



# **The Opinion of The Future Based on The Dam Due to Global Warming, Climate Changes**

**H. Yoshida**

*Ex-director of North Dam Office, Okinawa General Bureau, Cabinet Office, Gov. of Japan,*

**T. Asato, Y. Kawaguchi**

*Chief of Survey and Environmental section, North Dam Office, Okinawa General Bureau, Cabinet Office, Gov. of Japan  
Staff of Survey and Environmental section, North Dam Office, Okinawa General Bureau, Cabinet Office, Gov. of Japan*

## **ABSTRACT:**

“Future of Dams with Considerations for Climate Changed due to Global Warming – For Creation of Productive Water Environment that Characterizes Okinawa –,” a proposal, is introduced.

*Keywords : Global Warming, Climate Change, Okinawa Main Land, Dam, Water Environment, Measures*

## **1. INTRODUCTION**

Various issues related to global warming have been pointed out as urgent issues that need to be addressed since many years ago throughout the world. Climate changes due to global warming have also become obvious in Okinawa and we are concerned about the influence on the water environment in particular.

Responding to these situations, North Dam Construction Office, which has been developing a number of dams in the northern part of Okinawa Main Land, decided to discuss the future of dams, as one of the organizations responsible for the water environment administration. In preparation for the discussion, we established the “Council to Discuss Water Global Warming (referred to as “the council” hereinafter),” which consists of specialists from a wide range of fields including the river, disaster prevention and environment fields, as shown in Figure-1, and have been seeking advices from them.

This report explains the outline of the proposals discussed and put into shape at the council meetings as well as the vision of future efforts at North Dam Construction Office.

## **2. INTRODUCTION OF PROPORSALS**

Results of discussions by the council were reported in “Future of Dams with Considerations for Climate Changed due to Global Warming – For creation of productive Water Environment that Characterizes Okinawa - ” (Released in June 2010. Referred to as “proposals” hereinafter).

The proposals are focused on Okinawa and water issues arising from construction of dams, as the title indicates, although climate changes due to global warming have

already been discussed and addressed throughout the world including Japan.

### **2.1. Recognition of current situation of Okinawa**

In this chapter, the peculiarities of Okinawa in terms of various viewpoints indicated below are listed in preparation for the discussions to decide the goals and directions, which are also based on Chapter 2 and 3.

#### **2.1.1. Geographical properties**

Located at the southwestern edge of Japan and features subtropical marine climate, which is not observed in other parts of Japan.

- Because of the terrain and geological property of the northern part (referred to as “Yanbaru” hereinafter) of Okinawa Mainland, water resource development including construction of dams was centered around Yanbaru

#### **2.1.2. Natural environment**

- The temperature is warm throughout the year and the difference between the highest and lowest temperatures of the year is about half that of Tokyo (Fig.2).

- The average annual rainfall is higher compared with other major regions in Japan and the rain is concentrated in the rainy season and the typhoon season.

- Rich natural environment is maintained in Yanbaru (Fig.3).

#### **2.1.3. Social Characteristics**

- Population of the prefecture is estimated to grow until 2025 (Fig.4).

- The number of tourists visiting the prefecture will be 10 million per year (in around 2016), according to the goal set by the prefectural government.

#### **2.1.4. Water management**

- The rivers are comparatively short and feature swift current, resulting in substantial increase of flow amount during floods.

- There is a large difference in flow amount between drought and flood times.

- The areas where flooding is anticipated are limited, but population is concentrated in these areas.

2.1.5. Water resources, water utilization

- The amount of available water resources is smaller than other regions in Japan (Fig.5).

- Water resources are concentrated in Yanbaru.

- Rely on water from small rivers with limited flow amount for water resources.

Recovery of water level in dams is slow and the recovery relies on rainfalls during the rainy season and the typhoon season.

- The middle and southern regions rely on water resources in Yanbaru (It is called “water moves from north to south” referring to this situation in Okinawa).

- For effective development of water resources, the dams are connected by supply canals for integrated operation (Fig.6).

