Certificate of Appreciation

Presented to :

Bambang Istijono

in Recognition of Outstanding Contribution as Presenter
International Symposium of
The 82nd Annual Meeting of
International Commission on Large Dams (ICOLD)
2 – 6 June 2014
Bali Nusa Dua Convention Center, Bali – Indonesia

Bali, 4 June 2014

Dr. M. Basuki Hadimuljono
Chairman of INACOLD

INTERNATIONAL COMMISSION ON LARGE DAMS
COMMISSION INTERNATIONALE DES GRANDS BARRAGES

Invitation from Chairman of Organizing Committee and President of INACOLD

Dear ICOLD Members,

On behalf of The Indonesian National Committee on Large Dams (INACOLD). I would like to extend our invitation to participate in the 82nd Annual Meeting of ICOLD. The event will take place in Bali on 2-6 June 2014 at Bali Nusa Dua Convention Center (BNDCC).

Along with the history of ICOLD, Indonesia has been recorded as member country of this world prestigious organization. For Indonesia, this is the second time we have been entrusted to host such an important event of ICOLD. The first one was in Jakarta in 1986. I believe that through this important event, we will be able to show you the whole set of our experience in implementing the country's development and management in large dams in particular and in the water resources development in general.

The selection of Bali as the venue of the meeting is not just because of its reputation as a tourist destination, but more than that, it has proven record of hosting various kinds of international events. It is also an opportunity to see boundless variety of unique sceneries as well as countless traditional and cultural heritages.

Our Social programs are designed to provide you with unique opportunities to taste and feel the best of Bali's hospitality and its unique culture, through various exciting and full-filled activities held before, during and after the event. To complement these, the distinct culturally rich province offers an extensive range of hotels, exquisite cuisines, fascinating sceneries, a genuinely friendly and charming people practicing an authentic ancient heritage culture and almost unlimited recreational and cultural options.

We trust that the time you spend with us in Bali will be most rewarding, which leads to many experience and friendships. We are looking forward to welcoming you to the 82nd Annual Meeting of ICOLD and hope that your participation will be productive as well as memorable.

Dr. M. Basuki Hadimuljono

Chairman of INACOLD

Preface

The International Symposium, with the main theme on DAMS IN GLOBAL ENVIRONMENTAL CHALLENGES, conducted in 4th June 2014, is one among the events in the 82nd Annual Meeting of the International Commission on Large Dams in Bali, Indonesia. It is a great honour to have all ICOLD delegates and dam experts, professional managers, as well as decision makers from the international dam community to participate in the international symposium. The objective of the symposium is to collect the knowledge of the latest development from the dam experts from various field of expertise to share with dam engineers in developed and developing countries, and to transfer especially to young dam engineers to ensure the dam engineering sustainability.

The topics in the international symposium are listed as follows:

1. Social and environmental aspects of dam,
2. Engineering issues in dam development,
3. Challenging in tailing dam project,
4. Dams and water quality management,
5. Catchment area management for sustainable dam development,
6. Challenges in dam safety policy and implementation,
7. Dam operation in connection with climate change.

We have received 532 papers from 53 countries related to the theme and the topics. These papers were evaluated by national reviewer as well as international reviewer, involving experts related to dam engineering and environment from various countries. The result is that 246 high quality papers, of which 146 papers are presented in oral session and 81 papers presented on poster session.

We also provide awards for the best paper and presenter among young engineers to encourage their further involvement in the dam engineering, development, and management. We hope, the presentations and discussions are fruitful, and further provide contribution to the future sustainable dam engineering.

Bambang Hargono

Chairman of the Symposium and Workshop Committee,
The 82nd Annual Meeting of ICOLD, 2014, Bali.

