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THE ADVERSE IMPACTS OF EXTREME CLIMATE EVENTS AND PHYSICAL DETERIORATION OF WATERSHEDS ON SUSTAINABLE MANAGEMENT OF WATER RESOURCES

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ABSTRACT

Being the world largest tropical archipelago, Indonesia has an abundance of water with an average annual runoff per capita in the order of 17,000 m^3. Nevertheless, the water resources are distributed unevenly by islands and by regions. About 60% of the 210 millions population alone (December 1999), is concentrated on the Java Island, which is continuously to become the most limiting factors of the country's development. The rapid expansion of human settlement and industrial areas in the river basins – including urbanization, conversion of agricultural lands, and illegal settlements in the vicinity of the river territories -- have also contributed apparent hurdles that are hampering the water resources development and management (WRDM) endeavors. In the mean time, the problems of WRDM have also become aggravated, due to the inappropriate land uses, acceleration of erosion, declining the water retention capacity, and eventuality of frequent landslide incidents, which are hazardous to human settlement activities. The river runoff and the rainfall pattern relationship have been increasingly unpredictable -- especially with the presence of the La-Nina and El-Nino phenomenon.

Having the facts that the development program and its implementation during the last few years have been undertaken without adequate environmental consideration, a number of negative consequences have become apparent. Therefore, a special effort is indispensable for promoting the sense of crises as well as the sense of awareness of the public concerning the underlying predicaments of watershed environment. Subsequently, dissemination of knowledge and technology pertaining to sustainable utilization of water by virtue of "ecohydrological" approach is becoming eminently instrumental for reducing the pressures resulted from inappropriate natural resources *exploitation. In line with these matters, the Indonesia's policy and strategy in WRDM has been reformulated to an emphasis on operation and management of the water resources infrastructures based on integrated river basin management approach aiming for sustainable management of water resources as the ultimate goal. This policy review is based on several major aspects namely: (1) water resources management; (2) environmental management; (3) legal and administrative aspects; and (4) socio-economics as well as finance.*

Given the above indications, it becomes obvious that the absence of significant attention on "ecohydrological" consideration, the adverse impacts of extreme climate events and deterioration of watershed simultaneously, will become phenomenal to any WRDM program. This paper is about the adverse impacts of extreme climate events together with watershed deterioration resulted from human interventions. The analyses have been based upon a number of empirical evidences on flood and drought mitigation cases in Indonesia. The paper also discusses some aspects of river environment and micro-climatic trends, as well as their contributions to flood and drought incidents.

Key words: Ecohydrology; Extreme-Climate Events; Water-Resources Management; Indonesia

1. INTRODUCTION

1.1 General Feature of Water Resources and Population

Indonesia as the world largest archipelago having a total of over 17,000 islands -- About 6,000 are inhabited -- spread over along the equator at about 8 million square km of the earth's surface with the total land area of about two million sq. km, and three million sq. km of sea territory, with a coastline exceeding a total of 84,000 km. Being as an agrarian country, it has an actually cultivated agricultural area totaling of about 8.5 million ha, with a total potential of cultivable land suitable for paddy crop at about 25 million ha.

The overall water resources systems of the country are structured into about 5,590 rivers with the abundant river runoff distribution at the magnitude range between 45,900 million m^3/year and 550,700 million m^3/year. Despite of this abundance of water resources potential, the Indonesia's surface water resources have already experienced a shortage during the dry season, and flood events during the rainy season. This is due to the variability of its geographical as well as climatic conditions. The total water demands of the country for supporting irrigation, domestic, municipal and industrial (DMI) purposes are 1,074 m^3/sec, while the low flow available at the normal climatic year is only about 790 m^3/second. This feature gives indication of the current constraint due to unbalanced condition of demands and the potential availability of water, particularly at point of water scarcity of the year.

The total population of Indonesia has surpassed a grand total of 210 million people at the beginning of the year 2000. This magnitude comprises of about 36% of urban and 64% of rural dwellers with an average density of about 101 inhabitants per km^2, having the annual estimated population growth rate of 1.7%.

1.2 Hydro-climatic Predicament

In general, the country's climatic condition consists of two seasons, the dry season (April to September) and the wet season (October to March) with minor variations between east and west regions (climate zones) – the average annual rainfall is about 2,000 mm. Despite the abundance of surface water potential, however, the ground water potential is limited. This potential could only contribute limited support to urban and rural water demands. In fact, in some cases, ground water abstractions have caused overdraft, saline water intrusion and land subsidence at the rate of two to thirty four cm/year (particularly in the densely populated urban areas). The present climatic condition of the region has been increasingly jeopardized by seasonal and spatial variations of the climate and rainfall patterns. In addition, the lack of adequate storage has been one of the major issues that aggravate more and more significant conflicts as well as competition among water users -- on top of the increasing tendency of water related disasters such as floods, droughts, landslides, land subsidence and other such undesirable aftereffects.

