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View of Flood Disaster Management in Indonesia and the Key Solutions

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ABSTRACT:*Over the years, Indonesia has seen many flood disasters that have brought about great losses. The aim of this study is to address key issues that lead to flooding problems in Indonesia in response to the challenge of recurrent flood events. An overview of the past flood disaster profiles and ongoing flood management are presented. The problems with the current situation are identified and the critical solutions are recommended to manage flooding and mitigate the negative impact in a more sustainable way. This study shows that man-made factors, natural causes, and managerial issues are the factors that have contributed to the problem. The coordination and the public awareness are the challengesin improving the flood management. Efforts have been made to alleviate the problems through legal framework establishment, community participation programs, and flood-control projects. In the post-disaster stage, the authorities and public have been quite responsive. However, prevention and preparedness are still lacking. The overall current flood disaster management may lead to more recurrent events and cause severe impacts. Sustainable actions are needed to solve these problems that include environment-based flood integrated countermeasures, improving water retarding function, eradication of deforestation, meteorological and hydrological prediction, and political will and law enforcement.*

Keywords *–Flood disaster, Indonesia, disaster management, environment, flood countermeasures*

I. INTRODUCTION

Flooding has been recognized as one of the worst disasters[1]. It is one of the most frequent and expensive natural disasters in the world. Hundreds of millions of people around the world have been affected by floods. Floods lead to social and physical losses and may have significant impact on the economic condition of a nation. The worldwide distribution of natural disasters in the last decade, categorized by disaster type, is depicted in Fig. 1. It is noticeable that flooding is the most chronic natural disasters in terms of the number of occurrences and the impact on humans.

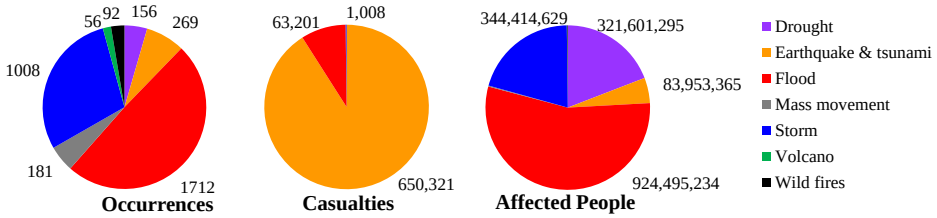

Figure 1. Worldwide natural disaster (2004–2013)[2]

Indonesia is an equatorial, tropical country with around 17,000 islands. With a total population of approximately 237 million people, it is the fourth most populous country in the world. Indonesia is frequently hit by natural disasters. Almost regularly, Indonesia experiences floods, landslides, earthquakes, tornados, cyclones, tidal bores, and droughts. In the last decade, Indonesia has faced frequent, recurrent flooding every year in many parts of the country[2][3]. Compared with other countries, Indonesia is considerably more vulnerable to floodingdisasters[4]. It ranks third and seventh in the world in terms of flood occurrence and the number of people affected, respectively (Fig. 2).

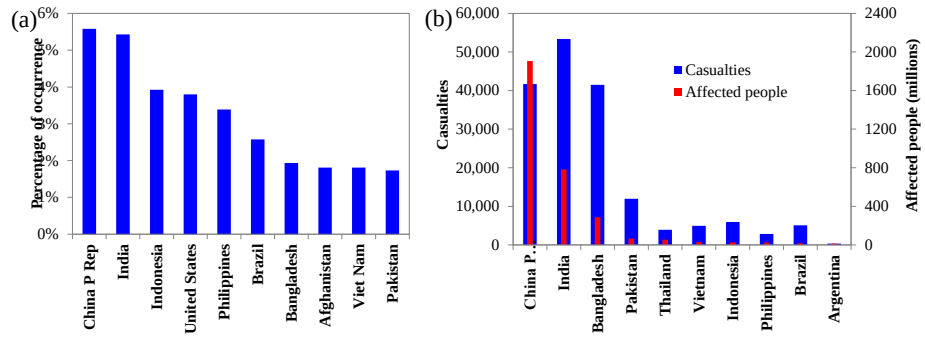

Figure 2. (a) Percentage of worldwide flood occurrence by country (1970–2011); (b) Number of casualties and affected people due to floods by country (1970–2011)[2]

Flood disaster management in Indonesia has not been as widely implemented as expected[5][6][7]. Between 2004 to 2013, flood occurred annually and affected more than 12 million people[8]. Annual incidences of flooding were worst in 2008 and 2009; however, these events only appeared as "routine" mass media coverage[9][10][11]. Environmental scientists believe that an increase in population, exacerbated by the effects of climate change, have contributed to these flooding catastrophes[12][13]. Although much work has been done by the government of Indonesia (GOI) to manage the flood problem, the complex issues, including budget allocation issue, awareness issue, and the need for expertise, remain challenges in achieving efficient flood risk management[5][7][14][9].

A few studies based on the flooding issues in Indonesia have been conducted, each dealing with various aspects of the problem. Some studies have researched the technical and engineering aspects of flooding, e.g. flood modeling, GIS utilisation, hazard mapping, and prediction [17][15][16]. Other studies have discussed flooding impacts, including physical damage, health risks, economic damage, and numerous other factors [14][18]. Several papers concerning the social and managerial aspects of flooding in Indonesia, such as public participation, non-physical countermeasures, governance, and regulatory issues, have also been written [5][17][9][12][19]. Some of these studies focused on a particular part of the country rather than the entire country. Scientific papers, in particular, still have limited discussions on concrete and deliverable solution that might be realized to reduce flood occurrence based on identification of the flooding problems.

With respect to the background described above, the objectives of this paper include: to identify the cause of subsequent flood disasters in Indonesia based on the profiles of past flood events and the present state of flood disaster risk management; to evaluate the effectiveness of current flood disaster management, and; to formulate the concrete solutions of reducing flood risk in Indonesia. The critical information provided in this paper and the proposed solutions are expected to be useful for the country to cope with future flood problems.

II.METHODOLOGY

2.1 Profile of Indonesia as Study Area

Indonesia is an island nation in South East Asia, located in the equator lying between 11°S to 6°N and 95°E to 141°E. Indonesia's total land area is 1,919,440 km^2, making the world's 14th largest country by total area, and includes 93,000 km^2 of inland water or accounts for 4.88% of country area. The population, as recorded by Statistics Indonesia in 2011 is 237,424,363, with the average population density of 125/km^2. The population is heavily concentrated at Java Island. Its population is 139 million inhabitants or accounts for 57% of Indonesia's population, making the world most populous island. The capital, Jakarta, is located in the western part of Java Island. Indonesia is classified as developing country with lower middle income. It has emerging market economy with current average per capita GDP is $3,464. Abundant natural resources contribute significantly to Indonesia's total wealth.

