ARTIFICIAL RAIN TECHNOLOGY AS AN ALTERNATIVE INCREASING SUTAMI RESERVOIR VOLUME IN EFFORT TACKLING DROUGHT DUE TO GLOBAL CLIMATE CHANGE

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ABSTRACT

Climate change is a change in climate variables, particularly temperature and rainfall that occurs gradually in a long period of time between 50 to 100 years. A new study in Australia about the ocean and rainfall concluded that climate change has transformed the ocean and rainfall around the world. Global climate change caused the high rainfall rate but the rain occurred in a shorter time. This will lead to change the amount and pattern of precipitation that can cause increment of magnitude and frequency of flood and drought. Sutami dam where the water comes from the Brantas River flow is one of the biggest dams in Java and one of the largest hydroelectric power suppliers in grid of Java-Bali. The dam which provides water for irrigation of 34,000 hectares of paddy fields in the downstream for years and has the capability to produce hydroelectric power of 400 million kWh per year, in the last 34 years has experienced a significant decline. Measurements in 2011 remain 145 million m^3 of effective storage and compare with 1977, it reached 253 million m^3. One of the factors causing the decline is due to shifting the rainy season and the long dry season which led to decreasing volume of Sutami reservoir especially this year. Based on information from the BMKG (Agency of Meteorology, Climatology, and Geophysics), in early October to December 2012 is estimated to have rain, but the condition is still not normal. This can threaten the water supply for irrigation, industry, water utilities and the Java-Bali hydroelectric power by interrupting the reservoir operation system. To anticipate the amount of water supply in this dam in order not to consist the deficiency in the provision of water supply, PJT I (The Public Company of Jasa Tirta I) Malang, the manager of this dam, has been designing concept of artificial rain technology as an alternative to deal with climate change.

KEY WORDS: Sutami reservoir, climate change, drought, artificial rain

1. INTRODUCTION

Sutami Dam is one of the largest dams in the Java Island, Indonesia. This is one of the largest hydroelectric power suppliers in grid of Java - Bali. Sutami dam is usually called with Karangkates dam because the location is located in Karangkates, Sumberpucung District, Malang, East Java.

The dam was built by the Department of Public Works after Jatiluhur Dam Construction Project in Purwakarta, West Java. The dam that was inaugurated by Suharto, President of Republic of Indonesia in 1977 was designed to control flooding and designed as a source of irrigation discharge for irrigation in the downstream area with the discharge can reach up to 24 m^3 per second in the dry season.

It means that this dam can guarantee the availability of water supplies to irrigate 34,000 hectares of paddy fields in downstream of the year. Sutami dam managed by PJT I (The Public Company of Jasa Tirta I) located in Malang has catchment area of 2050 km^2 with a water storage capacity of 343 million m^3 and sediment storage capacity plan for 90 million m^3.

The dam that has been being relied on by PJT I in the provision and management of water for

irrigation, industry, water utilities and electricity production in the last 34 years has experienced a significant decline in the reservoir volume. Global climate change is one of the causative factors of the decline in addition to reservoir sedimentation.

Convention of the United Nations (UN) about Climate Change defines climate change as a change in climate condition that is directly or indirectly related to human activities that have changed the composition of the global atmosphere. Global climate change as the implications of global warming has led to instability in the lower layers of atmosphere especially close to the earth's surface.

Intergovernmental Panel on Climate Change (IPCC) stated: "Observational evidence from all continents and most oceans shows that many natural systems are being affected by regional climate changes, particularly temperature increases" (IPCC, 2007)

Increment of temperature will affect the hydrologic cycle acceleration. The atmosphere which is warmer will save more water vapor, so that becomes less stable and gives rise to more precipitation, especially in the form of rain. Greater heat also speeds up the process of evaporation.