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Sub Theme 6: Challenges in dam safety policy and implementation

Sub Theme 7: Dam operation in connection with climate change

INTERNATIONAL SYMPOSIUM ON
DAMs IN A GLOBAL ENVIRONMENTAL CHALLENGES
Bali, Indonesia, June 1ST – 6TH, 2014

Estimation of Water Balance for Maninjau Hydropower using TRMM and Discharge Data

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Flow from Lake Maninjau in Agam Regent, West Sumatra, is used to generate a 68 megawatt hydropower and to irrigate 4200 ha paddy field. There are 19 rivers flowing into the lake, with main rivers being Batang Limau Sundai, Batang Maransi, Bandar Ligin, Jembatan Ampang, Batang Kalarian and Tembok Asam. Its outflow from hydropower station flows to Batang Antokan which ends in the Indian Ocean in the West. Water balance for both inflow and outflow from 2009 to 2012 show an increase from an average of 5.8 m3/second to 23.53 m3/second. This condition raised a concern that rainfall input cannot maintain sustainable water level. In addition, an instant discharge measurement on 25 and 26 March 2013 shows that input to the lake was smaller than the output. An initial study suggested that the discrepancy is due to an effect of ground water. However, this study did not confirm this through a field or model study.

The Tropical Rainfall Monitoring Mission (TRMM) has long been used as an auxiliary data for both prediction of rainfall in ungauged basins and for simulation in hydrological models that require spatially distributed rainfall input. We use daily TRMM data over the Lake Maninjau catchment from year 2000 to 2010 TRMM in 0.5^o x 0.5^o grid resolution in order to match ground measured rainfall. DEM (Digital Elevation Model) of SRTM (Survey Radar Topographic Mission) CGIAR-CSI in 90-m resolution. The data are validated using ground measured rainfall data from the station. Preceding studies show that high rainfall is over estimated and low rainfall is under estimated. In our study, we find that raifall flow is predominant during rainy season that contributes to dams outflow. Yet we haven't found any data that supports the contribution of subsurface flow into the outflow.

Keywords: TRMM, DEM, rainfall, outflow

1. Introduction

Lake Maninjau is situated in Tanjung Raya District, Agam Regent. The type of the lake is tectonic volcano, comprising an area of 9.500 ha, 461 m above sea level. Tanjung Raya district surrounding the lake has a total area of 24.400,03 Ha surrounded by steep topography. Main rivers flowing into the lake are Batang Limau Sundai, Batang Maransi, Bandar Ligin, Jembatan Ampang, Batang Kalarian dan Tembok Asam. Outflow flows solely through Batang Antokan that ends in the Indian Ocean in the west. The outflow is used for hydro power of 686 MW as well as for irrigation of paddy field of 4200 ha. Topography classes consist of flat (0 – 8% slope), mild (8– 15%), fairly steep (15–25%), steep (25–40%) and very steep > 40%. Topography in the North-West is fairly flat (0-2% of 115,51 ha). Topography in the East-South is hilly with slope of >15% as much as 95.79 ha.

Table 1. Inflow and outflow of Danau Maninjau
From instant measurement, 25-26 March 2013

No.	Tributaries/Location	Discharge m3/s
1	S. Maransi, Jorong Gasang Maninjau	0,044
2	Batang Air Karambia , Bayur	0,047
3	S. Rengah, Bayur	0,573
4	S. Bandar Katik, Bayur	0,588
5	S. Batang Banduran, Bayur	0,103
6	S. Banda Koto, Bacang Koto Malintang	0,063
7	S. Languang, Koto Malintang	0,058
8	S. Bandataruka, Jorong Pauah Koto Malintang	0,135
9	S. Sape, Jorong Pauah Koto Malintang	0,345
10	S. Tan Malayu, Jorong Rambay Koto Malintang	0,117
11	S. Muara Kurambi, Jorong Baruan Koto Gadang	0,751
12	S. Muara Suau, Jorong Baruah Koto Gadang	0,690
13	S. Jaus, Koto Gadang	0,497
14	S. Asam, Pasar Rabaah Koto Kaciak	0,636
15	S. Kulirah, Pasar Rabaah Koto Kaciak	1,227
16	S. Limau Sunday, Jorong Kugu Baru Maninjau	0,147
17	S. Balok Jorong Bancah, Maninjau	0,069
18	S. Tumayo, Jorong Kukuban Maninjau	0,036
19	S. Muara Pisang, Jorong Pasar Maninjau	0,316
	Sum of inflow	6,442
	Outflow	
1	Batang Antokan	14.13