Indonesia has a special characteristic of climate including the influence of monsoon season, tropical climate, and oceanic climate[20]. The climate in Indonesia is predominantly tropical, with two distinct monsoonal wet and dry seasons. The wet season starts from November and ends at March, which brings the rains, and the rest is the dry season. Its special climate characteristic contributes to the vulnerability to hydrological/climatological disaster. Average annual rainfall is considered quite high, which measures as much as 2000–3500 mm in the lowlands but up to 6000 mm in the mountainous area. From average precipitation amount of 2700 mm, about 90% becomes overland flow as a surface runoff, while the remaining of about 278 mm goes through infiltration/percolation[33]. Indonesia is a humid tropical country with average humidity of about 80%. Temperature usually ranges from 26 to 30°C and varies little throughout the years.

In the 1950s, the landscape of Indonesia was mostly covered by tropical rain forest for approximately 77% of the country[21]. However, the area of natural forest cover decreases significantly year by year. Currently, forest comprises only 51.8% of total land area. Between 1950 and 1985, Indonesia lost 27% of its forest area or 0.77% per year. Large scale deforestation driven by the expansion of urban and agriculture area as well as timber cutting. Moreover, destruction due to wildfires is a serious problem in Indonesia. The quite high growth of population in Indonesia of 1.9% highly contributes to the forest land conversion into other land uses.

2.2Data Collection and Research Method

Secondary data in the form of records of flood disaster events and the consequences is obtained from Indonesian Disaster Data and Information Database (DIBI) provided by Indonesian National Board for Disaster Management (BNPB) (Indonesian National Board for Disaster Management, 2014). Facts on flood events in the regions collected from emergency situation reports are also used. Primary data is used in this study to provide the study with specific information about the effectiveness of existing countermeasure, current management being implemented, and public perception on flood disaster. This data was collected through field survey and discussion with local people and also with authority during October 2015.

The profiles of past flood events and the present state of flood disaster risk management are investigated trough a review of database, literature, and interview result.The underlying causes are identified and the current management of these causes is described using content analysis. On the basis of the present status, the effectiveness of current flood disaster management is analyzed, and future needs are pointed out. Finally, some insights for further improvement of flood management in technicaland regulatory arrangements directed toward the sustainable flood countermeasures are discussed.

III. FACTS ON INDONESIA'S FLOOD DISASTER

3.1 Flood Disaster Profile in Indonesia

Indonesia is found to be vulnerable to a variety of natural disasters such as drought, earthquake and tsunami, and flood. Figure 3 shows the chart of occurrences of disaster events and the total loss for each disaster type within 1974 to 2013, which is obtained from DIBI. Flood is defined as significant rise of water level in a stream, lake, reservoir, or coastal region. The criteria for defining flood incidents are those that have ten or more people reported killed, more than a hundred people reported affected, declaration of a state of emergency, or call for international assistance. Based on these criteria, the pie chart indicates that the flood is the most frequent disaster in Indonesia.

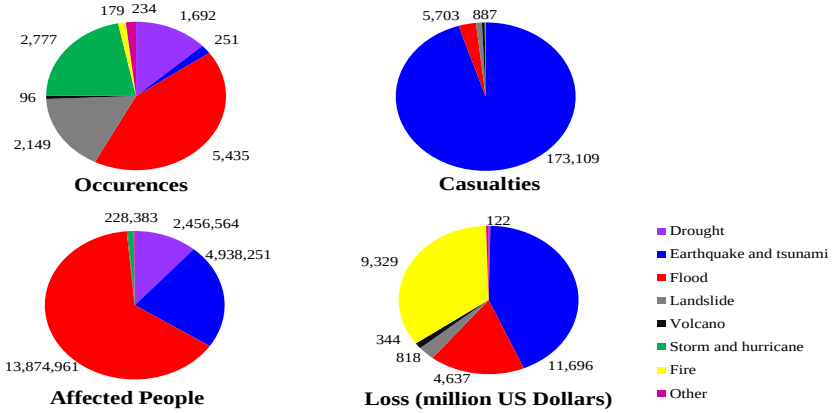

Figure 3. Natural disaster events, loss, casualties, and affected people by disaster type in Indonesia (1974–2013) (Source: National Disaster Management Agency, 2014)

In 2007, 2008, 2009, 2010, 2011, 2012, and 2013 the reported flood occurrence in Indonesia were 338, 490, 381, 990, 553, 540, and 520 events respectively, showing the tendency of increasing. In the tremendous incidents in 2008, 191 people were killed and more than 150 thousand people were affected. In that year, the most serious floods were happened at Situbondo Regency at East Java Province and Jakarta capital city. The 2010 is identified as the year that suffered most from floods in the last five years that killed 502 people. Many floods took place repetitively in some provinces like East Java (January, February, May, June), West Java (February, March, May, September), Central Java (almost all months), and Jakarta capital city (February and October). The numbers of flood occurrence in Java islands are considered quite big, as in East Java Province alone in 2010 the number of flood is 10 events. Over last 40 years, Central Java Province has had the highest occurrences of flood (740), followed by East Java (662), and West Java (535)[8].

The flood disaster severity is determined based on its negative impact, usually including casualties, affected people, and economic damage. Flood is responsible to the second deadliest disaster in Indonesia's history of past 40 years. In terms of the number of casualties, it is in the second most severe disaster after tsunami (mostly contributed by 2004 Indian Ocean earthquake and tsunami). In terms of the damage, flood is in the third most expensive disaster after tsunami and wildfire. Millions of people in Indonesia have been affected by flood in last five decades, giving the flood the most serious disaster in terms of the number of affected people.