The increment of temperature that occurs in the earth's surface globally will lead to seawater, rivers, swamps and other water reservoirs temperature increase. The water temperatures increase will lead to faster evaporation. Plenty of water vapor causes the number of clouds formed much as well. With the high humidity, automatically rainfall in a region will also increase. This leads to greater rainfall intensity and lasts for a long time in certain areas. Contrary to warming, some of very cold periods may occur. On the other hand, the water will evaporate more quickly from the ground. Some regions will become drier than ever. The wind will blow harder and probably with a different pattern. Cyclonic storm (hurricane) that draws its strength from the evaporation of water, will be greater. As a consequence, weather patterns are unpredictable and extremer.

This can result in a shift of the season so as to make the dry season in Indonesia is longer but in a certain period can also lead to a prolonged rainy season. Long drought has made the Brantas watershed as the sole supplier of water to the Sutami reservoir become drought. As a result, the discharge that flow into Sutami reservoir less and make its operation pattern do not work optimally to serve the society needs (i.e. irrigation, industry, water utilities, and hydropower)

1.1 Scope of The Study

The scopes of the study that are presented included:

a) The condition of upper Brantas watershed as the only water supplier for Sutami reservoir.
b) The Influence of climate change for upper Brantas watershed and Sutami reservoir.
c) The impacts occur if Sutami reservoir volume has decreased water level below the pattern.
d) Artificial rain technology in an effort to increase the Sutami reservoir volume to tackle drought due to climate change.

1.2 Goals and Objectives of The Study

Objective discussion of this study are included:

a) Describe the present conditions of Brantas watershed as a water supply in Sutami reservoir.
b) Understanding the influence of climate change for upper Brantas watershed and Sutami reservoir.
c) Understanding the impacts if the Sutami reservoir went dry.
d) Describe the process of cloud seeding in the area of Malang

The goal of this study is that is artificial rain technology can be used as consideration in an effort to tackle drought in the Sutami reservoir due to the long dry season.

2. LITERATURE RIVIEW

2.1 Reservoir Utilization for Society

The presence of the dam would provide its own benefits for people, especially people whose land flooded by the construction of reservoirs. Various activities are conducted in people around the dam reservoir utilization include agriculture, tourism, and aquaculture. In the upstream Watershed (DAS), the river water is used by some people to irrigate agricultural land, and some other residents use irrigation water to irrigate their farmland. In the residential

areas around the reservoir and in the river basin do not use water or reservoirs to meet the daily needs of their water resources, because they are already using water both from PDAM (Water Company) and water well.

In addition to tourism activities, the reservoir is also used for aquaculture cages, aquaculture and fishing nets bulkhead either using rods, and nets. Fishing activity is carried out in almost all parts of the reservoir.

2.2 Condition of Sutami Reservoir in 2012

Based on the monitoring of the Ministry of Public Works (PU) for the 71 reservoirs scattered in Indonesia, until the end of August 2012, there were 19 normal reservoirs, 42 alert, and 10 dry. Normal reservoir water condition is occurring due to the actual elevation greater than normal. Sutami Reservoir was included in the alert category.

Be wary if the volume is less than normal but greater than idle drought. While dry if the actual elevation is lower than the elevation of drought alert.

Although the Sutami reservoir was in alert category, but in the eight districts of Malang has been threatened by drought and water supply. Not only that, water utilities and hydropower will suffer large losses. For water utilities, the company will suffer economically, quantity, and quality. It can make people disappointed with the services provided because they are already paying the same monthly fee to get clean water from the taps turned out what they provide does not match what they get. For hydropower, the company will incur a loss because they cannot produce the maximum power, while the demand for electricity grids Java – Bali is big.

2.3 Artificial Rain Technology

Artificial rain is rainfall that made by human intervention with making rain through cloud seeding or laser pulse. This technology has to be practiced in cloud seeds that contain enough water, have a low wind velocity (approximately 20 knots below), and the other requirements.
This is the attempt to change the amount or type of precipitation that falls from clouds, by dispersing substances into the air that serve as cloud condensation or ice nuclei, which alter the microphysical processes within the cloud. The usual intent is to increase precipitation (rain or snow), but hail and fog suppression are also widely practiced in airports.