- Economic activities in Okinawa are supported by water supplied from dams and rivers (Fig.7).

- The ratio of domestic use water is higher compared with agricultural use water and daily life of Okinawans is directly affected by droughts.

- There is no margin for water saving during drought.

- Okinawa consists of a number of islands and it is difficult to obtain water from other regions during drought.

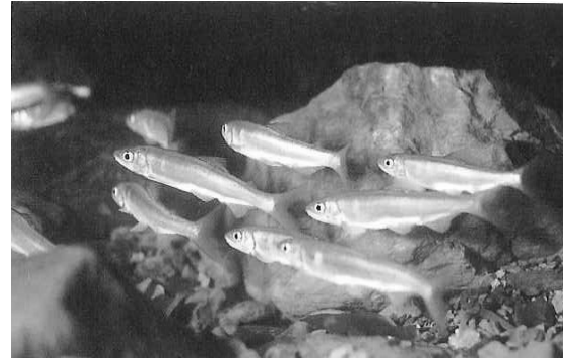


Figure 3. Plecoglossus altivelis ryukyuensis

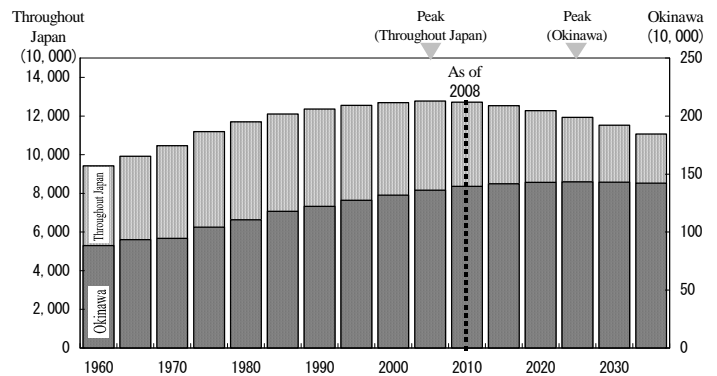


Figure 4. Population of Japan and Okinawa

\*Population of 1960–2005: Census

\*Population of 2010–2035: Estimation by the National Institute of Population and Security Research

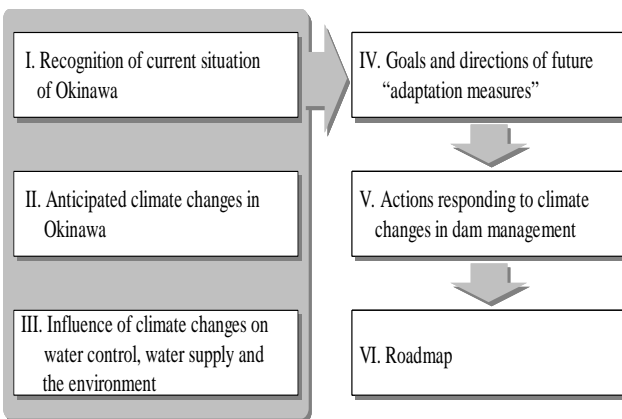


Figure 1. Classification of the proposals

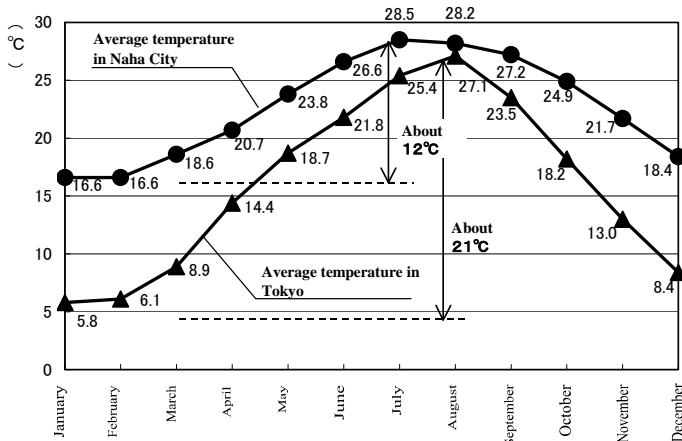


Figure 2. Average temperature of each month (mean value of temperatures from 1971 to 2000)

