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Floods and climate change - observations from Java

by

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Summary

Java is exposed to a number of factors that affect the flood risk and flood vulnerability, such as (in random order): El Niño (mesoscale) climate oscillations; global climate change; volcanic eruptions and earthquakes; changed land use; land subsidence related to groundwater abstraction; sand mining; river regulation; and general development of the physical infrastructure. With land slides as a related calamity, serious (and apparently escalating) consequences to human lives, crops, properties and infrastructure have occurred in recent years.

Flood proofing measures are in progress or are being planned at the national, province, regency/municipality and community level of administration. They include flood storage capacity; dykes; flood channels; drainage (flow) capacity maintenance and enhancement; land conservation in headwater areas; erosion control (terracing, re-greening, reforestation and sabo works); flood hazard mapping; public awareness; and forecasting and operational warning.

Acronyms and abbreviations

BIT: Bandung Institute of Technology

ENSO: El Niño Southern Oscillation

IPCC: Inter-Governmental Panel on Climate Change

Glossary

Adaptation: Adjustment to new circumstances

El Niño is an occasional eastward surface drift in the Pacific Ocean along Equator, causing a temperature increase of more than 0.5°C across the Central Pacific. In most years the warming lasts only a few weeks or a month; but when the it lasts for many months, related weather anomalies can be serious and widespread, such as low rainfall in Indonesia. The reverse phenomenon, La Niña, is a westward surface drift in the Pacific along Equator that is related to increased rainfall in Indonesia. The frequency of El Niño events is 2-7 years and the duration can be 1-2 years

Flash flood: An abrupt flood caused by extreme rainfall in upstream mountainous areas; difficult to predict more than a few hours in advance

Flood damage: (1) The actual damage done during a flood that has occurred; *or* (2) the estimated potential damage done due to floods (over a period of time)

Flood impact: In Java, same as flood damage (because the impacts are negative. In some other Asian countries, like Bangladesh and Camodia, flood impacts can be positive)

Flood preparedness: Due awareness of the flood risk, and knowledge and ability of appropriate response. A good flood preparedness is supported by measures such as awareness campaigns, education, and flood proofing measures

Flood proofing: Preventive (structural and non-structural) measures to reduce the impact of floods; can include land use planning, operational warning and contingency planning

Flood protection: Measures (such as embankments, storage and drainage, and reservoir operation) to reduce the flood risk - *'to keep the floods away from people'*

Flood risk: The probability that a location or an area will be flooded (or, in more detail, exposed to a certain flood level over a certain period of time)

Flood vulnerability: Conceptually, *'flood vulnerability* = *'flood risk'* x *'potential flood damage'*

Flood-prone: With a high flood risk

Mesoscale (in meteorology): Somewhere around 10-30 years

Mitigation: Reducing an (adverse) impact (once the damage has occurred)

Sabo: (1) Japanese word for *'erosion control';* (2) name of a school of comprehensive erosion control management, with a particular view to mountainous areas, and involving structural adaptation and maintenance of vegetation cover. Introduced in Japan by a ministerial decree from 1871, based on an ancient national tradition for forest conservation; and applied in Indonesia since 1970. *Ref. Okamoto, Masao (Jan 09): The structure of sabo administration, published on the website of the International Sabo Network: http://www.sabo-int.org/*

1 Introduction

In late December 2007 and early January 2008, persistent heavy rains led to overflowing rivers, flooding and landslides throughout Indonesia, resulting in numerous fatalities and crop losses. The two largest river basins, Bengawan Solo and Brantas (Central and East Java) were the hardest hit - particularly the former - with more than 100 people killed and hundreds of thousands affected.

A recent study of climate change vulnerability[1] observes that

> *'... Jakarta in Indonesia comes out as the top most vulnerable region in SE Asia. Moreover, the areas in western and eastern Java are also vulnerable using the regional standard.'*