The most common chemicals used for cloud seeding include silver iodide and dry ice (solid carbon dioxide). Liquid propane which expands into a gas has also been used. This can produce ice crystals at higher temperatures than silver iodide. The use of hygroscopic materials, such as salt, is becoming more after promising research. To form a heavy rain, it usually takes 3 tons of salt were seeded into potential cloud for 30 days.

Artificial rain is generally done with aim to face drought for an area due to the long dry season that could disturb life (i.e dry fields, failed crops, dry wells, dry rivers / lakes, cracked soil, clean water shortages, animal death, etc.). This was expected to supply the water needs for living.

2.3.1 Cloud Seeding Method

Artificial rain does not mean that humans are able to create rain, but the method of accelerating the rain. The way of creating artificial rain with cloud seeding using hygroscopic material (absorbs water) can make the water particles are formed faster and the rain can be occurred.

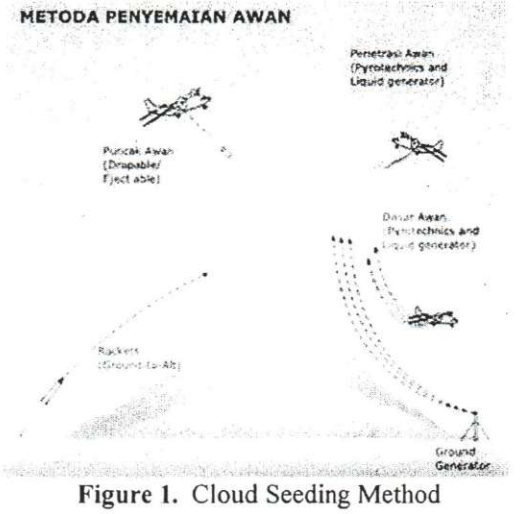

Figure 1. Cloud Seeding Method

Clouds that are targeted for cloud seeding are a type of Cumulus (Cu) clouds that are active; this type is characterized by its shape like

cauliflower. Cumulus clouds may occur due to process of convection.

Cumulus clouds are divided into three types, they are: Strato Cumulus (Sc), is newly emerging cumulus clouds; Cumulus and cumulonimbus (Cb), are large Cumulus clouds and they may include some Cumulus clouds that have been merged into one.

Cloud seeding with chemicals may use an aircraft or dispersion devices located on the ground (generators, as in or canister fired from anti-aircraft guns or rockets). Using aircraft is most commonly used. In addition to using the aircraft, aircraft modifications may be done from the ground by using a static system with Ground Base Generator (GBG) in the mountainous area to modify the orographic clouds as well.

Since 1998, BPPT and PT INCO have been working with companies from the U.S. using the method of cloud seeding with silver iodide flares technology. In this technology, it does not need a very large aircraft. It is enough with small aircraft that is equipped with 24 tubes of silver iodide flares installed in the wings of airplanes and air rocket launchers.

Scientifically, weather modification technology is not simply to sow salt into convective clouds, but there are other modifications. Essentially there is no rainmaking, but only utilize the cloud in order to more rapidly degrade water droplets with the help of certain ingredients such as salt (NaCl) and calcium chloride ($CaCl_2$) is capable of absorbing water vapor to form rain clouds. Generally, this condition appears at an altitude of 4,000-5,000 feets, or about 15,000 feet.

2.3.2 Laser Method

In some countries, weather modification technology develops further. British scientists claim to create water droplets using a high-powered laser beam. This technique is called laser-assisted water condensation.

The research team was also able to reveal the secrets of the water cycle and helps people decide when and where the rain can be lowered.

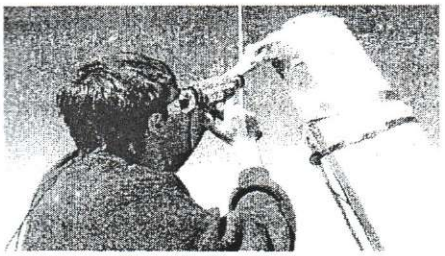

Figure 2. Swiss Team Create Rain By Firing Laser Beams Into The Sky

The research team conducted experiments with the laser is on the banks of the Rhone, near Lake Geneva, after building a giant laser installation moves. After 133 hours of firing a high-intensity laser beam, which creates nitric acid particles in the air, resulting in an intermolecular bonding of water and produce water droplets. Although it was not really rain, the team is optimistic that scientists can manipulate the weather conditions.

