island Miyakojima (March 31<sup>st</sup>, 2008)*”, the citizens pledge to:

- *Keep the ground waters safe which bolsters the lives of the islanders*
- *Protect the sea and coral reefs*
- *Cherish the limited resources and energy through knowledge and effort*
- *Respectfully take action toward the goal of a beautiful Miyakojima and a the garbage-free world*
- *Think and act together with the world’s citizens to recover and keep a better global environment and hand it over to the next generation*
- *Protect the fauna, the seas and the sky and take steps to establish an environment where all living things are able to live together.*

In January 2009, the “Environmental Model City” approved by the Prime Minister and is a turning-point to realize above declaration.



**Figure 2: Environment Model City**

We will discuss more details about this model in the second part of this report, where we found a lot of smart and interesting ideas which make human life friendlier with the environment.

## II. Interesting Points Following The Visited Schedule

### 1. Ninto-zeiseki Old Tax Monument (The Head Tax Stone)

According to Kunio Yanagida, a folklorist who visited Miyako in 1921, the “Bubakariishi” or measuring stone was used to levy taxes on the local islanders. Citizens whose height exceeded it had to pay taxes. Miyako island had a long history of heavy taxation until modern tax laws were introduced on January 1, 1903. In 1637, the Ruykyu Kingdom enforced a poll tax on Miyako and Yeayama islanders which was collected in the form of textiles such as “Jofu” fabric, and millet. In 1659, tax amounts were fixed, and by 1710 the tax was



**Figure 3: Head Tax Stone**

universally enforced on all men and women aged fifteen to fifty. Men paid their taxes in grain while women paid theirs in textiles. It is not certain why the stone was called the “Bubakariishi” or head tax stone but it is assumed that it was used by officials as a standard to measure approximate age. (*Hirara city Department of Finance, Commerce and Industry*)

## 2. Natural Spring Well

### a. Yamato Well (Yamatoga)

Yamatogaa is a natural spring in a cave located in the North-eastern portion of Hirara, in Miyakojima City. The spring is believed to have been excavated around 1720, according to the Yosei-Kyuki, an ancient document. Stone steps lead down to the spring which is surrounded by a mixture of large and small curved stones. It is said that the use of this spring was limited to government officials from Shuri, the capital of the Ryukyu Kingdom, and was not open to the



**Figure 4: Yamato well**

public. It is also said that there were guardians and two gates leading to the spring. Yamatogaa displays excellent stonework as well as the special relationship between the people and water on this Southern island.

### b. Muika Well (Muikagaa)

The Muika cave spring is one of the largest springs in the Hirara area. It has 103 stone steps which aided the women and children in their strenuous daily task of carrying water up from the spring. Before the development of the water system, the people of Miyako depended upon rain water and springs for their water supply. Many villages in Miyako developed



**Figure 5: Muika well**

around springs, so the history of Miyako cannot be properly discussed without talking about the springs. Near the Muika cave, a kitchen midden was discovered along with many shards of celadon porcelain earthenware. This gives an impression that a large village once stood on the site. The historian Kenbu Inamura theorizes that this site was once occupied by the Yonahabara family, who ruled Miyako in the 14<sup>th</sup> century and were based at the spring, however, sufficient evidence to support this theory does not currently exist.

### c. Nugusuku Spring

The Nigusuku ruins, dating to the 13<sup>th</sup> to the 14<sup>th</sup> century, are located on a Ruykyu



**Figure 6: Nugusuku Spring**



limestone hill that stretches from east to west along the northeast coast in Fukukita village. The spring is situated in the southwest part of these ruins. Nugusuku spring is a natural uriga, cave-type spring. Its mouth is thought to have been used by the Nugusukuaji family, who are believed to have been associated with the Nugusuku ruins. However, precisely when the mouth of the spring was fitted with stones is unknown. Recently, a unique type of algae, which grows only in the Nugusuku spring, was identified making the spring of great value to both biologists and archaeologists.