Source: Dinas PSDA Sumbar

Instant measurement on 25 and 26 March 2013 shows that input inflow is smaller that the outflow (Table 1). There is a discrepancy between inflow and outflow that cannot be explained by hydrologic measurement alone. This condition raises a concern that it may disrupt the operation of the hydropower since the outflow into Batang Antokan does not reflect water use by turbine, and the outflow cannot be controlled by power plant operator. This condition raised two hypotheses. First, the difference between outflow and inflow results from subsurface flow from soil surrounding the lake. Secondly, the difference results from direct precipitation on the lake surface. There is no research that has been done to answer this question due to difficulty in measuring parameters related to the problem. Therefore, indirect method is proposed in this study by the use of satellite data.

2. Methodology

Secondary data for rainfall, discharge, and land cover are gathered from Dinas PSDA Sumatera Barat. Quantitative analysis is employed in this study. Topographic map is processed from DEM (Digital Elevation Model) from SRTM (Survey Radar Topographic Mission) CGIAR-CSI in 90 m. Rainfall data are processed from TRMM over Lake Maninjau dari tahun 2000 to 2010 TRMM in 0.5^{o} x 0.5^{o} resolution. Sampling points are taken around the lake (6 points) from the TRMM and are labelled as in Fig. 1. Data are processed to obtained daily rainfall time series for further analysis.

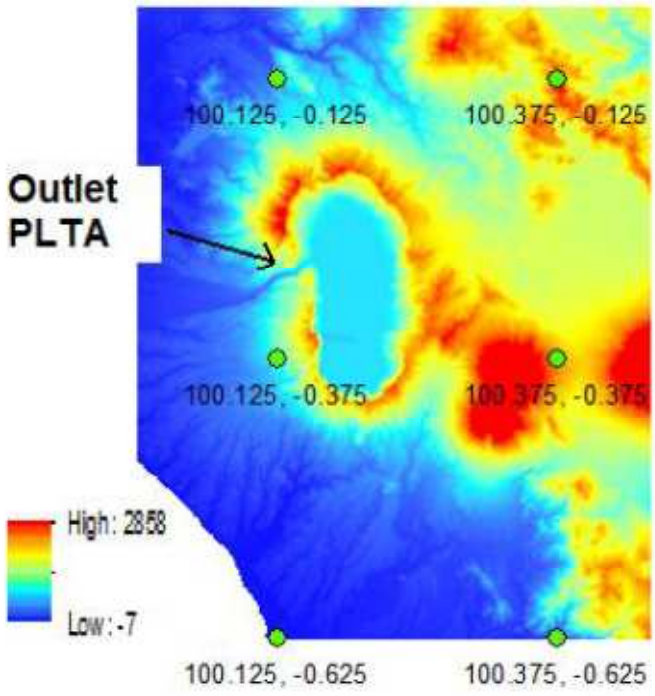

Figure 1. Topographic map of Lake Maninjau and TRMM sampling positions.

3. Results and Discussion

Rainfall data from Maninjau station from 1984-2000 shows that monthly rainfall average is 299 mm, and annual rainfall over this period is 3661 mm. The wettest month is November and the driest month is June. Annual rainfall exhibits a decline trend over the period. For instance, in 1984 the rainfall is 1984, but in 2000 it drops to 2000 about 50 %.

Discharge for hydro power is approximately the same with outflow into the river. Discharge measurement from 19 rivers flowing into the lake on March 26, 2013 shows that total discharge is 6.44 m3/s. This discharge is fairly small compared to annual average outlfow. There is an indication that some portion in the outflow comes from direct rainfall and subsurface flow of the catchment.