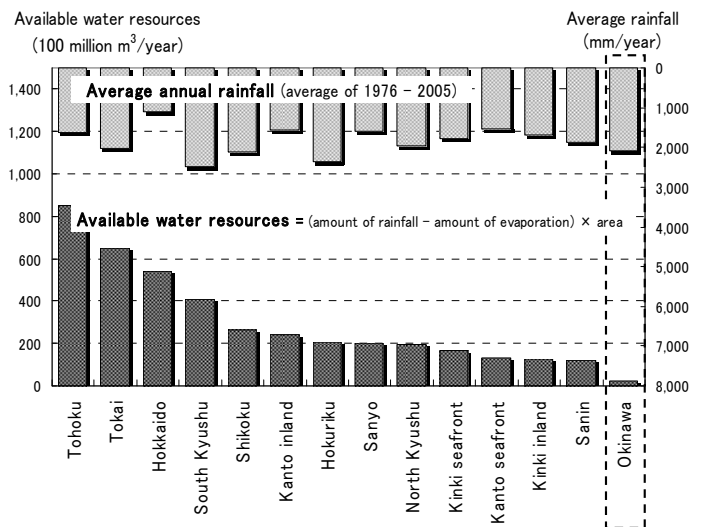
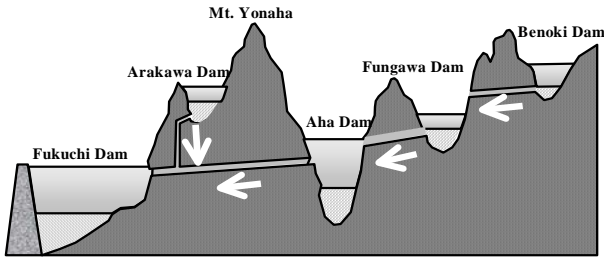
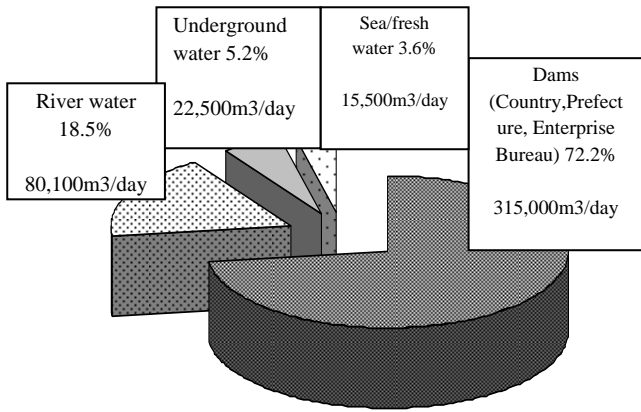


Figure 5. Amount of available water resources

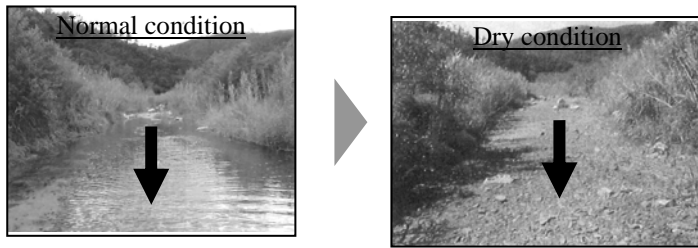
Reference: Created by North Dam Construction Office based on “Water Resources in Japan, FY2009 version” (Water Resources Dep., Land and Water Bureau, Ministry of Land, Infrastructure, Transport and Tourism, 2009)