2. THEORETICAL BACKGROUND AND GLOBAL EMPIRICAL PERSPECTIVES

2.1 Dynamic Theories and Analysis Model of Water Resources Management

Learning from experiences, we all aware that the conventional economic science does not appear to be well positioned to analyze the impacts of extreme events on sustainable water resources management. This is because macroscopic and dynamic theories and models of real analytical processes are still far from complete to be able to explain the irregularity of the extreme climate events. In most theories, models and analysis instruments, however, ideas that fits the results of constant expansion of inputs and outputs appear to be bias or even irrelevant when interfaced with the new constants or discontinuity, fluctuation, and statistical outlying.

The conception of the analysis process as a mechanical analogue involves trajectories of systems measured as averaged historical trends, and that are assumed to be deterministic, linear, equilibrium, reversible, static and driven by constant forces, which in fact are misleading. This internal logic demands that when extreme events fade away, the water resources system will return to its previous condition or state and therefore its previous trajectory.

In reality, all impact analysis of climate changes on water resources management were based on a comparative static analysis of this type of system operating in two different equilibrium. The analysis of climate scenarios is defined in terms of averages instead of variances. Whereas the climate extremes, transition, and economic dynamics between the two climate states, are not yet analyzed. That is, asymmetry and time, and the reciprocal coupling and feedback between the climate and production systems, are not accounted for. Introducing concepts such as singularities, bifurcation's, catastrophes, chaos, and accelerated reference frames, within an empirical context, provide interesting insights on discontinuity, uncertainty, fluctuation which eventually suggest possible directions forward.

2.2 Climate Changes and River Flooding

A number of scholars argued that the increasing tendency of extreme climate events and the shift of climatic regularity has something to do with the underlying enhancement of greenhouse effects due to the lack of concern on environmentally friendly practices on earth. To investigate the possible role of the enhanced greenhouse effect in the recent river flooding events, the relevant physical processes have been analyzed and an extensive literature survey has been carried out. Based on these analysis, a number of conclusions have been drawn.

Physical arguments clearly indicate that global warming will cause an increase of evaporation from the ocean. Moreover, a warmer atmosphere can carry more moisture, which can lead to larger amounts of precipitable water. Global warming will also induce higher temperature differences between the land and sea surfaces, causing an increased of the mass movement of precipitable water to the continents, and an increase of conventional rainfall.

The general circulation models (GCMs) are currently the most effective instruments discussed all indicate an intensification of the global hydrological cycle as a result of global warming. The analysis model indicates that at a doubling of the atmospheric CO_2 concentration (expected at about 2070) the estimated increase in mean annual global precipitation varies from 3 to 15%. The general consensus is that we should expect increases at high latitude throughout the year, and in areas affected by monsoon rainfall (India, Northern Australia), and greater amounts of rainfall (10 to 20%) is much of the mid-latitudes during winter. There is qualitative agreement between most models on a shift toward more heavy rainfall events and higher rainfall intensities. Similarly, there is consensus that in arid and semi-arid areas, the amount of rainfall is expected to decrease or remain more or less constant.

Observations of regional trends in rainfall are consistent with the GCM predictions described above. Some studies conclude that evaporation rates for different parts of the ocean have increased since the seventies. There is, for instance, observational evidence of more rainfall in northwest Europe. This is due to an increase in the frequency of the zonal circulation (leading to more wind from the sea), causing wetter and milder winters. Another example at one station in the Netherlands, an increase of +5% has been measured over the period 1961-1990 (compared to 1930-1960). In the United States case, the monsoon regions increases in the frequency of heavy rainfall events have also been observed.

The possibility of substantial precipitation changes must be considered as realistic. In spite of the uncertainties and the lack of quantitative data we are fairly confident that, as a prediction, it is quantitatively correct. Given the nature of weather statistics, a small change in the mean weather comes with changes in the frequency and magnitude of what we call extreme events. This tendency is supported the records on recent flooding and on paleo-flooding which indicate the high sensitivity of flood occurrence to changing climate for river basins in the USA and Europe. Analyses also indicate that there is no simple proportionality between the scale and frequency of floods and climate variations. However, in general, increases in precipitation lead to proportionally larger increases -- though are not linearly related with runoff.