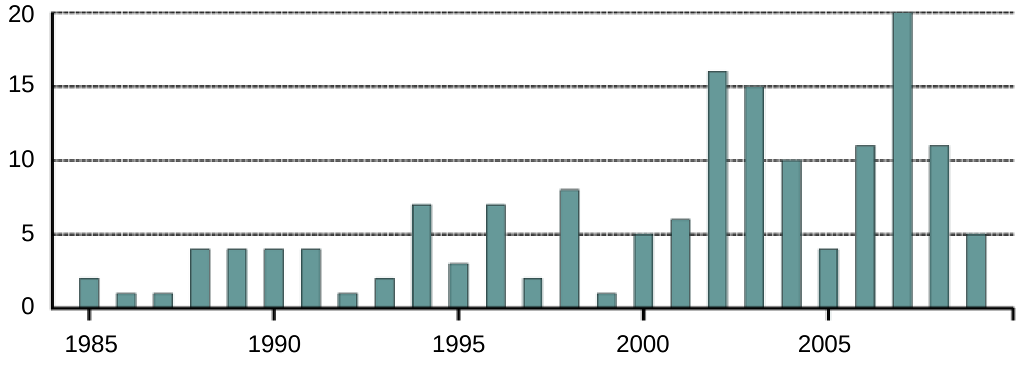
The present paper provides a summary of the related hazards of floods and climate change in Java.

2 Floods and flood risk

Recent severe calamities in Java include a mudslide on the northern shore in January 2006; floods in Jakarta in early 2007; and floods in the Bengawan Solo Basin in December 2007/January 2008, and again in early 2009.

There is some convincing evidence that the flood risk is increasing, as indicated by the figure below. The figure shows 154 flood events in Indonesia - more than 6 per year, but clearly escalating over the period. 54 of these floods were classified as severe; more than 40 of the floods occurred in Java, and most of these in the Bengawan Solo Basin.

Figure 1: Number of floods per year in Indonesia



Data: Dartmouth Flood Observatory: Global active archive of large flood events

[1] Yusuf, Arief Anshory and Herminia A Francisco (Jan 09), p. 13. This study evaluates the vulnerability on the basis of exposure, adaptive capacity, and population density. Java has a high vulnerability, even if the adaptive capacity is high, because also the exposure and the population density are high

Figure 2: Location map

The 2007/08 floods and landslides in the Bengawan Solo Basin killed more than 100 people (mostly due to landslides) and affected hundreds of thousands. A major road (between Solo and East Java Province) was cut off, impeding access to the worst affected disaster areas. In Solo municipality, some 6,500 households were inundated (and many more elsewhere in the basin), with the worst damage in the poorest neighbourhoods. The damage was estimated at around 200 mio. USD, including damage to crops and infrastructure.

The direct cause of these floods were intense rainfalls over the upper parts of the basin, peaking at 124-141 mm/day (a 55-500 years return period). The related river flows varied from place to place between a 30-years and a 50-years return period, with the flood protection schemes being designed for return periods of 5-10 years.

Figure 3: After the floods: Flood height during the Dec 07/Jan 08 flood, Solo City (Surakarta)

At the same time, in the adjacent Brantas Basin, rainfalls were recorded at up to 578 mm in 23 hours (at one station, Dampi). In the largest reservoir in that basin, Sutami, the water level increased by 7.97 m over 24 hours; but comprehensive flood damage was prevented, due to adequate control structures, completed river improvement projects on the Brantas mainstream, and a functional warning system.

In January-March 2009 a series of four floods occurred in the Bengawan Solo Basin. These flood inundated a smaller area than in 2007/08, but the duration was longer. The damage was estimated at around 100 mio. USD.

In this basin, the floods and their impacts were amplified by watershed degradation, lack of flood control structures, incomplete river improvement projects, lack of drainage and storage capacity, and lack of an operational flood forecasting and warning system.

Figure 4: The Sutami Dam, Brantas Basin

The Sutami project was completed in 1972, with a live storage of 253 mio. m3.
Since then, due to siltation, the live storage has decreased to 148 mio. m3

Figure 5: Flash flood, Brantas Basin, 2006

3 Climate change effects

According to Yusuf (Jan 09, page 6), the dominant climate-related hazards for Java are droughts, floods, landslides, and sea level rise.

Studies reported by Ratag (07) and Susandi (07) indicate long-term increases in temperature, evaporation and average rainfall, as well as increasing occurrence of extreme rainfalls - a main cause of floods in Java.

In comparison, an IPCC study indicates a slight long-term decrease in rainfall over Java[2], but supports the possibility of increased rainfall irregularities, including extreme rainfalls (in which case both the drought risk and the flood risk may increase).

On top of the long-term variations, Indonesia is exposed to significant ENSO-related meso-scale climate variability: Drought during El Niño episodes and extreme rainfall during La Niña episodes. For example, the 1997/98 El Niño episode triggered forest and bush fires over 9.7 million hectares in Indonesia[3]. (Such fires, in turn, cause soil erosion, release sediments, and add to the flood risk).