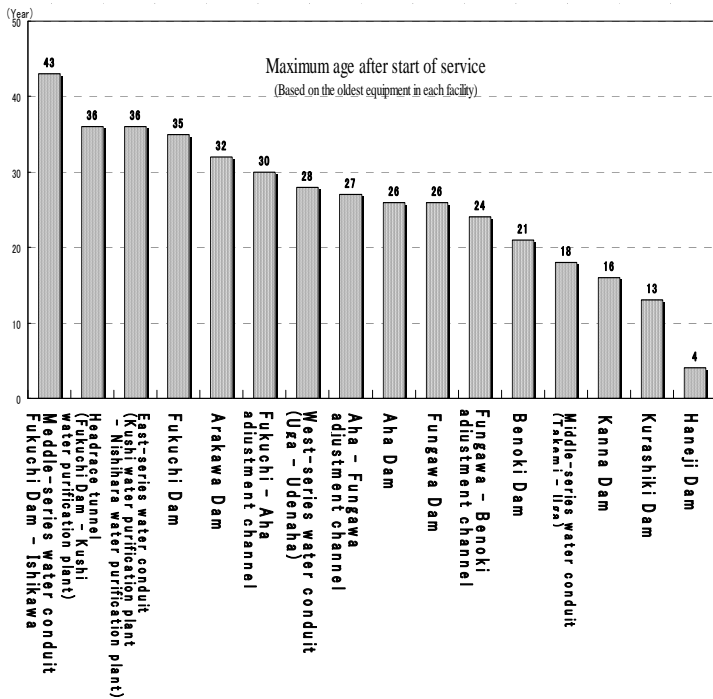
**Figure 6.** Integrated operation (longitudinal sectional views) of 5 dams in the northern part



**Figure 7.** Water intake volume per day water source (daily average: 441,100 m<sup>3</sup>/day)  
Reference: Created by North Dam Construction Office based on “Water Amount Records” (Okinawa Prefectural Enterprise Bureau, FY2008)

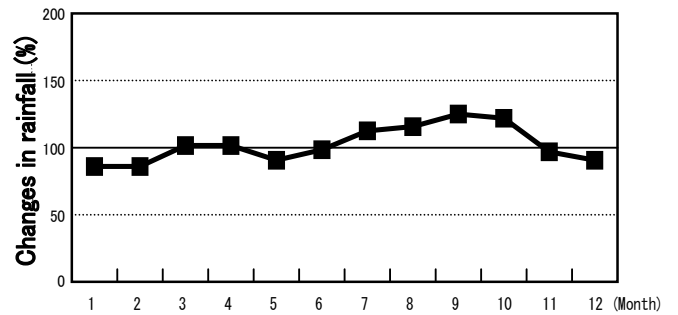


**Figure 8.** Generation of dry riverbed due to reduction flow amount (Oku River in Kunigami Village)

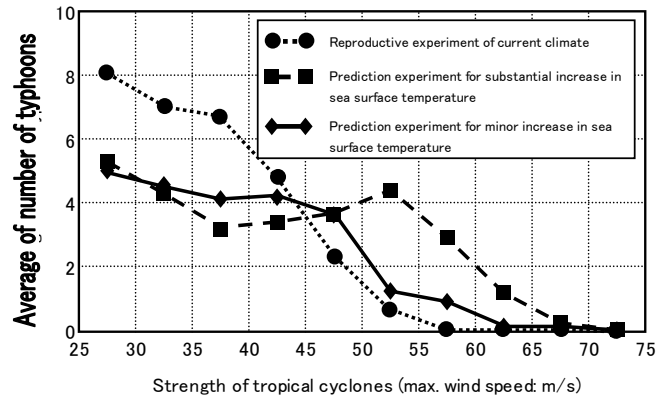


**Figure 9.** Ages of water resource facilities in the northern part of Okinawa  
Reference: Created by North Dam Construction Office based on “From the Era of Gallon, 20 years’ history of city water and industrial water projects in Okinawa” (Okinawa Prefectural Enterprise Bureau, 1993)

- (6) River environment
- Flow amount of rivers without dams are insufficient (Fig.8).
  - Brackish waters are decreasing due to blocking of river mouths and existence of water intake facilities.
  - Flow out of red soil sediment due to heavy rain.
- (7) Maintenance of river control facilities and water resource development, etc
- Increase of facilities that have been developed since the years around the return of Okinawa to Japan and progress in aging of the facilities (Fig.9).