Several hydrologic modelling studies indicate that greater precipitation will cause higher runoff and an increase in soil moisture, as expected. For the Rhine river, for instance, it is estimated that a 20% increase in precipitation will double the occurrence of what used to be an one-in-two year peak flow event. However, it is difficult to distinguish climate-change induced effects in the river regimes from changes caused by the natural variability of the climate, and various man-made alterations (urbanization, land use, drainage, channelization, dams etc.). Separating these from other effects can be done by modelling, but such studies are highly sophisticated, and yet still currently in a very premature undertaking.

The recent floods in northwest Europe (1933, 1995) and in the USA (1993) were caused primarily by unusually high rainfall amounts in combination with a saturation of soil due to proceeding rainfall (and, to a lesser extend, human interference in the catchment basin). Individual flooding events cannot be attributed directly to the enhanced greenhouse effect. The recent floods cannot be taken as a proof of climate change as the associated rainfall events still fit in the natural variability of our climate, and floods of comparable magnitude have been observed early this century. What can be said is that an increased frequency of unusual amounts of rainfall and floods as we have witnessed over the last decade are still consistent with the climate model predictions.

As greenhouse gases continue to accumulate in the atmosphere we should expect an increase in rainfall and a (non-proportional) increase in river flooding events, in particular in mid-latitude regions. Given the long lead time of CO_2 build-up in the atmosphere, it is difficult, if not impossible, to prevent (some of) the expected increase in river flooding events. What can be done in the short term is slowing down climate change by reducing greenhouse emissions. In the long term, such a (preventive) strategy can be aimed as stabilizing greenhouse gas concentration.

2.3 General Outlook of the La Nina and El Nino

The presence of La Nina phenomenon as the warming of the Pacific Ocean's surface is bringing a ripple effect on climatic conditions in far flung regions of the earth. This evidence gives worldwide message of the shift of tropical rainfall, which affect wind pattern and hence mass movement of moisture transportation over much of the globe. It appears that the dense tropical rain cloud distort the air flow. The waves in the air flow, in turn, determine the positions of the monsoons, and the storm tracks and belts of strong winds aloft which separate warm and cold region at the Earth's surface. During the El Nino years -- when the rain area that is usually centered over Indonesia and the far western Pacific moves eastward into the central Pacific -- the waves in the flow aloft are affected, causing unseasonable weather over many regions in the Pacific rim, and of the globe in general.

State climatologyst John James agrees that El-Nino does not causing hurricanes, instead, "it's enhancing them, moving them farther northward". It's a strong El-nino and we can expect unusual weather conditions. For example, the impacts of El Nino upon climate in temperate latitudes show up most clearly during winter time. But even during winter time, El Nino is only one of a number of factors that influence temperate climates. El Nino years, therefore, are not always marked by "typical" El Nino conditions the way they are in parts of the tropics.

As El Nino approaching, it affects the marine life in the Pacific and influences weather pattern throughout the world, and hence, we have to accept the reality that the abnormal atmospheric and oceanic conditions during The El Nino or the La Nina years affect significantly of the human beings. The fact that the El Nino and the La Nina events and their regional consequences is still hardly explained by causal relationship, therefore much effort is still required to have as much as possible information or prediction about the characteristic of the El Nino or the La Nina transformation.

In an attempt to have the benefit of scientific prediction, the scientists are now trying to step further by incorporating the descriptions of events into numerical prediction models of processes that occur in nature. Such models are mostly in the form of sets of numbers, describing the present state of the atmosphere-ocean system. Updated sets of numbers, which the models produce, indicate how the atmosphere-ocean system might evolve over the next seasons of the year. The result thus far, though by no means perfect, give a better indication of the climatic conditions that will prevail during the next one or two seasons that simply assuming that rainfall and temperature will be "normal". Several government of developing countries provide examples of how short term El Nino and La Nina forecast can be instrumental to the countries' economic development, particularly to food production, which is fairly sensitive to the climate irregularities. In most instances, the forecasts are presented in terms of four possibilities; (1) Near normal conditions; (2) A weak El Nino with a slightly wetter than normal growing season; (3) A full blown El Nino with slightly wetter than normal water offshore; and (4) with higher than normal chance of drought.

The Indonesia's Outlook: Based on the proposition that the ability to anticipate how climate will change from one year to another will lead to better management of agriculture, water supplies, fisheries and other resources, the foresight of extreme climate events in Indonesia has also been adopted. Parallel with the significant deterioration of watershed ecosystem (ecohydrology) in Indonesia, the tendency of shift of environmental characteristics have been tested through a comparative analysis by contrasting the theoretical perspectives and the actual events together with their related impacts at the fields.