4 Cause-effect relationships

Java is characterized by

- a high population density (around 1,000 people/km2);
- a seasonality of rainfall and river flows that varies from low in West Java to high in East Java;
- a mountainous geography with related intense rainfalls (thunderstorms) and high rainfall variability, and a high risk of landslides;
- a dynamic morphological context, affected by a string of volcanoes and frequent earthquakes; and
- a well developed water management infrastructure with many reservoirs (including multi-purpose reservoirs) and irrigation systems.

Examples of causes and effects of floods in Java are given in the following table.

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2 IPCC Technical Paper VI (Jun 08) page 26

3 IPCC (2007), page 478

Table 1: Flood-related causes and effects

Causes:	• Global climate change • ENSO (mesoscale) climate variability	• Volcanic eruptions • Earthquakes • Deforestation • Forest fires	• Groundwater abstraction	• Changed land use • Infrastructural development • Population pressure
Primary effects:	***Flood risk*** • More frequent extreme rainfalls • Sea level rise	• Sediment releases, causing reduced storage capacity and increased flow resistance • Intensified runoff	• Land subsidence (up to 8-10 cm/year in some towns in Java)	***Vulnerability*** • Increased vulnerability
Secondary effects:	• More frequent and more severe floods • Land slides • Water logging	• More frequent, more severe and more abrupt floods • Land slides • Water logging	• Increased inundation	• Loss of human lives • Damage to properties, crops and infrastructure • Disruption of trade, education and employment

5 Adaptation measures

A distinction can be made between flood risk - the probability that a flood will occur - and the potential flood damage - once the flood occurs. Both the flood risk and the potential flood damage are partly manageable.

Adaptation must involve the central government, as well as the province governments, regencies/municipalities, communities, and civil society.

Flood risk management

The flood risk can be reduced by measures such as

- flood protection, flood retention and drainage schemes, including dykes, dams, reservoirs, and floodways):
- dredging of reservoirs and critical flow channels;
- river improvement projects (to increase the flow capacity);
- land conservation, catchment management planning; and
- erosion management (terracing and sabo works: Re-forestation, re-greening, sediment control structures).

This summary does not include land subsidence, which has different causes (and mitigation options) but similar effects.

Management of potential flood damage

The potential flood damage can be reduced by measures such as

- public education and awareness of floods and the environment;
- flood hazard mapping, to be mainstreamed into related sector planning and structural design; and
- operational flood forecasting and warning.

Figure 6: Neighbourhood flood alarm, Solo City (Surakarta)

International collaboration

Climate change is an international phenomenon. International collaboration includes technology transfer and capacity-building, data sharing, and collaboration within weather and climate monitoring and forecasting, including long-term assessments.

A new framework for disaster management

A new framework was provided by the 2007 Disaster Management Law, instituting preventive risk management along with response to specific disasters, and involving the entire society in the efforts.

The Indonesian Disaster Management Law No. 24/2007

This law has created three fundamental shifts of paradigm:

The first one is that the emphasis of disaster management is shifting from emergency response to risk management. This shift leads into substantial change of perception. In the past, disaster management was viewed as a series of complex, expensive and instantaneous specific actions limited to the emergency situation which were undertaken merely by the experts. Now, disaster management is not only about responding to emergency situation, but also how to undertake risk management.

The second shift of paradigm is about the issue concerning public/people's protection which was previously considered as the actualization of the government supremacy. Now, it is considered as the protection of human rights. Therefore, through democratization and regional autonomy, the Government accountability has moved closer to the constituent.

The third shift of paradigm is that a disaster - previously deemed as the responsibility of the Government - now has turned into a mutual concern of the society. On this note, disaster management is moving from the *'domain of Government'* to *'everybody's business',* where all the aspects of disaster management, such as the policy, institutional, coordination and mechanism must include the participation of civil society and the private sector.

Quoted from Triutomo (Dec. 08), page 4

6 Conclusion

Two recent floods in the Bengawan Solo Basin have caused losses of human lives and damage for a around 300 mio. USD.

During the first of these floods, in 2007/08, the adjacent Brantas Basin was exposed to comparably extreme rainfalls, but the damage caused was much less, due to effective structural flood protection.

There is clear evidence that the flood risk has increased significantly over the last decades. Climate change - particularly the expected increased rainfall irregularity - will further add to the risk.

A number of management options are available to reduce the flood risk and the vulnerability to floods.

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