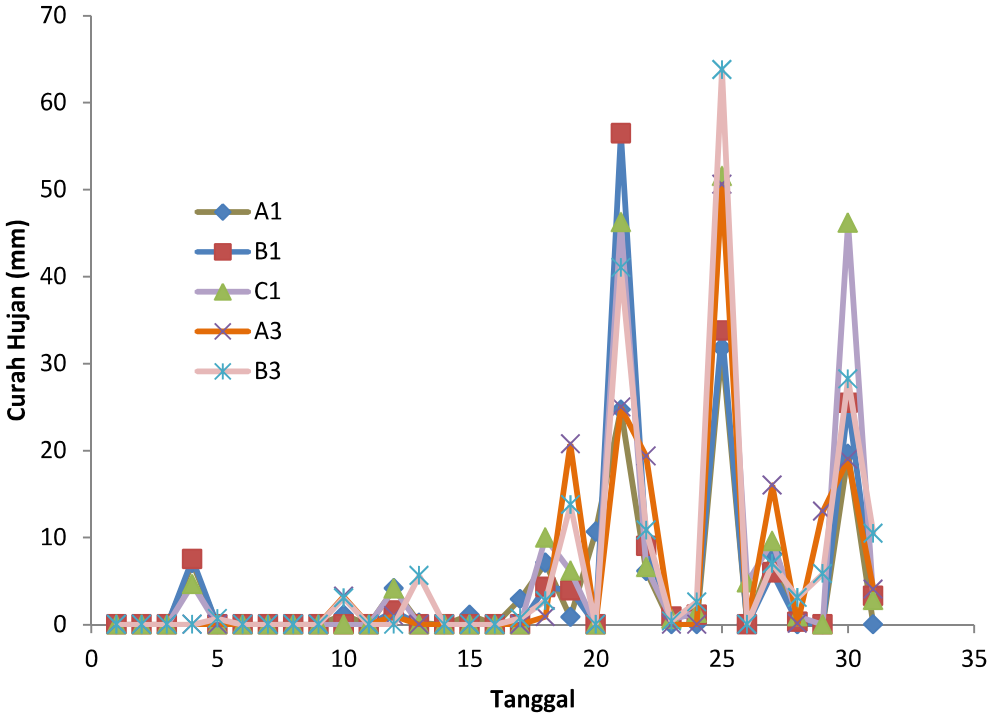

Figure 2. TRMM in March 2013

To confirm these hypotheses, we plot TRMM data in March. TRMM data shows that on 25 March there is rain around the lake. There is no rain on 26 March. Maximum point rainfall is 63 mm. Assuming all rainfall flows into the lake surface, maximum discharge due to the rain can be calculated as:

$$Q = (63/1000)x9500x10000/(24x3600) = 69.27 \text{ m3/second.}$$

that comes solely from the rain. If subsurface flow is taken into account, we need to estimate time to reach the lake from topmost ridges and retained flow by local topography after the rainfall event.

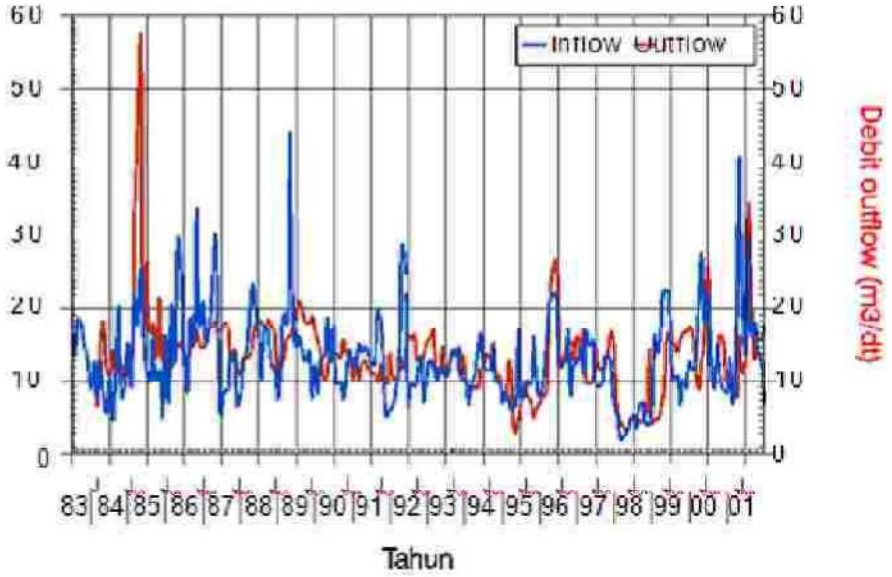

Figure 3. Inflow and outflow of Lake Maninjau 1983-2001 (Source: Dinas PSDA Sumbar)

Fig. 3 shows that fluctuation of outflow is almost in phase with the inflow. This indicated that both surface precipitation and surface runoff may have significant contribution to the outflow.