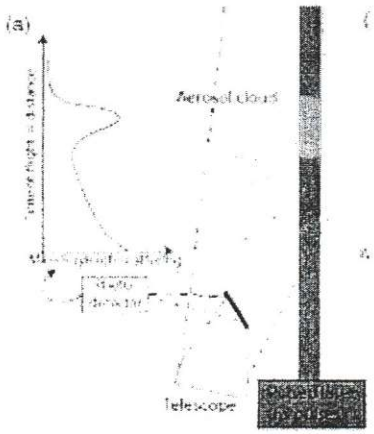

Figure 3. Lidar Principle. Laser pulse is emitted into the atmosphere.

The light backscattered carries information about the size and density of the number of aerosol particles encountered, through the cross-section.

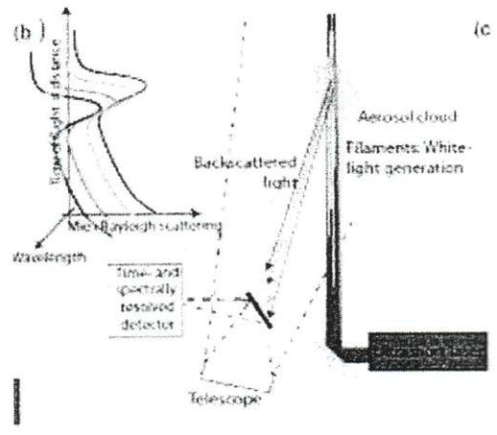

Figure 4. Principle multispectral (or white-light) Lidar.

Filament produces a wide spectrum upstream of the area to be analyzed, which were left unaffected by the laser wavelength, but to re-deploy any detection device

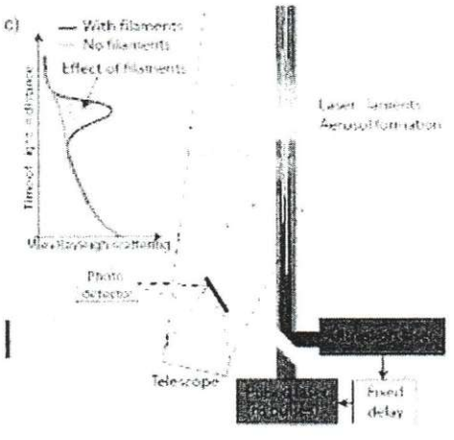

Figure 5. Principle of pump-probe Lidar.

Particles produced in situ by ultra-short laser filaments in the atmosphere, depending on atmospheric conditions. These particles were investigated after the delay set by Lidar with collinear beams with filaments.

3. METHODS

3.1 Type of Study

This study included in the descriptive research. This research is intended to collect informations about a symptom status according to what it was at the time of the study. The study is not intended to test a specific hypothesis, but simply describes what it is about a variable, symptoms or condition.

Data collection is conducted through a variety of journals, books, articles and news.

4. RESULTS AND DISCUSSION

4.1 Conditions of Brantas Watershed

Brantas Watershed is watershed that has strategic value. Brantas watershed has a vast of 14,103 km ² and covers with 9 districts and 7 cities in East Java. There are several dams that have a primary function to control flooding, irrigate more than 345,000 ha and Hydroelectric Power with a capacity of 900 GWH per year.

Conditions of the watershed currently logged critical category. One indication is based on the results of a survey in July 2012 found segowar dam in Nganjuk should irrigate an area of 1,336 ha of rice fields, but does not work because the river is dry.