In an attempt to test the implications of the extreme climate events on the water resources management, this study has been based on the evidences given by the flood and drought incidents after the El Nino and La Nina predictions in 1997-1998. Having the La Nina prediction with the possible impacts on particular provinces, the preparatory anticipation has been focused on the flood prone as well as drought prone areas indicated by the extreme climate outlook. The resulted monitoring activities in the referred areas are compared and contrasted with the predicted trends for improving the capacity to anticipate and hence to be prepared with the impacts of the extreme climate events toward a sustainable management of water resources.

3. EMPIRICAL CONDITION OF RIVER ENVIRONMENT AND MICRO-CLIMATIC TREND OF RIVER BASINS IN INDONESIA

3.1 General Trend

Over the last few years, evidences have shown a large number of river flooding events, not only in Indonesia, but also on global scale. These floods and the related damages can be attributed to large extent to the growing exposure of human society and infrastructures to extreme weather events. Despite the argument of the notion that the weather itself, the climate, is changing as a result of the enhanced greenhouse effect, this analysis will concentrate mainly on the general impacts based on the empirical evidences.

With the inclination of exploitation of natural resources to keep up with economic development simultaneously with ungovernable population explosion, the human intervention in the river environment has increasingly been contributing significant impacts on the river ecosystem, and in the ecohydrology in general. One of the major consequences of inappropriate land uses in the river basins has been the increasing of erosion and decreasing the water retention capacity as well as the acceleration of land-slides incidents in the human settlement areas. In addition, the rapid expansion of human settlement and industrial areas in the river terrestrial – including conversion of agricultural lands, and illegal settlement in the vicinity of the river or flood plain -- has also been encumbering the water resources development and management endeavors. It is also apparent that the general shift of pattern of environmental characteristic tends to be more uncertain and the river flows has been more and more inconsistent with the characteristic of the existing long-run data records. In line with the above trend, the river runoff and the rainfall pattern relationship have also been increasingly unpredictable.

The impact of global climatic changes in the one side, and the change of micro climate characteristic in another -- i.e. the extremely high intensity but very short-term duration of rainfall -- has been more apparent. Similarly, the occurrence of extreme drought during the dry season has also become more difficult to predict, and hence to mitigate.

3.2 Deterioration of River Basin Environment

In general, the evidence of the underlying river basin deterioration is undeniable, however, for the analysis purposes, the determinant factors of this physical transformation must be explained through the tangible parameters. Therefore, the extend of the current deterioration of river basins in this analysis has been based upon the following parameters: (1) Deterioration of river terrestrial in terms of erosion and land slide problems due to the significant decrease of surface vegetation; (2) Hydrological pattern, sediment transportation, water uses index, discharge fluctuation, and rapid worsening of water quality; (3) Socio-economic patterns including public awareness, poverty index etc.; (4) Capital investments in the river territories; (5). Government policy on regional development, protected forest, special development areas, etc.

Taking into consideration all these parameters, a total of 473 prioritized river basins have been identified in terms of watershed development and management urgency. Out of this number, some 62 river basins have been under the very high priority for appropriate development and management. Most of these river basin areas on Java Island have exceeding the justifiable limit of the deterioration criteria. Fore more information see the river basin condition presented in Figure 1 to Figure 4.

FIGURE 1. GENERAL MAP OF RIVER BASIN CONDITION IN INDONESIA BASED ON THE MAGNITUDE OF *"COEFICIENT OF VARIATION - CV"*

FIGURE 2. GENERAL MAP OF RIVER BASIN CONDITION IN INDONESIA BASED ON THE MAGNITUDE OF WATER USE POTENTIAL INDEX - "WUPI"