3.2Impact of Flood Disaster

Flood catastrophe could lead to some severe negative consequences directly and indirectly that include social, environmental, and economic impacts. These impacts vary with different severity according to the distance, vulnerability, and flood extent[7][17][11][12][18]. Major flood causes health problems, including community disease, injuries, and disabilities. The worst effect a flood creates is the loss of human life due to fast-flowing water and waterborne disease. In addition to the physical problem, the flood causes psychological stress. Lost the family member, evacuation, interruption of work, loss of home and livelihood may cause the enduring psychological impacts. One of the negative environmental disruptions due to flooding is the contamination of soil and water with hazardous substances because of the abnormal drainage system. Flood also destroys ecological habitat, resulting in the loss of animal and plant. Aside from the devastation in response to large floodwater, landslide and sedimentation brought by flood appear as another concern for environment. High velocity flooding may directly destruct the physical properties such as streamside, housing, infrastructure, and agriculture land. The failure of those assets and the cost to repair the destroyed construction brings the monetary losses[22]. Furthermore, the flood-related supply disruptions severely impede the economic activity of Indonesia[23].

Recurrent flood occurrences that have been faced between 2004 and 2013 in every year across the country have brought significant damages and losses. No less than 1500 people have been killed and around 12 million people have been affected. Table I shows the data of damages and losses in this period obtained from DIBI[8]. In Jakarta, flood in January and February 2007 is considered to be the greatest flooding in last three centuries. Flood induced by high rainfall with 195 mm/day rate has inundated about 40% to 70% of the capital city area and about 320,000 people were driven from the houses by floods. The flood disaster took 80 lives in total due to being swept, flood-related disease, and electric stun. The total monetary loss due to 2007 flood is estimated to be in the range of more than 400 million US dollars. On October 2010 a devastating flood struck TelukWondama Regency at Papua Province. Heavy rains caused destructive flash floods, landslides, and mudslides, which have killed at least 161 people. The flood caused damages to major infrastructure facility include the airport and brought more than 30 million US dollars in losses[24]. In 2013, Jakarta has suffered from severe flooding again, which caused 33,500 people were displaced. In this year, the maximum daily rainfall of 168 was somewhat lower than 2007 flood event; however, it was distributed evenly over the region. In the middle of 2013, Ambon City flooding has caused the death of 11 people. In the end of 2013 and beginning of 2014, many cities have experienced flooding, including Manado City at North Sulawesi Province, Medan at North Sumatera Province, Kudus at Central Java, and Samarinda at East Kalimantan.

Table I. Flood damages and loss in Indonesia between 2004 and 2013

Damage	Quantity
People killed	1,546
People injured	105,180
People evacuated	3,007,125
People affected	12,771,746
Houses damaged	2,268,356
Schools damaged	6,251
Bridges damaged	454
Land damaged	1,161,170 Ha

Source: National Disaster Management Agency, 2014.

3.3 Present Status of the On-Going Management Measures

The current organisation is Indonesian National Board for *Disaster* Management (BNPB), a ministerial level non-departmental government institution[24]. According to the Law of Republic of Indonesia Number 24 of 2007 concerning disaster management[25], the roles of BNPB in disaster countermeasures cover three stages: pre, during, and post disaster circumstances. In the less disaster prone area, pre-disaster tasks comprise of

preventing the disaster by protecting natural resources from overexploitation, planning the disaster countermeasures plans, increasing community resilience, estimating the disaster impact, analyzing the disaster risk and reduction, and conducting the education. Countermeasures in disaster-prone area typically embrace all aspects of preparedness and mitigation. Observation and prediction, emergency response plan, and early warning system are the elements of disaster preparedness under BNPB responsibility. Works done during disaster are focused on damage analysis and rescue and evacuation. The post-disaster responses enable the disaster area recovery through rehabilitation and reconstruction. They are made up by physical elements consisting of environment, facility, infrastructure, and residential recovery in addition to non-physical ones such as social, psychological, economy, culture, governance, and public service.

The implementation of disaster management at sub-national levels is handled by the representative of BNPB in every province and regency/municipality, known as Regional Board of Disaster Management (BPBD)[21][25]. In general, the responsibilities of BPBD are identical to those of BNPB, but they are different in the jurisdiction level. The BPBDs play major roles in the disaster management activities in their respective areas backed up by BNPB and Indonesian military, thereby the BPBD is expected to act quickly with well thought-out plans. The mandates of the government, whether central or local, are set out in the establishment of BNPB or BPBDs and their disaster management policies to maintain public welfare. Furthermore, the governments have responsibility to include disaster countermeasures and disaster risk reduction in the developmental works with allocating specific budgets for those purposes.

In the implementation of disaster management, BNPB works along with related state-owned and non-state-owned corporations. Regarding prediction of flood, BNPB collaborates with Meteorological, Climatological, and Geophysical Agency (BMKG), Coordination Agency for Surveys and Mapping, Ministry of Public Works, and its local office in every region, river basin management authorities, and so forth. Indonesia Red Cross Society, National Search and Rescue Agency, Ministry of Social Affairs are the main institutions concerning to flood emergency response. The mechanisms of collaboration to those institutions are governed generally.

3.4 Past and Current Efforts of Flood Alleviation

There have been some recent efforts to alleviate the wide range of flood problem through structural measures at national level, either independently or by assistance of international agencies. For instance, land use spatial planning in Jakarta Flood East Canal Project, integrated water resources management carried out by Brantas River Basin authorities, provision of adequate coastal inundation problem at low-lying area of Semarang, and resettlement of river squatter in Solo River[26][11]. Some major river including Ciliwung River, Brantas River, and Citarum River have been equipped by system for flood warning for operational purpose[9][11]. However, instead of rainfall short-range forecasting, they are supplied by real time rainfall monitoring, long-range rainfall forecasts, or even none, possibly due to lack of expertise. Technical cooperation with some developed countries is undertaken in establishing model for flash flood disaster mitigation management with empowering local government or society and also in other fields. On the water resources side, some projects to promote water supply and demand efficiency were launched including stream normalisation from Mt. Merapi volcanic debris and dredging of some vital reservoirs, such as Sutami Dam at Brantas River Basin[11][27]. Rainwater harvesting is encouraged as part of flood and drought management such as in Semarang city[7][17]. Within the last couple of years, significant investments and efforts toward Jakarta flood reduction has been made. It includes the large scale dredging project and squatter clearance, pump revitalisation, promoting the construction of 2 million infiltration wells.