#### d. Tomori Amaga Well

Tomori Amaga is a natural cave spring located between Sunakawa and Tomiri and to the west of the Tomori-Motojima ruins in Gusukube. The distance from the entrance to the water is about 20m. For a natural cave from a spring of this type, it is fairly big and has a large quantity of water. It provided the villagers with a vital source of water from the spring, and it was a daily chore of women and children in this area. Some of the stone steps are heavily worn, suggesting the difficulty of their duties. The date of the spring excavation was unknown even at the time of the ancient manuscript Yosei Kyuki, which dates to 1727. This means that the spring had been utilized for long time by the villagers of Tomori, Sunakawa and Shizato before the largest tsunami of the Meiwa era hit Miyako in 1771. This gives us valuable information to aid in our understanding of how the villagers at that time utilized water in their daily life.

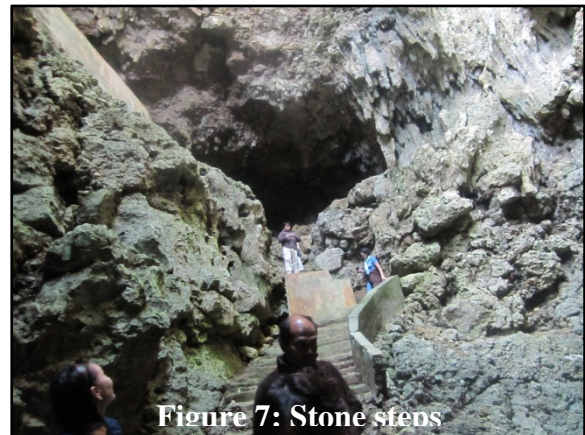


Figure 7: Stone steps



Figure 8: Tomori Amaga Well

### 3. Floristic composition

Miyako island, like many tropical and subtropical climates with coastal areas, has a diversified subtropical species, mangroves forest and an important eco-system surrounding them.

#### a. Shimajiri mangrove forest

The Shimajiri mangrove forest, located at Batarazu-bay, developed in a km long inlet and it is the largest one on Miyakojima. There are five domestic mangrove species from 3 families that have been identified. The Japanese names of the five species are Yaeyama hirugi, Ohirugi, Mehirugi, Hirugimodoki and



Figure 9: Shimajiri mangrove forest

Hirugidamashi, which is not found at latitudes north of Miyako. What makes Miyakojima's mangrove special is that it was developed in an area without any rivers. Mangroves are sites composed of plants of various sizes which grow in a muddy area near the coast. In these areas, sea water and fresh water mix creating a unique ecosystem. Since mangroves only grow in tropical and subtropical regions, Japan's few examples of mangroves are distributed throughout the southwest islands with the Kiiri mangroves in Kagoshima prefecture being the furthest north. In Okinawa prefecture, six species of mangrove among different four families have been recognized: 6 species in Yaeyama, 5 species in Miyako, and 4 species on mainland Okinawa. Mangrove, also called the forests of the sea, have a unique ecosystem. Since mangroves, like Shimajiri, are the best places for people to study the food chain of such ecosystems and proper environmental protection should be provided for this area. According to the botanical scientists, this is a rare occurrence and this area is of great interest. Besides all the technical facts, the natural beauty surrounding the Shimajiri mangroves is quite nice and deserves a visit.

b. Upukaa mangrove walking trail

Unfortunately, we could not find any English version introduction from this place but we were very amazed because of its beauty. The mangrove species here are similar with the Shimajiri and the dominant species is *Aegiceras corniculatum*, which belongs to the Myrsinaceae family. We also enjoyed a beautiful sunset in this cape.