**Figure 10.** Changes in monthly rainfall on the Nansei Island [Annual average for 2081 – 2100]/[Annual average for 1981 – 2000] x 100 (%)  
Reference: “Estimation of global warming, vol.6, Results of estimation by RCM20 (A2 scenario)”



**Figure 11.** Distribution of tropical cyclones, in annual average and by strength, obtained by global warming experiments. Reference: “Climate changes in Japan and the impact” (Ministry of Education, Culture, Sports, Science and Technology, Meteorological Agency of Japan, Ministry of the Environment, 2009)

Chapter 2. Anticipated climate changes in Okinawa  
 Climate changes in Okinawa during the coming 100 years are estimated as follows on the basis of latest reports on climate changes due to global warming from research institutes.

- (1) The average temperature will increase by approximately 2°C
- (2) The annual maximum daily rainfall will increase by 8%
- (3) The amount of rainfall will decrease in winter and spring, while it will increase during the period from the rainy season to the autumn rainy season (Fig.10).
- (4) The frequency of heavy rains (50 mm/day or more) will increase by 0 to 3 days per year, and the days without any rain will increase by about 10 days
- (5) The average ocean level will increase by about 13 – 19 cm
- (6) In respect to typhoons, frequency of tropical cyclones will decrease, while frequency of strong typhoons will increase (Fig.11).

Chapter 3. Influence of climate changes on water control, water supply and the environment

In this chapter, influences of dams in Okinawa are examined in terms of water control, water supply and the environment to be fully aware of the damage potential (potential damages and weak points). We determined considerations should be given to the following points among the phenomena anticipated to be generated by climate changes.

- (1) Water control (Fig.12).
  - Decline of water control safety along rivers and increase of floods attributable to the increase in daily rainfall and power of typhoons.
  - Increase of unexpected floods attributable to localized torrential rain in a short time.
  - Increase in severity of sediment disaster attributable to localized torrential rain.
- (2) Water supply (Fig.13).
  - Decline in safety of water supply attributable to extremely small amount of rainfall and increase in periods without any rainfall.
  - Change in water demand periods and increase of water demand attributable to expansion of demand for drinking water, etc.
  - Decline in quality tap water attributable to decline in quality of water in fam lakes.