Recently, raising public participation program has become attention of GOI. Many actions have been done to promote the consciousness in flood hazards and to increase community preparedness in managing the surroundings hazards, for instance public empowerment for disaster risk reduction in Jakarta, dissemination of flood knowledge to the community, conducting workshop of local government and community leader, and education through formal and religious organization[9][7][12][28]. In order to increase the resilience in facing flood disaster, the government has been encouraging the public to have self-initiative in facing their surrounding flood hazard by their own local resources, or known as of community based disaster management. In addition to the improvement of the governance matters, recently Indonesia has noted much advancement in the research of flood disaster prevention, which should contribute to the development of effective and efficient flood countermeasures plan. Strengthening the national disaster database in Indonesia through DIBI Project introduced by UNDP and GOI is one attempt to facilitate risk assessment and pre-disaster decision making. Some scientific meetings have been conducted to discuss the flood disaster in Indonesia as well as integrated flood and drought management, e.g. the establishment of Indonesia's Partnership for Disaster Risk Reduction[25].

As found previously, in the strike of disaster, the authorities often are quite responsive to the events. Local military force and volunteer rescue workers provide rescue and evacuation service organized by local government quickly. In the TelukWondamaflash-flood case, the Ministry of Health through provincial health

office, district health office, and port health office has responded to the situation by supplying medical services and logistic within one-day aftermath the disaster[29]. No less than 10 thousand people, that consists of armed forces, civilian defense unit, red cross, search and rescue agency, and other units have been assigned by the GOI to assist the flood emergency responses at the 2007 Jakarta flood[30].

Although much effort and resources have been expended for post-disaster response, the prevention and preparedness actions are seen to be lacking. The policy has been addressed to emphasize natural hazards rather than the cause of vulnerability[6]. Inconduciveconditions for designing substantive plan are identified, which leads to the weak planning in both central and regional levels. Despite the established legal framework in the areas of disaster preparedness as elaborated in the review of policies and institutional capacity for early warning and disaster management in Indonesia[31], there remain difficulties towards the implementation of disaster management regulation. Indeed, today, the people obedience to law and professionalism in law enforcement in Indonesia remain low. Lack of coordination is still found between the central and provincial governments as well as with the counterparts. Along with decentralisation policy, Indonesia's disaster management is now in the transition from the centrally planned to the empowerment of local institution[23]. Notwithstanding the above, BNPB are continually to improve the system towards a more efficient coordination among elements. On the policy maker side, regional sectors often consider that the disaster handling is the tasks of BNPB and central government rather than synergistic mutual cooperation.

IV. ANALYSIS OF MAJOR CAUSES OF FLOOD DISASTER SEVERITY IN INDONESIA

In this section, the underlying causes of severe flooding in Indonesia and the current handling of these causes are identified. The analysis is conducted based on the review of the past flood events and the present state of flood disaster risk management. The effectiveness of current flood disaster management is analyzedbased on the present status. The content analysis reveals several causes of damaging floods which are described below.

4.1 Natural Caused

Flood is said to be natural if the cause is high rainfall intensity. Being the country with high annual rainfall, the problem of flood in Indonesia becomes serious[23]. Wet monsoon brings much rainfall through moist southwest wind that contributes highly to the flood in Indonesia[20]. Beside rain seasonal variability due to monsoon, the rainfall pattern also has unique interannual variability influenced mainly by ENSO. The variability of rainfall patterns varies in different areas of Indonesia at different times. The climate change likely triggers a number of flood occurrences[11][13][12]. Under climate change, the hydrological variables tend to have large spatial and temporal variability and the chance of extreme rainfall is significantly increasing, which make prediction is more difficult. There are more than 5590 small and big rivers in Indonesia[27], of which about 30% pass high density population. Except those located in Kalimantan, most of them have limited water conveying capacity. Moreover, generally, rivers are originated from the volcanic mountains that may convey much quantities of sediment. Hence, along with high rainfall in the catchment, the rivers pose more flood hazard due to river sedimentation. The determinants of flooding could be the combinations of those conditions and some other factors, such as the existence of low lying area, tidal effect, or river morphological factor.

4.2 Human Caused

Occasionally, flood is a natural phenomenon driven by rain. However, when the flood becomes recurring events with frequency more than its return period, factors linked to society or anthropogenic factors may be part of the cause. Overpopulation and its accompanying urbanisation pose significant risk of flood[9][12][22][27]. Along with the high population growth which is closely connected with industrialisation and poverty, the spatial layout would change. The need of more land has driven the deforestation. Land use alterations that are not considerately schemed contribute primarily to the forest degradation problem[11][21][23]. Furthermore, in many cases, watersheds are increasingly being degraded by extensive encroaching practices, such as illegal logging and uncontrolled land use change. Meanwhile, forest is essential to absorb the rainwater into the ground and vegetation helps to intercept the rainwater. Flooding will happen if the soil is saturated so that the rain water has no space to be collected on the ground. At the same time, the channel capacity is not sufficient to convey the excess water. In many urban areas the squatter settlements in the river passage are quite extensive, which causes channel narrowing[6]. There is significant evidence that this human activity along the river banks exacerbates the problem of flooding. These situations are widely found in Java Island and have brought many flood incidents as reported within past fifty years. In the big rivers, the erosion and sedimentation are also the contributing factor to the flooding problem. The large flood transports the sedimentfrom upstream and deposit on river bed, which consequently makes the river shallower. The habit of the people to throw the solid waste to the river body has received the high attention[27]. Due to the blockage of drainage with the garbage, the rainwater has no space to drain and eventually overwhelms the floodplain. Flood hazard map provided by

Indonesian National Board for Disaster Management highlights the region prone to flooding considering the contributing factors to flood[24], which shows that 309 out of 497 cities/regencies of the territory of Indonesia are at medium to high risk to flood threats.

The structural countermeasures have been the focus of recent flood handling programs. The planning of river works for prevention at the level of the whole river basin is indeed very essential. In many places in Indonesia, however, they are undertaken partially[14][9][24] and decided by local stakeholders' own account. Socio-economic feasibility is often insufficient, which makes the master plan exists more as a blueprint than as a thorough plan[23]. For many years, newly built flood control structures are destroyed by flood or else becomes the cause of flooding due to improper design without considering the aspect of design sustainability. Moreover, the delivery of implementation scheme is usually slow due to insufficient expertise[9][23]. In any case, ineffective existing flood management has contributed to the recurrent flood problem. Governance and accountability are still the glaring challenges encountered by Indonesia today in improving natural disaster management.