Figure 10: *Aegiceras corniculatum*

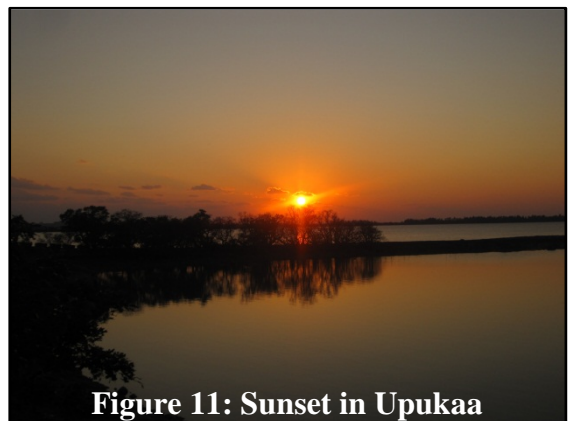


Figure 11: Sunset in Upukaa

### III. Sub-Tropical Ecosystem Biomass In Miyako Island

The main industry on the islands is agriculture where the main crop is sugar cane, and cattle for meat. With the aim of construct Eco-Island, the island has developed solutions about sugarcane waste and cattle waste to protect the environment, and groundwater resources (crucial resource on the island)

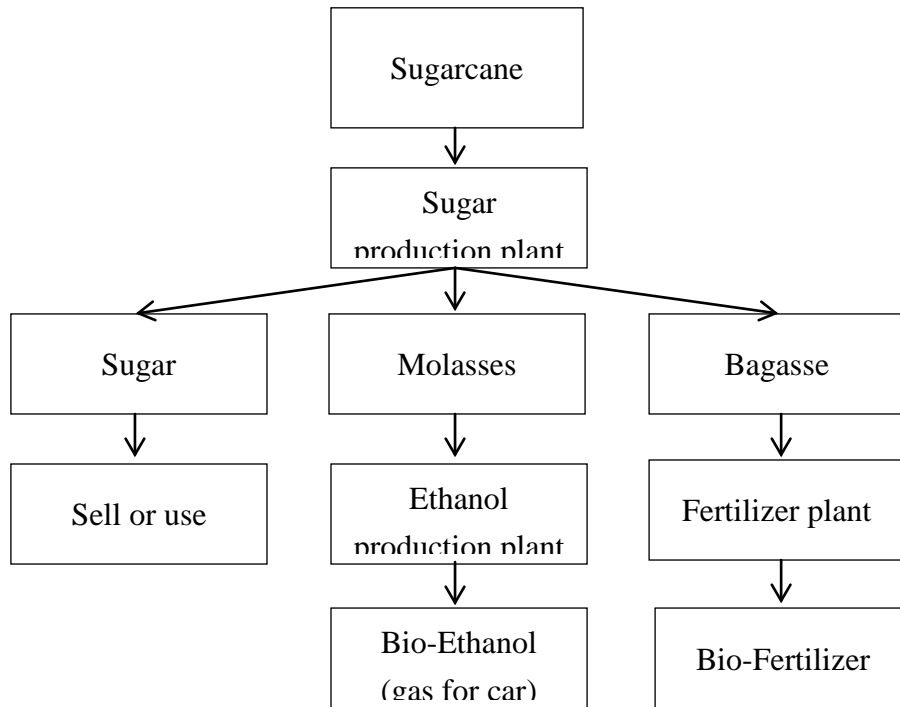
#### 1. Sugarcane

Sugarcane is the input for the sugar factories. Outputs are crude sugar, molasses, and bagasse. Where:

- Sugar: will be used in daily life of local people or exporting to other regions.



- Molasses: is the input for the production of ethanol- a kind of green energy.
- Bagasse: is the input for the liquid fertilizer factory.



**Figure 12: Sugarcane processing**



**Figure 13: Some illustrate picture about sugarcane processing**

## 2. Cattle waste

In order to reduce impacts and protect the groundwater resources and produce bio-fertilizer for the island's agriculture, the island has a Resource Recycling Center.