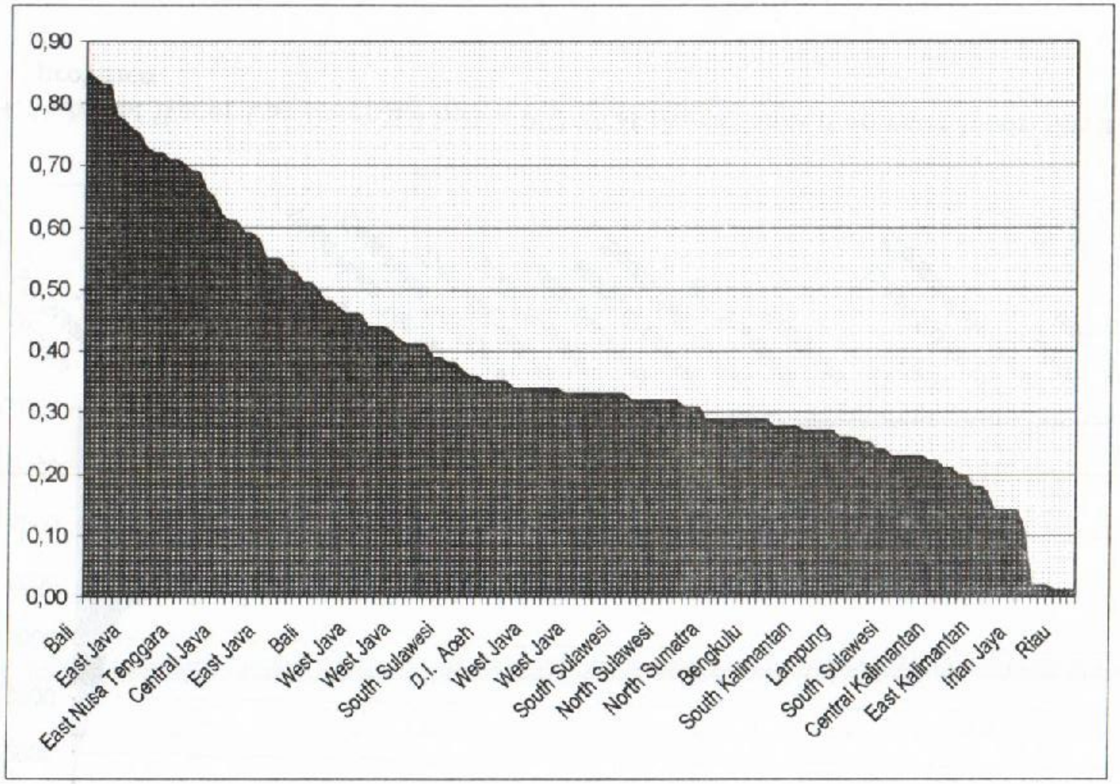

Figure 3. Value of Coefficient of Variation (CV) for a number of rivers, based on river basins in the province.

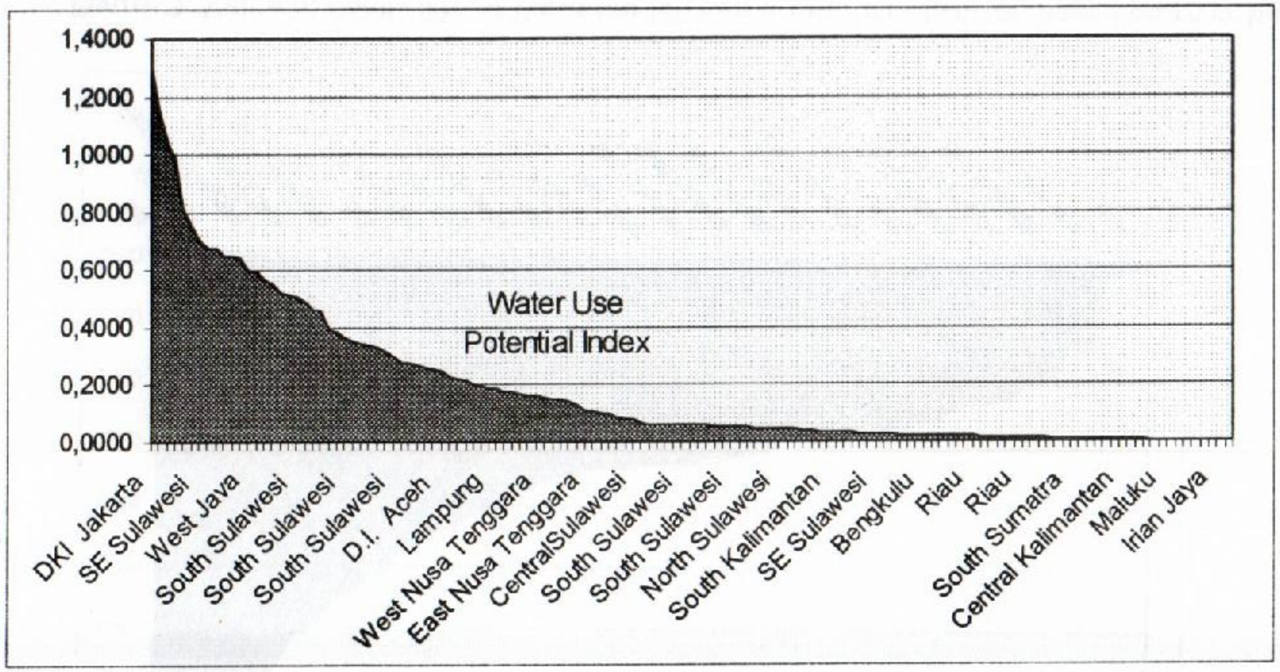

Figure 4. Value of Water Use Potential Index WU PI of rivers, base d on river basin territories in the province.