4.3 Contributing Factors to the Damaging Flood

Flood-related problem in Indonesia is liable to be the result of a combination of some factors indirectly. Besides the above mentioned factors, there are other aspects contributing to the damaging flood. In almost all cases, high death toll results from lack of flood warning[23].In order to provide a critical warning, there is a need for accurate and timely meteorological-hydrological prediction. However, generally, weather forecast provided by meteorological agency can only predict storm in relatively large spatial scale and give general alert [11][16][23]. Proper flood hazard mapping is still insufficient in regional scale, which may result in delayed flood responses.In the case that the system is well provided, the lack of understanding of forecasting and warning system by the lower organisation levels and low public responsiveness in early warning mechanism may hinder their full and effective implementation[21][23]. In fact, there are still unclear or overlapping role of authorities during emergency situation[9]. Schematic drawing showing factors contributing the flood disaster occurrences in Indonesia is given on Figure 4.

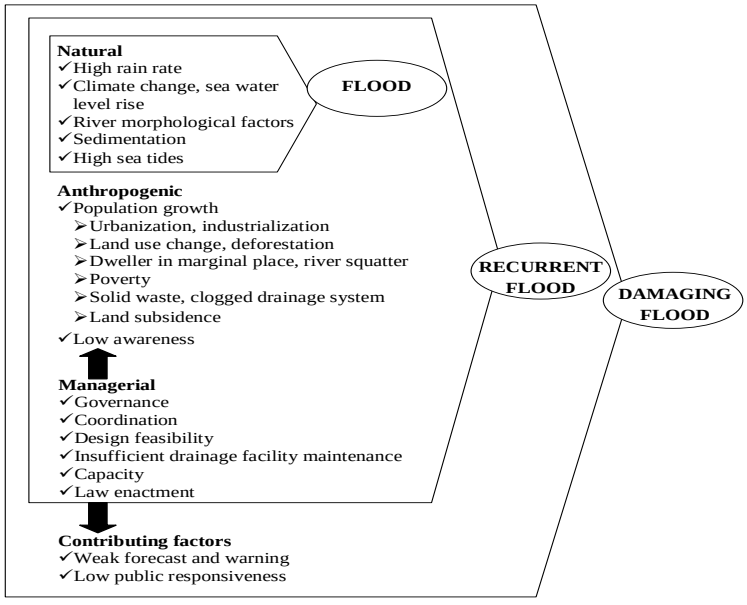

Figure 4. Factors and circumstances contributing to the flood in Indonesia

V.PROPOSED SOLUTIONS TO ACHIEVE EFFICIENT AND SUCCESSFUL FLOOD MANAGEMENT AND MITIGATION

Having the detailed knowledge of shortcoming of the existing system as elaborated previously, the subsequent attempts in improving the current management aimed at flood risk reduction could be formulated. This part offers integrated recommendation for resolving the urgent flood disaster problems in Indonesia upon analyzing the aforementioned state and problems. Recently, the international flood management has shifted toward more integrated one[19]. The key solutions are focused onthe deliverable *solutions for* sustainable development.

In order to stop the flooding from occurring recurrently in the region vulnerable to flood, such as Jakarta, the physical measures through construction works are now being conducted. Levee construction, dredging, shortcut or inter-catchment water transfer, and floodgatealong the river should provide defense against the inundation. Deep tunnel reservoir system which is currently proposed will greatly prevent the Jakarta municipality from flooding. Nevertheless, flood physical countermeasures have a limited capacity and economical constraints. The government should runlarge budget for structural measure.

5.1 River Restoration Program

As a matter of fact, drainage channel widening is not always a good solution. The large scale dredging throughout the channel provides the bigger channel capacity. In the low-flow condition, it causes the sediment accumulation therein, which requires additional maintenances. The dredging should be conducted only in the narrow part of the channel for the removal of the bottleneck. The river normalisation without enough assessment of river characteristic greatly changes the natural condition of the stream. It may even worsen the effects of extreme natural events if the structures fail to overcome the flooding. Regarding this matter, river restoration concept aiming to bring back the river to the natural states is recommended rather than the river engineering concept. Instead of increasing the channel capacity, the river normalisation is carried not only aiming to, but even further to provide wider riparian zone for protecting the environment. In addition, the relocation of the people from river bank as a part of channel normalisation works is needed based on the social engineering technique. The government housing policies should aim to encourage people living in the vertical housing in order to promote the urban basin revitalisation.

5.2 Basin-Scale Environment-Based Flood Countermeasures Plan

For upper of Greater Jakarta and other areas such as Bojonegoro, Manado, Samarinda, or Medan which has riverine flooding problem, the proposed idea is providing the environment-based flood integrated countermeasures plan in the river basins. For example, in Samarinda city, Karangmumus River, as a sub catchment of Mahakam River which is in critical condition is set as a pilot project. The idea is restoring the river bank by well preserving the riparian area. The vegetation surrounding the streams protects the environment, support the biodiversity, and increase the hydraulic resistance from flood. The natural preserved meander has big roles in flood risk reduction through preventing the erosion and sedimentation as well as providing the space for reserving the water. In accordance with this program, the traditional flood measures which now exist in the target area is adapted for supporting the idea of developing the basin-scale environment-based flood countermeasures plan initiated with a pilot project. In fact, Dayak community which is the main ethnic group in East Kalimantan has local wisdom of land utilisation. The Dayak common law regulates the forest utilisation and the activities to create a precondition for living in balance with environment. Involving the local people is a way to bring about the public participation in this program.

5.3 Improving Water Retarding Function

The flood hard countermeasure in Jakarta particularly has been focused primarily on conveying away the water as quickly as possible through the flood canals. In fact, it is important to understand that the rain water is not a waste but a source of groundwater recharge. The structural works providing river normal capacity in carrying the water should be balanced with the system to retain the water.

A natural way to reduce the runoff and increase the storm-water infiltration is by decreasing the whole catchment runoff coefficient through providing green space, which highly contributes to the reduced storm runoff. The man-made facilities include the household scale water harvesting such as recharge through infiltration pit and hole or the more sophisticated techniques such as detention pond and retention basin. In a condition where the river water volume is extremely big to be handled by the existing facilities, wetland and meander are significant to reduce runoff as well as recharge the groundwater resources. Applying the bioengineering technique in the basin-scale environment-based flood countermeasures plan project improves the basin retarding function, which can maintain the higher base flow during dry season and slow water releasing during the high flow.