Livestock waste, etc. (mainly from cow and chicken) have been collected and through a treatment process, became fertilizer. This process is illustrated in the following picture (Fig 14):

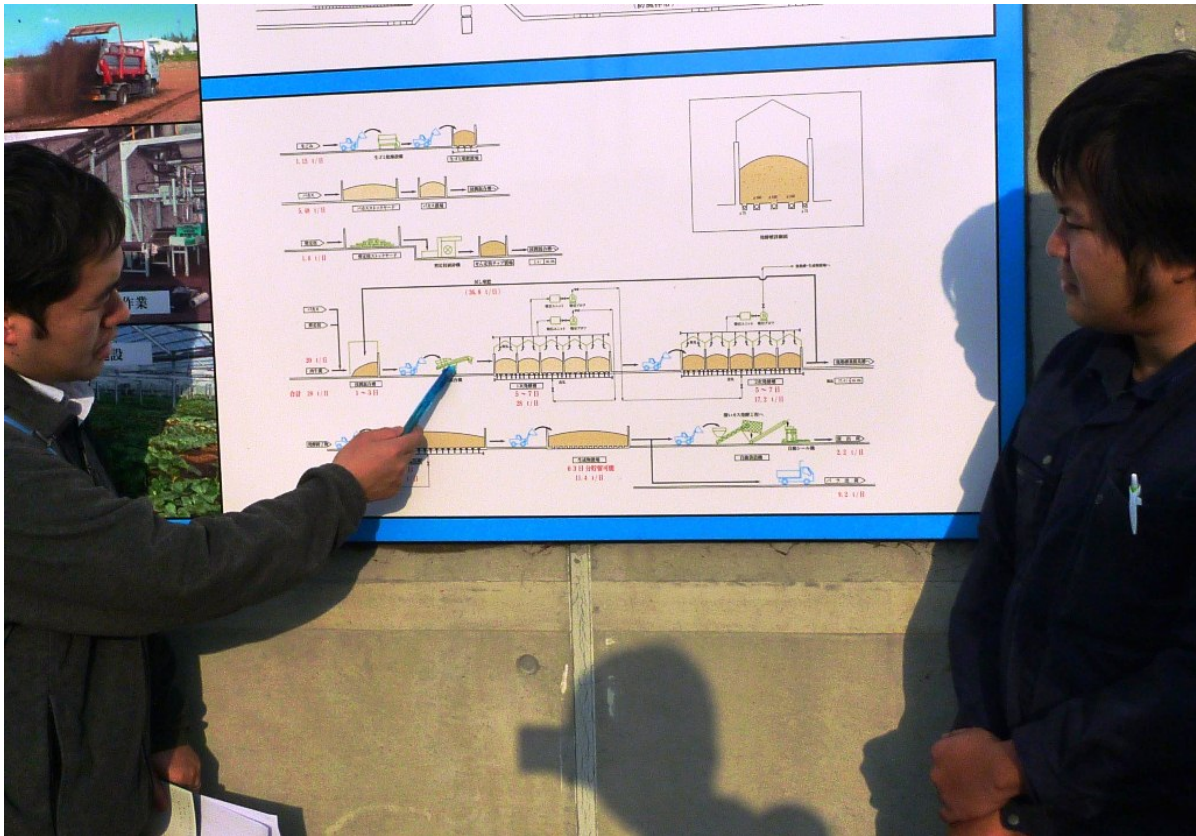


Figure 14: Process of fertilizer production from livestock excreta



Figure 15: Two kinds of fertilizer of the Resource Recycling Center

#### IV. Conclusion

With five days on Miyako Island, we had wonderful chance to visit many beautiful sights, many interesting places, and we also get some practical knowledge about the groundwater resources, the mangrove ecosystem, green energy, and green

agriculture. The most impressive thing to us is all the citizens of Miyako island have a responsibility in protecting the community property such as ground water, and the environment. We all do believe that with 6 projects to develop the Biomass Town (Composting project, Liquid fertilizer project, Effective resource use project, Ethanol production project, Methane fermentation project, and the BDF project) , the island will be successful in building a recycling based island that utilizes the local biomass.