Table 2. Discharge in Batang Antokan in 2009-2011

No	Month	2009	2010	2011
1	January	4,72	14,00	30,00
2	February	5,01	13,20	30,50
3	March	3,84	20,80	28,20
4	April	4,71	24,30	25,60
5	May	3,15	38,70	17,70
6	June	3,34	20,40	10,60
7	July	1,82	14,60	31,80
8	Agust	5,13	17,00	18,60
9	September	9,01	17,40	19,20
10	October	7,52	20,70	31,40
11	November	11,31	17,60	18,50
12	December	10,08	20,40	20,30
	Average	5,80	19,93	23,53

Source: Dinas PSDA Sumbar

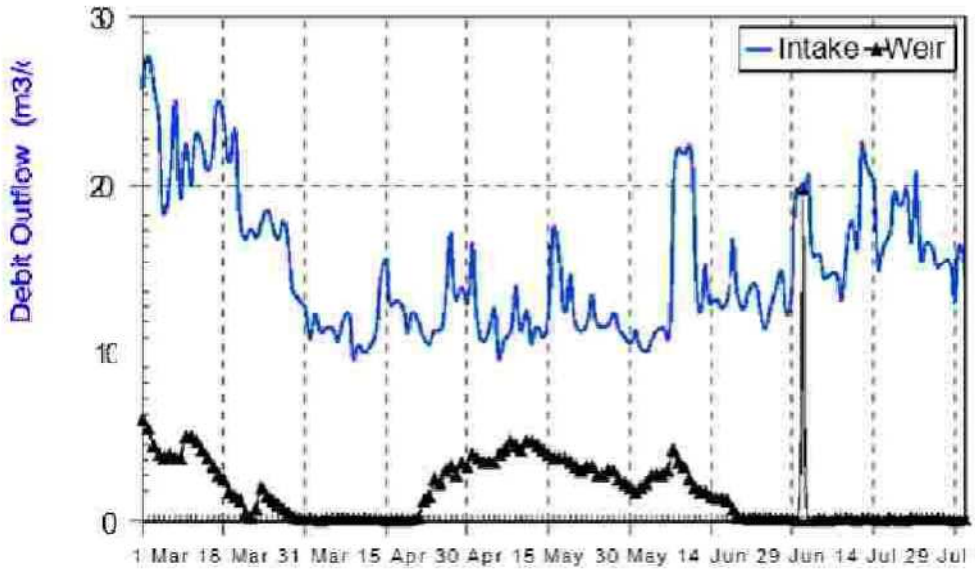

Figure 4. Flow to hydropower intake in 1984.
Source: Dinas PSDA Sumbar.

Inflow and outflow between 1983-2001 shows that outflow is smaller than inflow.

In three years, there is an increase in the outflow of the Antokan. In the mean time there is no increase in rainfall that contributes to the flow (Table 2). Theoretically, this is only possible by subsurface flow. Yet, retention time from rainfall events to the subsurface flow remained questioned.

4. Conclusion

Analysis of TRMM and ground-measured rainfall shows that the difference between inflow and outflow comes from direct rainfall over the lake. Yet, TRMM alone does not explain the remaining flow after rainfall events. This leads to another hypothesis that subsurface flow plays an important role in the inflow magnitude. However, we cannot prove the contribution of the tributaries in the inflow component. This is important in water conservation i.e. priority area among the tributary's sub catchment. There is an opportunity to study the contribution od subsurface flow in the difference on inflow-outflow.

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