In the advanced countries which are particularly less vulnerable to flood disaster, there are some strategies of flood control that put forward the harmony with natural environment. In Japan, along with control works introduce at the rivers, watershed protection is formally implemented forming the integrated flood disaster prevention actions. In order to reduce the level of vulnerability of flood in Indonesia, some good practices of watershed protection in Japan can be adopted. However, it should be noted that as a developing country, Indonesia has limitation to take full advantage of the scientific efforts. The selection and adoption of the possible means to be introduced in Indonesia case needs different strategies. Park retarding basin and school yard reservoir are the infrastructures recently introduced to the public facilities at urban river basins in Japan. The idea of school yard storage facilities is utilizing the outdoor sports fields to restore the storm water

temporarily during heavy rain. The construction includes depression reservoir or underground storage tank provided with discharge facilities and dyke around the storage location. This can be applied also in other public facilities, such as park or parking area. Figure 5 shows the illustration of this infrastructure.

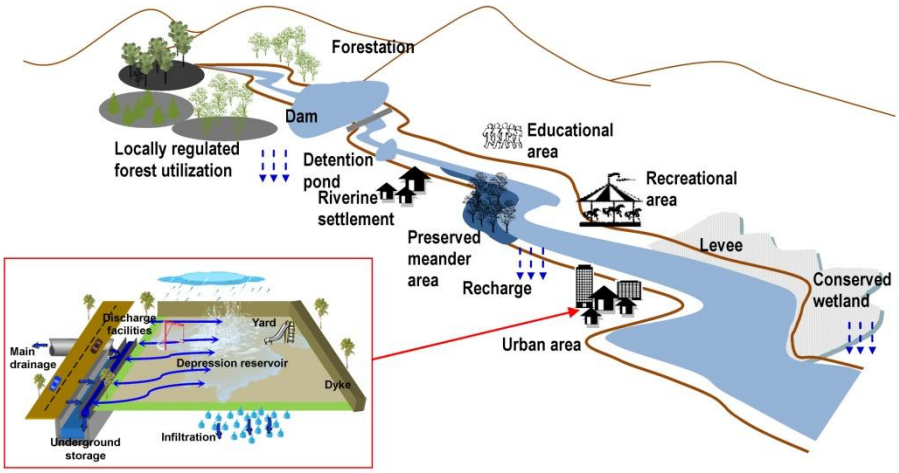

Figure 5. Basin-scale environment-based flood countermeasures plan and yard retarding basin

Even though this measure does not necessarily substantially reduce frequency of flooding, it contributes to the decrease of amount of storm water. It gives the added benefit by allowing the retardation of rapid drain into the river, water reuse, and finally groundwater recharges. By constructing storage facilities in 0.5 hectare school yard, the stored storm water is about 1000 m3. This amount is the equivalent of water needed for 5000 times of bathing. With more than 500 number of school in southern Jakarta, restoring the storm water by utilizing the schools yard could significantly alleviate the flood problem in the downstream of Ciliwung River. This illustration helps convincing the administrators to provide thesesystems. If such practice is successfully implemented, either with government subsidy, external support, or self-funding, it reflects the public concern over the flooding. Whilst there is a need to allow sufficient time for the familiarisation of the full system, the government might bring out a green building ordinance which establishes the standard for improving construction to allow much water to be conserved.

At the same time, this system also facilitates flood and drought management to overcome water shortage persists in many regions in Indonesia. The principle is providing more places to store safely the excess water during wet periods and allocating it efficiently during dry periods. Whilst construction of the large dams may be criticized because of the adverse environmental and social impact, as well as the financial aspect, the small reservoir locally called “embung” can be proposed. In order to promote the water conservation, there should be a policy of water conservation in Indonesia to encourage all citizens to reduce the runoff coefficient of each land plot in a basin as well as rain water harvesting.

In the case of constructing the flood countermeasure works, thorough and comprehensive planning, construction, and maintenance are indeed very essential to ensure their effectiveness. The environmental options in the flood physical countermeasures should be also included. It is expected the measures would sustain its long-term usefulness without adversely affecting other region or environment. As noted before, in post-disaster situations, when the damagesrestoration is required quickly, the quality of the construction is often ruled out. In effect, the reconstruction efforts are supposed to result in less-hazard-resistant structure. Care must be taken in designing the control works, whether the constructions will accommodate the dominant flood or design flood. Therefore, the fund wastages, which frequently occur due to ignorance of importance of sustainability, could be minimized.

5.4 Public Awareness and Participation

Non-structural measures could offset the tremendous expenditure of control works. Moreover, structural measures alone, which are effective in only certain flood magnitude, may not be sufficient. The big effort put on structural measures may cause a false sense of security of the public.Therefore, in parallel with the river restoration program, another important point is awareness on the cause of disaster related to human activity. Flood happens regularly, and the campaign of man-caused flood has been held extensively over recent years in Indonesia through government and NGO, but public awarenessremains low. Even so, the disaster education should still be implemented vigorously to ensure its entrenchment. Flood awareness is the basis of the developing public attitude to flood problem, and this is a prerequisite of community participation in flood prevention.

We identify two ways to increase public awareness in flood disaster. First, the adequate environmental education has an important role in the flood management program. It includes the insertion of ecological content in mainstream formal education, training of community group,target groupstraining for professional and employee for capacity development. Having made this point, public awareness fosters active participation of the community in the design of local strategies for flood control, known as community-based disaster management. In this notion, teacher, priest, and community leader as influential patrons play vital roles in bringing awareness in the society.

Second, the objective of developing basin-scale environment-based flood countermeasures plan is not only for flood control, but also raising public awareness. Providing the recreational area which allows the people to access the riparian area would become the part of the efforts. This area is arranged to have environmental education programs, which aims to increase people's knowledge and awareness about the environment and flood hazard. The components of the program are introduction of watershed management, river engineering to against flooding, local tradition, and flood drills. Maintaining the healthy of riparian area and showing the interconnection with other natural resources will encourage the people to conservation concern in the river basin.

Such symbiotic relationship between maintaining urban life for economic growth and conserving the natural resources in river basin is a great potential to contribute to the sustainable flood countermeasures. In parallel with flood hazard reduction, the benefit of the proposed program is an investment in public awareness enhancement that generates more resilient floodplain. The basin-scale environment-based flood countermeasures plan as illustrated in Figure 5 is expected to stimulate the greater resultants to the broader community by gradual accumulation of public positive response.