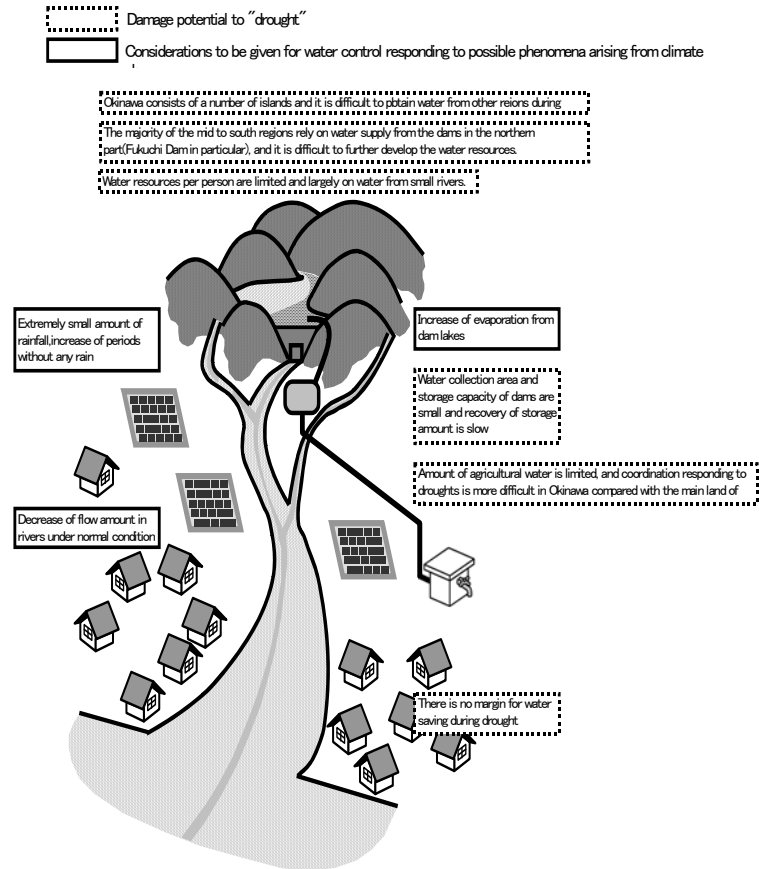


Figure 12. Damage potential and estimated in phenomenon (Flood)

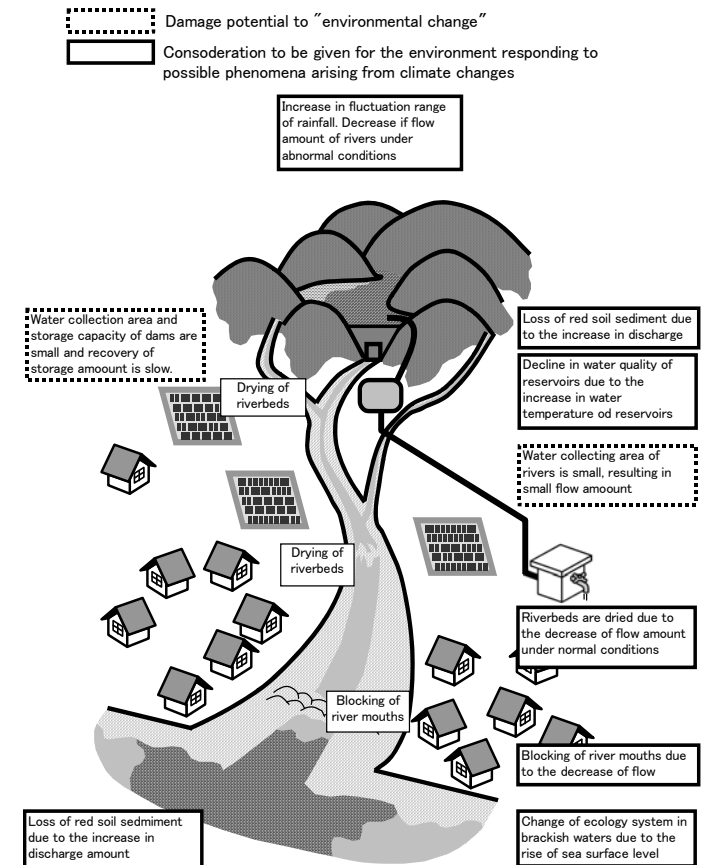
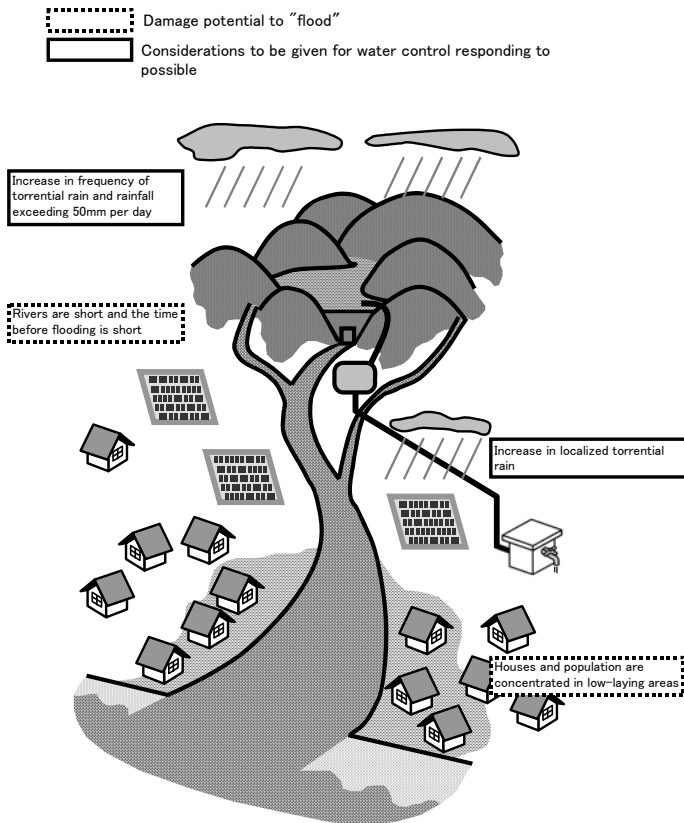
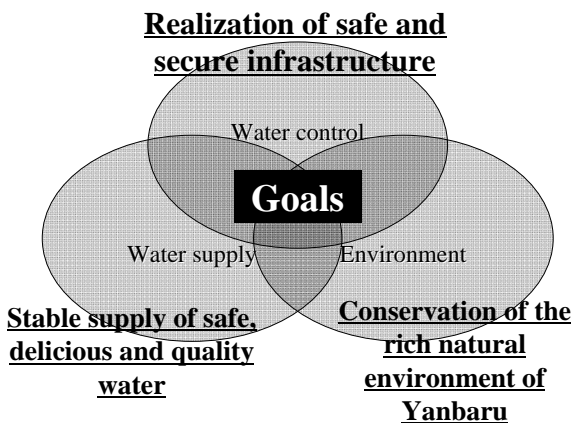