The obvious consequences of watershed deterioration based on the above indication is that the river basin management will suffer from a number of river management problems. The problems among others are:

(1) The discharge ratio between the dry season and of the rainy season river flow, expressed in terms of "coefficient of variation (CV)" become more apparent -- for instance, the magnitude of CV in some rivers on Java often exceeding the magnitude of 0.40 (i.e. 0.59 for the Citarum Basin in West Java; the Jratunseluna Basin of the Central Java in the range of 0.61 to 0.72; the Brantas basin in East Java In the range of 0.41 to 0.76 in; and the Jeneberang Basin in South Sulawesi Province in the range of 0,59 and 0,84). From the point of view of sustainable river basin management criteria, the above values of CVs are not recommended at all; (2) The increasing tendency of excessive sedimentation, and hence entailed with silting problems in the downstream parts of the river; (3) The river basin organization will suffer from the more apparent hardship to undertake a sustainable operation and management of river basin infrastructures.

3.4 Phenomena of Micro Climatic Trends

Learning from the records of the most recent flood and drought occurrences, there has been a clear indication of micro-climatic changes. One of the most apparent indication of micro climatic change is the shift of pattern of rainfall from normally statistically predictable tendency to extremely highly unpredictable ones. With respect to the flood incidents, they become more uncertain and are no longer consistent with the underlying probability prediction. As a result, the flood patterns are tending to be transformed into locally specific characteristics, in addition to the fact that the flood occurrences that are frequently trigged by the short term but high intensity rainfall. Thus, the trend of flood occurrence has shifted from a more gradual characteristic to be highly fluctuated ones due to the extremely high intensity of rainfall with relatively shorter duration of interval.

As the matter of fact, the flood records give a clear evidence that the shift of runoff characteristics of the Java Island, in particular, the flood incidents occurred in the region where the rainfalls were predicted to be above normal. Similarly, on the Sulawesi Island, the flood incidents were only occurred on certain locations to which the heavy rainfall were not previously predicted (i.e. Ujung Pandang, Maros and in the downstream of the Jeneberang river). In contrast, for the areas which were predicted to have strong probability of rainfall occurrences, in fact, were not reportedly having any significant flood incidents.

With regard of drought incidents, the records gave clear indication that they also tend to occur more frequently than the statistically predicted drought year, and yet the time pattern of the particular year has also shifted, and apparently become more uncertain.

4. FLOOD AND DROUGHT INCIDENTS

4.1 Flood Incidents

Referring to the history of the flood prone areas, some 79 flood occurrences have been recorded by the "Flood Crisis Center Unit of the former Ministry of Public Works" for few weeks, since the beginning of October 1998. These flood incidents were occurred at 13 provinces. In addition, three major landslide incidents were also recorded at three provinces.

During the La Nina period of 1998, out of the 15 provinces predicted to suffer from flood as the effect of the La Nina, only 10 provinces were recorded to having suffered from flood incidents. Four other provinces out the predicted area, in fact, suffered from a number of flood incidents.

The flood and the land slides has affected a total area of 39,780 ha of irrigated paddy fields, inundating some 5.5 km of national roads, 15.5 km of provincial roads, 60 km of local roads, and some 56 km of village roads. The water level at the inundated areas were recorded in the range of 15 cm to 2 meters. Some six people were killed in the flood incidents and 43 people in the landslide incidents.

Based upon the records, the major causes of the flood were: (1) High rainfall -- (In October 1998 with an average of two hours at the total of 200 mm, while in November and December 1998 the rainfall duration had been more than 10 hours with an intensity of about 290 mm. In most cases, the flood has been trigged by a short-term duration with an extremely high intensity rainfall); (2) Breaches of river protection dykes; (3) Overtopping on the river embankments; (4) Failures of urban drainage and flood prevention channel facilities due to inadequate conveyance capacities; (5) Garbage and or debris blockages at the water gates and river channels perimeters.

4.2 Drought Impacts

Prior to the occurrence of the above mentioned flood season as assumed to have been related to the La-Nina Phenomena, the impacts of El-Nino had also hampered the dry season crops of 1997, particularly to the 10 provinces of the major rice producing areas of the country.

The total area that was scheduled for the 1997 dry season paddy in the 10 provinces (Aceh, North Sumatra, West Sumatra, South Sumatra, Lampung, West Java, Central Java, South Kalimantan, and South Sulawesi) was 2.923 million ha, of which only 1.897 million ha was successfully realized. Out of the seasonally scheduled cultivated-areas, about 38,000 ha of irrigated area suffered from drought with some categories of adverse impacts. In addition, some 990,000 ha of the scheduled area for paddy was not realized, except some potential areas were transformed into other variety of upland crops.