Environmental issues that are most prominent in the Brantas watershed are land use change from forest to plant vegetables, increment of the water quantity and quality, and land degradation. Human activities such as farming, animal husbandry, trade and others do in the middle part of the watershed. The destruction of most of the watershed in Indonesia caused a third of the upper watershed is used to human activity that does not function as a conservation area.

Forest areas along the Brantas watershed across 16 districts / cities known at 1.5 million hectares. As per the provisions of Law No. 26/2002 on Spatial Planning, ideal precentages of total forest in the watershed are at least 30 percent in the form of protected forest, it means that only approximately areas of 450 thousand hectares of forest remain in Brantas watershed. However, the rill condition in the Brantas watershed protection forest is left only about 3.42 percent or about 60 thousand hectares. This is due to the increasing number of clearing new land at the expense of protected forests for personal gain. For example, illegal logging, unauthorized deforestation to use a residential area and is used for apple plantations and crops.

Thus, diminishing protected forest without thinking about the impact or greater risks. Since the loss of protected forests, especially in the upstream side of Brantas watershed caused many springs that are no longer in production. 426 springs from Batu, Malang until now produces only 50 percent lived alone. At brantas springs, Batu, springs from the existing 117, now only 53 springs. In fact, when the dry season comes, the largest water source that produces only the remaining three.

In addition, the Brantas river narrowed, while the rainfall tend to high. Consequently, when the rainy season arrives in the city of Malang some areas inundated by water.

4.2 The Impact of Climate Change

4.2.1 The Impact of Climate Change for Brantas Watershed

Brantas River discharge, Batu, East Java continues to shrink every year. In the last 20 years, the original water flow reaches 12 liters per second is now only two liters per second. Climate change and land use have led to the decline in the quality and quantity of the Brantas River. Perum Jasa Tirta (PJT 1) is currently working on a research and plan for adaptation to climate change.

4.2.2 The Impact of Climate Change for Sutami Reservoir

Water crisis due to prolonged drought makes PJT I Malang, East Java worried. Sutami reservoir elevation has decreased dramatically. On October 21, the dam was already in deficit reached 7 million m3 or 1.28 m. The elevation was already under the pattern. PJT I started doing artificial rain on October 23, 2012 in cooperation with BPPT, Air Force, BMKG, East Java provincial government and the army in order not to continue to run a deficit.

4.3 The Impacts Occurred when droughts struck East Java and Sutami reservoir volume has decreased water level below the pattern.

4.3.1 Agricultural Sector

Drought is a natural disaster that threatens lives and causes huge losses. Measurements of drought for paddies in 10 years (1993-2002) by the Department of Agriculture, agricultural lands that have been affected by drought were gained. These have been reached from 220,380 hectares to 43,434 hectares of parched paddy fields and equivalent loss of 190,000 tons of milled rice.

In September 2012, the drought impacted on thousands of hectares of paddy, corn, and other crops. At least 2113 hectares of paddy fields were parched in Bojonegoro, Lamongan, Tuban and Gresik. Parched paddy field in Bojonegoro has recorded 1746 acres, 141 acres Lamongan, Tuban 122 acres, and 104 acres Gresik

Head of Agricultural Department Bojonegoro, East Java, said that drought caused 8179 hectares of paddy parched. A total of 5410 hectares on May 2012 and the remaining 2769 hectares of parched paddy fields occurred in June 2012. Parched paddy field reached up to 1746 hectares. The average ages of parched plants are approximately 30-40 days. Losses estimated at USD 7.857 billion, besides the losses of farmers Rp 4 million up to Rp 6 million per hectare. There are currently 2769 farms that do not suffer with parched, but threatened by drought.

4.3.2 Industrial Sector

Water reservoirs drying may disrupt the working process on the industrial sector. Not only people need clean water for daily life, but Industry also require water supply as raw material for both the management and production activities.

4.3.3 Water Utilities

Drought in water reservoir which is the source for water utilities may cause in water shortages. This condition threatens the distribution of clean water to the customers, because the existing raw water only lasts for a few weeks. If the drought continues, water coming from the taps will totally end.