Figure 13. Damage potential and estimated in phenomenon (Drought)



**Figure 14** .Damage potential and estimated in phenomenon (Environment change)



**Figure 15.** Goals of future “adaptation measure”

(3) Environment (Fig.14)

- Fluctuations and increase of discharged sediment attributable to the increase in torrential rains as well as the increase in amount and strength of rains.
- Deterioration in water quality of rivers and lakes attributable to changes in stream regimes under normal condition and floods.
- Impact on the growing environment of creatures and

changes in ranges of fish and shellfish attributable to the increase in river water temperature.

- Impact on the ecology system in brackish waters and increase in discharge amount of red soil sediment attributable to rise in sea level.

Chapter 4. Goals and directions of future “adaptation measures”

In respect to the issues of global warming, the 4th evaluation report of the “International Panel on Climate Change (IPCC)” points out that “Global warming “easing measures” with a focus on reduction of greenhouse effect gas including CO<sup>2</sup> are limited in effectiveness, and “adaptation measures” responding to various effects of global warming are as important as the “easing measures.” Goals of the “adaptation measures” (Fig.15), which have been established on the basis of the findings explained in Chapters 1 – 3, are introduced in this chapter.

To attain the goals, the following 6 directions have been set for future activities.

- (1) Place priority on measures that utilize existing facilities

Prepare for extreme floods and droughts attributable to climate changes by utilizing existing facilities.

- (2) Place priority on non- structural measures

Improve accuracy of rainfall prediction to enhance the capacity of existing facilities and review action plans established in preparation for floods and droughts.

- (3) Place priority on collaboration and approach with local communities and related authorities

Realize collaboration of river administrators and local governments and establish new systems for publicity and education utilizing the information network. In addition, realize approaches with local communities and related authorities such as improvement of reclaimed water utilization and promotion of rainwater utilization.

- (4) Promote integrated and flexible water resource management

Promote integrated and flexible water resource management with a special focus on measures against expansion of damage caused by droughts.

- (5) Place priority on maintenance and improvement of safety as well as improvement of service life of existing facilities with considerations for current conditions and risk management

Place priority on effective use of existing facilities through collaboration and approach with related authorities.

- (6) Place priority on measures for easing of global warming

Investigate the possibility of introducing natural energy by utilizing existing facilities.

Chapter 5. Actions responding to climate changes in dam management

Actions for each of the “adaptation measures” indicated in Chapter 4 are explained in detail, in respect to dams in Okinawa.