5.5 Deforestation Issues

Promoting forest conservation by eradicating illegal logging is the critical step toward solving the menace of flooding in Indonesia. The condition in Indonesia is quite difficult where population increasing threats natural resource. With proper spatial planning, the area could become urbanized without deforestation, and accordingly all the nature places in cities are thoroughly schemed as well. In order to ensure that the plan is executed as intended, oversee its implementation is no less important than the planning itself. In this regard, enforcing law of illegal deforestation plays important roles.

5.6 Meteorological-hydrological Forecasting

Preparing accurate and quick forecasting of severe rainfall and flood in operational setting provided by BMKG could help reducing the risk of flood catastrophe. Further, the adverse weather information should be provided at small scales in such a way that it can encompass the localized regions in the short term, i.e. a week to months in advance. In such a context, the forecasting can be viewed as an attempt to provide flood hazards outlook and warning in specific region or catchment. In Indonesia, each major river is managed by one river agency or organisation in charge of "in-stream" water resources management, water allocation, and infrastructure management within a particular basin. This agency could have an opportunity to play important roles in facilitating the flood prediction within one river basin system supplied by weather forecast product. Once the warning is issued by the agency, the responsibility for responding to the emergency situation addressed to the people is held by BPBD along with local government. In turn, support from local government is needed to raise the community capacity in reacting to the warning. Cooperation with international organisation with respect to assistance in finance, cutting-edge technology transfer, and capacity-building expertise will be necessary to realizing the idea.

5.7 Political Will and Law Enforcement

Programs of improving flood disaster management aresubstantially in line with Indonesia national developmental needs. Consequently, governmental at all levelsmust include them into overall development plan and formulate the policies. Furthermore, the program should include the provision of equitable developmentto all areas, especially at islands outside Java-Bali. One of the essential steps towards the successful program would be to increase the coordination and integration between central and local governments as well as between related state-owned and non-state-owned corporations.Strengthening the commitment of *poli*cy makers fordevelopment and implementation of the strategic approach to solve flooding problem accompanied by law enforcement are absolutely compulsory.

VI. CONCLUSIONS

This paper addresses the issues of flood disaster threats in Indonesia. A comprehensive review of progress achieved in dealing with flood management and their effectiveness are presented in detail. Flooding in Indonesia is a recurring event, and each year, floods cause losses in terms of human lives, infrastructure, livelihoods, and social and economic disruption. Man-made factors such as poor planning and management

compounded by natural factors are considered to account for this catastrophe. Overpopulation and its accompanying urbanisation are significant contributing factors. A legal framework in the areas of disaster preparedness has been established, and improvements in governance matters are being sought continuously. Basically, natural disaster prevention, mitigation, and rehabilitation are handled by BNPB, a ministerial-level government institution. It is supported by legal measures, special budget allocation, and professional experts. Nevertheless, there remain lack of coordination and difficulties towards the implementation of disaster management regulation. In the aftermath of a disaster, the people and authorities are quite responsive. However, the review identifies a lack of prevention and preparedness actions. On analyzing the aforementioned state and problems, the key solutions that are focused is the development of environment-based flood countermeasures plan which is initiated with basin-scale pilot project. The idea is restoring the river and maintaining the riparian area. Local people and their indigenous practices for flood mitigation should be involved to allow for the public participation. The promotion of storm water harvesting may not be an easy task; however, we consider that it to be the best solution to deal with water resource's constraints that lie ahead. Simultaneously, raising public awareness through environmental and flood hazard education should be integrated. Furthermore, eradication of deforestation is the critical step towards solving the flood problem; otherwise, human security in Indonesia will be endangered. Reliable flood forecasting and warning should contribute by alerting people about an impending flood rather than just reacting to the disaster. To conclude, political will and law enforcement are imperative in order to solve the flood disaster problems in Indonesia. The deeper discussion on technical arrangement of flood plain management through integrated flood and drought management will be explored in a future study.

REFERENCES

[1] Few, R. Flood hazards, vulnerability, and risk reduction, in Few, R. and Mattheis, F. (Eds.), *Flood Hazards and Health: Responding to Present and Future Risks*, Earthscan, London, 2006, 8-27.

[3] Tse, C. W. Do Natural Disasters Really Lead to Forced Migration? Evidence from Indonesia in *Proceeding of Northeast Universities Development Consortium Conference*, New Heaven, USA, 2011.

[2] Centre for Research on the Epidemiology of Disasters (CRED). *EM-DAT (The International Disaster Database)* [online]. EMDAT, Brussels http://www.emdat.be/, 2014.

[4] Dutta, D. and Herath, S. Trend of floods in Asia and flood risk management with integrated river basin approach in *Proceeding of the 2nd International Conference of Asia-Pacific Hydrology and Water Resources Association,* Singapore, 55–63, 2005.

[5] Wardani, S. P. R., and R. J. Kodoatie. Disaster Management in Central Java Province, Indonesia in *Proceeding of the 2nd International Conference on Geotechnical Engineering for Disaster Mitigation and Rehabilitation*, Beijing, China, 2008.

[6] Texier, P. Floods in Jakarta: When the extreme reveals daily structural constraints and mismanagement.,*Disaster Prevention and Management*, 17(3) [online]http://www.emeraldinsight.com/doi/abs/10.1108/09653560810887284 (Accessed 10 November 2015), 2008.

[7] Marfai, M. A., L. King, J. Sartohadi, Sudrajat, S. R. Budiani, and F. Yulianto. The impact of tidal flooding on a coastal community in Semarang, Indonesia.,*The Environmentalist*,28(3) [online] http://link.springer.com/article/10.1007%2Fs10669-007-9134-4#/page-1(Accessed 10 November 2015), 2008.

[8] Indonesian National Board for Disaster Management.*Indonesian Disaster Information and Data*[online]. BNPB, Jakarta. http://dibi.bnpb.go.id/DesInventar/dashboard.jsp, 2014.

[9] Rahayu, H. P., and S. Nasu, S. Good practices of enhancement early warning system for high populated cities - A case study for Jakarta Flood in *Proceeding of Society for Social Management Systems International Symposium,* Kochi, Japan,2010, SMS10-163.

[10] National Aeronautics and Space Administration (NASA).*Heavy Rainfall Floods Indonesia*[online] NASA Earth Observatory, USA.http://earthobservatory.nasa.gov/IOTD/view.php?id=8376, 2008.

[11] Hidayat, F., H. M. Sungguh, and Harianto.Impact of climate change on floods in Bengawan Solo and Brantas River Basins, Indonesia in *Proceeding of 13th International River Symposium,* Brisbane, Australia, 2008.