Clearly, this can suffer a huge financial loss to the company because the company can not sell water to the customers. Additionally the company will suffer losses in terms of both quality and quantity as well.

This will be called losses in terms of quality because if the reservoir dries, water in the reservoir will be contaminated by the elements that surround the reservoir such as soil (sediment), the decay of algae, etc.

4.3.4 Hydroelectric Power

This year's dry season that has lasted nearly six months has resulted in the availability of water in the most of reservoirs in Java shrink, even went dry. Hydroelectric power energy productivity would be reduced due to the discharge from Brantas that flow into the reservoir has declide.

The other conditions of hydroelectric power in other regions, based on the Indonesia's media, althoughs the water has been shrinking, the dam was still useful. The Hydroelectric powers are Jatiluhur (150 MW), Saguling (700 MW), and Cirata (1008 MW), which are in West Java. However, if the drought continues, the operation may be stopped

4.4 Artificial Rain Technology for Malang Area

Job operational of weather modification technology (TMC) or artificial rain technology began on October 23, 2012. TMC Post was located in the old terminal of Lanud Abdul Rachman Saleh. Team from technical unit of artificial rain technology of BPPT will work for 36 days, in accordance with the contract already signed cooperation PJT I and BPPT. Elevation of Sutami reservoir on October 21, 2012 was recorded at 262.17 meters and the operational system was 263.45 meters; an elevation deficit of 1.28 meters and shrinking volume of 7 million m^3.

Ir. Alfan Rianto, the head of business development of management and technology of PJT 1 has launched TMC operational work to address the discharge of Brantas Watershed in East Java, in the old terminal of Lanud Abd Saleh. BPPT has prepared a CASA 212-200 aircraft with rain making version belongs to BPPT which was operateby PT. Buana Nusantara Air and the operation was supported by a unit of band mobile radar belongs to BPPT, and the operation would be supported by Juanda radar as well.

Cloud seeding was directly done in the Sutami reservoir area, so that the rainwater will be collected into the reservoir. Rainfall monitoring post where are located in two points of Sutami and Poncokusumo were involved in the work.BPPT used radar to monitor the growth of clouds until the clouds were ready for seeding. The selected clouds would be directly seeded salt (NaCl) by aircraft. If the clouds that have been seeded were ripe, approximately rain would occur in an hour to an hour 15 minutes (Head of Artificial Rain Unit of BPPT, F. Heru Widodo, M.Si)

It was planned there would be two flights to conduct cloud seeding for a day. Each flight, the aircraft would bring the salt between 800 pounds to one ton. One ton of the salt would be dispersed on the clouds that were ready for seeding. There were only clouds that had rainy potential could be seeded.

This will be evaluated within next 20 days with aim to know if this will be stopped or continued by monitoring the potential of rainfall, elevation, and the others. This technology could be practiced less than 36 days if the elevation is enough for needs. The cost of artificial rain that has been dealt with PJT I and BPPT is in accordance with government regulations. The cost for one day of weather modification technology operation is up to Rp 113 million. The cost is including for human resources, equipment, materials, salt, aircraft and the others. PJT I has to spend Rp 4.06 billion for 36 days.

Head of the technical unit for BPPT artificial rain has requested data of landslide-prone areas and data of anti-water plants around Sutami reservoir and Brantas watershed so that artificial rain he made does not have bad effects for society. Increment elevation of the storage over operating system is expected to protect food security in East Java, drinking water distribution and hydroelectric power. If Sutami reservoir elevation drops, it will have a profound effect of the Java society (food, hydroelectric power and water utilities).

5. CONCLUSION

It can be concluded that artificial rain technology is an appropriate solution to face drought in the Brantas watershed in order to make condition of Sutami reservoir be normal, so that it can work optimally as a major supplier of water for irrigation, industry, hydroelectric power, and water utilities.

A cloud seeding method using aircraft and hygroscopic materials is suitable technology to be practiced in Indonesia. In addition to the cheaper cost than using a laser, this method has been repeatedly practiced in many regions of Indonesia and it does not cause environmental problems.

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