Chapter 6. Roadmap

Outline of the schedule for the coming 20 years is explained (Fig.16), in respect to the detailed measures indicated in Chapter 5.

3. Considerations and prospects for future actions

(1) Considerations

It is difficult to predict climate changes and their impacts and the predicted range is wide, making it impossible to come to definite conclusion, which needs to be remembered in future actions regarding climate changes due to global warming. In carrying out the measures, it is essential to fully understand estimated climate changes and social changes in Okinawa, validate the effect of measures and promote the measures continuously and flexibly from a new point of view.

In respect to issues on water, which is included in the proposal, collaboration with related authorities, not only with North Dam Construction Office, is essential and attention should be paid on the following points.

- (1) Setting of priority based on degree of urgency.
- (2) Evaluation for feasibility in terms of budget and technology.
- (3) Appropriate information gathering on the social situation.
- (4) Optimum role sharing with related authorities in execution of measures.
- (5) The environment where each authority can take actions positively and continuously (setting of councils, etc. for discussion).

(2) Future prospects

The proposals introduced here were disclosed to mass media in June 2010. They are also posted on the website of North Dam Construction Office. The proposals need to be widely known, and a symposium was held in Naha City in early October. The symposium included keynote speeches and a panel discussion attended by the council members, where future actions on the basis of the proposals were discussed. We will expand the wave of our efforts through professional publications, delivery lectures, etc.

To realize rich water environment that characterize Okinawa, collaboration with related authorities, for timely and appropriate actions based on understandings on characteristics of Okinawa and responding to frequent climate changes due to global warming, is essential. We position the proposals as the motivators for future actions and intend to establish a long-term new cooperative system involving residents of Okinawa.

Direction of actions	Measures	Schedule		
		5 year	10 year	15 year
(1) Place priority on measures that utilize existing facilities	Monitor the amount of rainfall and flow amount in rivers – Evaluate safety level of dams and downstream sites of rivers with considerations for climate changes	Monitoring – safety level		Continuous execution if necessary
	Study the possibility of increasing the capacity of dams.		Discuss the possibility	Continuous execution if necessary
	Study the possibility of reorganizing the dam capacities by purposes		Discuss the possibility	Continuous execution if necessary
	Monitor the environment of dam lakes and rivers – Evaluate the river environment with considerations for climate changes	Monitoring – safety level evaluation		Continuous execution
	Study possibility of increasing the capacity by unspecified amount and flash discharge to improve the environment of downstream rivers	Discuss the possibility		Continuous execution if necessary
(2) Place priority on non-structural measures	Develop technologies for rainfall observation and prediction		Continuous execution	
	Discuss, create and support action plans in preparation for floods and droughts	Support for creation	Review rainfall/discharge prediction technologies responding to situation	
(3) Place priority on collaboration and approach with local communities and related authorities	Establish collaboration system with authorities related to global warming			
	Promotion and education to improve awareness of residents on floods and water saving	Promotion and education to improve awareness of		Continuous execution
	Promotion of rain water utilization by expansion of storage and infiltration facilities		Promotion of rain water utilization	
(4) Promote integrated and flexible water resource management	Actions for integrated and flexible water resource management and promotion of calculated water supply plans, collaboration with related authorities		Promote water resource	
	Study the possibility of using existing facilities for utilization of idle water sources, springs, rainwater reservoirs and underground water	Study the possibility		
(5) Place priority on maintenance and improvement of safety as well as improvement of service life of existing facilities	Check and examine safety of existing facilities	Investigation, discussion		Continuous execution if necessary
	Promote creation of plans for increasing the service life of existing facilities	Investigation, discussion		Continuous execution
	Collaborate and approach with related authorities for improvement of seismic resistance and doubling of conduit routes	Approach with related		Continuous execution if necessary
(6) Place priority on measures for easing of global warming	Feasibility study for small-scale hydraulic power generation systems that utilize dams and water conduits	Study the possibility		Continuous execution if necessary
	Possibility of effective use of natural energy utilizing reservoirs		Study the possibility	Continuous execution if necessary

Figure 16. Road map