5. MONITORING, EVALUATION, RISKS AND SENSITIVITY ANALYSIS

5.1 Flood Prone and Drought Risk Areas

Based on the record of flood history, the flood prone areas scattered over the provinces are about 1.7 million ha in total (About 122,000 ha urban areas, 265,000 ha of rural areas, 803,000 ha of fishpond areas, and upland agricultural areas of 502,000 ha). On the other hand, out of about three million ha of dry season paddy, only about 750,000 ha are supported by about 50 major storage reservoirs, the drought sensitive area scattered over 10 provinces covers a total area of about 1.1 million ha. The impacts to which, depend upon the magnitude of drought incident at that particular year as well as drought management and the success of rescue efforts.

The flood prone areas have been traditionally determined by historical data that have been recorded for several series of flood years. However, the most recent trend has shown significant shift to irregular patterns. If this unknown phenomenon has yet to be uncovered, the flood forecasting, warning and mitigation would remain a least effective endeavors.

Despite inadequacy and inconsistency of data that were considered in this preliminary identification, there is a strong indication that the flood prone areas are tended to be coincided with the river basin areas that were identified as under the most critical category -- however, this matter is subject to further detailed analysis.

Consistent with the criteria for determining the category of critical river basins, with few exceptions, however, all of the critical river basins are indicating significant susceptibility to drought, while having a higher level of drought probability, despite view exception of minor symptom.

5.2 Risk Analysis of Flooding and Drought on Paddy Production

In an attempt to demonstrate the impacts of flood and drought incidents to agricultural and resettlement areas, the risk analysis have been undertaken in this study on the basis of the effects to paddy productivity. The rationale behind the determination of paddy productivity -- as the main object of analysis -- is merely because rice as the staple food of Indonesian people that has been strongly adhered to socio-economic life of the community. In this analysis, several assumptions have been taken in the context of determinant parameters that are affecting the impacts and sensitivity of paddy production to flood and drought impacts -- i.e. inundation time, water depths, and stages of plant growth. The impacts of which are compared with the average productivity of paddy under the normal condition (without flood and drought effects).

The total recorded area that was affected by floods (i.e. 39,780 ha), has been manipulated as being affected by different categories of flood occurrences, namely: light, minor, intermediate, severe, and very severe impacts.

At the same time, the treatments are also differentiated with a number of sensitivity parameters as follows:

- Inundated up to 3 days, with 40 cm water depth at = 30,913 ha;
- Inundated 3 to 7 days with 60-cm water depth at = 7,126 ha;
- Inundated more than 7 days with deeper than 60 cm at = 1,741 ha;

With the assumption that the recorded floods incidents have been the intermediate category, the total productivity losses is calculated at about 29.80% or about 52,000 ton out of the total normal productivity level at about 175,000 ton of unhusked dry-paddy per crop.

The risk analysis of flooding with various parameters of water depths, time of inundation, plant growth stages at three level of simulation categories -- the level of productivity at 4.4 ton of dry paddy/ha (of normal average productivity) has been assumed. The analysis results for the differentiated categories are as follows:

- For the very severe impact category, the productivity losses = 78.65%;
- For the severe impact category, the productivity losses = 56.65%;
- For the intermediate impact category, the productivity losses = 29.80%
- For the minor impact category, the productivity losses = 14.40%;
- For the light impact category, the productivity losses = 2.87%.

The risk analysis of drought with different categories of impacts would produce more or less similar indication to the flood impact, with exception of fire incidents that would mostly causing 100% productivity losses.

From the above analysis, it could be concluded that the risk of productivity losses of paddy due to flood incidents could be minimized by a number of endeavors. The most significant one is by means of accelerating the time of discharge release and or minimizing water depth of flooding by means of pumping or ditching in accordance with the sensitivity of plant growth-stages to flooding.

Similar rationale would apply to the drought incidents with several means of minimizing the risk of productivity losses by supplying additional irrigation water to meet the sensitivity of water demand according to the plant growth-stages due to drought. The drought impacts are mostly dictated by condition of water supply source, categories of water users, level of water utilization, water quality, and institutional capacity to perform the rescue undertakings.

6. POLICY ACTION PLAN FOR FLOOD AND DROUGHT MITIGATIONS

In an attempt to tackle the problems resulted from flood and drought events, it is imperative to take as realistic action plan as possible. The action plan consists of immediate (short-term), intermediate and long term time horizon, taking into account of the relevant countermeasures such as preventive, repressive, remedial, and rehabilitative measures -- both for structural and non-structural means.