[12] Harwitasari, D., and J. A. van Ast. Climate change adaptation in practice: Peoples responses to tidal flooding in Semarang., Indonesia. *Journal of Flood Risk Management,* 4(3) [online] http://onlinelibrary.wiley.com/doi/10.1111/j.1753-318X.2011.01104.x/abstract (Accessed 10 November 2015), 2011.

[13] Manuta, J., and L. Lebel. Climate change and the risks of flood disasters in Asia: Crafting adaptive and just institutions in *Proceeding of Human Security and Climate Change: An International Workshop*, Oslo, Norway, 2005.

[14] Marfai, M. A., L. King, L. P. Singh, D. Mardiatno, J. Sartohadi, D. S. Hadmoko, and A. Dewi. Natural hazards in Central Java Province, Indonesia: An overview.,*Environmental Geology*, 56(2) [online] (Accessed 10 November 2015), 2008.

[15] Farid, M., A. Mano, and K. Udo.*Urban flood inundation model for high density building area,Journal of Disaster Research,* 7(5) [online]https://www.fujipress.jp/finder/xslt.php?mode=present&inputfile=DSSTR000700050004.xml (Accessed 10 November 2015), 2012.

[16] Otok, B.W., and Suhartono. Development of rainfall forecasting model in Indonesia by using ASTAR, transfer function, and ARIMA Methods., *European Journal of Scientific Research,* 38(3) [online] Development of rainfall forecasting model in Indonesia by using ASTAR, transfer function, and ARIMA Methods (Accessed 10 November 2015), 2009.

[17] Marfai , M. A., and L. King. Coastal flood management in Semarang, Indonesia.,*Environmental Geology*, 55(7) [online] http://link.springer.com/article/10.1007%2Fs00254-007-1101-3#/page-1 (Accessed 10 November 2015), 2008.

[18] Phanuwan, C., S. Takizawa, K. Oguma, H. Katayama, A. Yunika, and Y. Ohgaki. Monitoring of human enteric viruses and coliform bacteria in waters after urban flood in Jakarta, Indonesia.,*Water Science and Technology*, 54(3) [online]http://www.ncbi.nlm.nih.gov/pubmed/17037154 (Accessed 10 November 2015), 2006.

[19] Ward, P. J., Pauw, W. P., van Buuren, M. W., and Marfai, M. A. Governance of flood risk management in t Time of climate change: the cases of Jakarta and Rotterdam, *Environmental Politics*, 22(3) [online]http://www.tandfonline.com/doi/abs/10.1080/09644016.2012.683155?journalCode=fenp20#.VkJc2NIrK00 (Accessed 10 November 2015), 2013.

[20] Aldrian, E., L. D. Gates, and F. H. Widodo.*Variability of Indonesian rainfall and the influence of ENSO and resolution in ECHAM4 simulations and in the reanalyzes*. Report No. 346 [online]. Max-Planck-InstitutfürMeteorologie, Hamburg.https://www.mpimet.mpg.de/fileadmin/publikationen/Reports/max_scirep_346.pdf (Accessed 10 November 2015), 2003.

[21] Forest Watch Indonesia and Global Forest Watch (FWI/GFW). *The State of the Forest Indonesia* [online] Forest Watch Indonesia, Bogor; Global Forest Watch, Washington DC, 2002.

[22] Kusumastuti, R.D., S. S. Wibowo, and R. Insanita. Relief logistics practices in Indonesia: A survey in *Proceeding of 5th International Conference on Business and Management Research 2010,* Jakarta, Indonesia, 2010.

[23] Sutardi.*Action Report toward Flood Disaster Reduction-Indonesian Case* [online]. Indonesia Water Partnership, Jakarta. http://www.internationalfloodnetwork.org/AR2006/AR06Sutardi.pdf (Accessed 10 November 2015), 2006.

[24] Indonesian National Board for Disaster Management.*Map of Flood Hazard Index in Indonesia*[online]. BNPB, Jakarta. http://geospasial.bnpb.go.id/2010/02/19/peta-indeks-ancaman-banjir-di-indonesia/, 2009.

[25] Law of Republic of Indonesia (LRI).*Law of Republic of Indonesia Number 24 of 2007 Concerning Disaster Management*. [online], 2007

[25] United Nations Development Programme (UNDP). *Lessons Learned: Indonesias Partnership for Disaster Risk Reduction*. The National Platform for Disaster Risk Reduction and the University Forum, 2009.

[26] Asia Disaster Preparedness Center (ADPC). *Policy and Institutional Arrangement for Disaster Management in Indonesia* [online].Southeast Asia Section Publications, Bangkok.http://www.adpc.net/pdr-sea/publications/6-PIA-Ind.pdf, 2001.

[27] Sutardi.*Water Resources Management towards Enhancement of Effective Water Governance in Indonesia* [online].Country Report for 3rd World Water Forum, World Water Council, Kyoto.http://www.worldwatercouncil.org/fileadmin/wwc/Library/Publications_and_reports/country_reports/report_Indonesia.pdf (Accessed 10 November 2015), 2003.

[28] Pribadi, K.S., and A. Mariani.*Implementing community-based disaster risk reduction in Indonesia: The role of research institutions and religious-based organizations* [online]. Disaster Reduction Hyperbase, Asian Application, Japan. http://drh.bosai.go.jp/files/3f11992da3de433954239df73ce8bc31e85ee4df/7_PT2_P.pdf (Accessed 10 November 2015), 2007

[29] WHO.*Emergency Situation Report of Flash Flood in TelukWondama District, West Papua Province, Indonesia*.[online] WHO, Emergency and Humanitarian Action.http://www.searo.who.int/LinkFiles/Indonesia_ESR-1FF-Papua-05-10-2010.pdf, 2010.

[30] WHO.*Emergency Situation Report No. 5 of Floods in Jakarta Province, Indonesia*. [online] http://www.who.or.id/eng/contents/esr/ESR%20%2805%29%20Floods%20in%20DKI%20Jakarta%20Province,%20updated%2009%2002%2007.pdf, 2007.

[31] United States Agency for International Development (USAID).*Review of Policies and Institutional Capacity for Early Warning and Disaster Management in Indonesia*. [online] U.S. Indian Ocean Tsunami Warning System Document, 2007.

[33] The Water Dialogues.*Indonesia Contextual Analysis in Water Supply and Sanitation Sector* [online] www.waterdialogues.org/documents/8.6ContextualAnalysis.pdf, 2009.