6.1 Immediate (short-term) Action

For the short-term action, preventive measure is normally associated with preparatory effort by means of identification of the updated flood prone areas with the shifted flood patterns, and incorporating the tendency of positive relationship with the magnitude of flood events based on the river basin categories. The preventive action is also meant to conduct identification of locally sensitive parts of the river systems (infrastructures) by means of mutual "walk through" along with the flood prone localities. Provision of the necessary equipment and materials, as well as communication facilities and acceleration of the "structural" measures by means of construction of flood control infrastructures, normalization of river morphology, and institutional preparedness to the sudden flood potential with unusual intensity. Most importantly, is the "non-structural" measures by intensifying the flood forecasting, warning and mitigation systems.

In addition to the immediate actions, preventive action is also required by virtue of accelerating the emergency repairs (remedial action) through the coordination of the regional office of the Ministry of Public Works, by involving the public and private participation. For this purpose, follow up actions are required for empowering the society and private sectors through intensive coordination with the local "task-force" units or under the coordination of the regional task-force units at the province and the local task-force unit at the district level. This coordination including training, dissemination of information, early warning, and emergency actions toward mitigation of the immediately approaching flood occurrences.

For effectiveness of the implementation program, the Ministry of Public Works apparatuses at the local and regional areas are required to intensify and to enhance the disaster preparedness including "drought" that would give significant impacts to the water resources infrastructures. In some very special cases (subject to a very careful scrutiny), cloud seeding or artificial rain often advocated to support the emergency condition of the plant growth or for storing additional volume of water to the potential reservoirs.

Particularly for drought mitigation, the immediate efforts in the short term could be implemented in the forms of drought management: including reservoir optimization, intensification of discharge monitoring in the rivers having no reservoir, prioritization for human, cattle, irrigation and for other purposes, conjunctive use of surface and ground water, demand management, crop diversification, and other means of rotational water distribution techniques.

6.2 Intermediate Action

Rehabilitation, reconstruction and recovery of the public works infrastructures, including other related flood infrastructures are amongst the intermediate actions that are urgently required. In addition, upgrading measures by means of reconstructing the flood control infrastructures while adjusting their function with the increasing demands of the flood control infrastructures are also essential for intermediate actions.

In some cases, immediate actions are often taken in supporting the intermediate program by utilizing the shallow well pumping system, reuse of drainage water, and other such efforts.

6.3 Long-Term Action

With respect to the long-term action for flood and drought mitigation, a realistic policy action plan is necessary to accommodate several recommended endeavors as follows:

- Rehabilitation of the critical and supercritical river basins by means of re-greening as well as reforestation program, and with the provision of other related civil works measures;
- Basin Water Resources management strategy by adopting the principle of "River Management" including the appropriate water allocation, water quality management, flood management, supported by an effective data base and information system as well as regulatory measures. Among the many regulatory measures that are commonly practiced, the following are urgently required: water right system; application of cost recovery through the user and polluter pay principle, institutional empowerment, participation of staff and community members, law enforcement and other such means. In addition, other civil works and vegetative sodding are also essentially required for slope protection as well as operation and maintenance (O&M) of river infrastructures;
- Establishment of independent public corporation for river basin to implement planning and management for the river basin that have been identified to having adequate economic, technical, institutional as well as human resources potentials;
- Non-structural efforts for drought mitigation including among others: awareness campaign; encouragement of Water Conservation Movement (GHA) implementation; reforestation and re-greening program in the catchment areas; consistent application of appropriate spatial planning; overall review and re-evaluation of water resources allocation as well as water right system etc.
- Structural measures for drought mitigation such as provision of storage or regulatory reservoir, check dams, "sabo" dams, and other means of water retaining systems.
- Implementation of continuous and consistent research and development (R&D) activities not only by means of biographical model, but also by means of socio-cultural models. Thus, all of the adverse impacts of flood and drought could be minimized by a comprehensive inter-sectoral or inter-disciplinary kinds of considerations.

7. CONCLUDING REMARKS

With the exceptionally rapid expansion of human settlement and industrial areas in the river basins – the sustainable development and management of water resources have been least effective. In fact, a number of evidences give a clear indication that the problems of water resources development and management (WRDM) have increasingly become aggravated. This is because of the inappropriate land uses, acceleration of erosion, and declining the water retention capacity, which are jeopardizing the economic development as well as human settlement activities.

Owing to the fact that the underlying development program and its implementation have been undertaken without adequate environmental consideration, a number of negative consequences have become apparent. The analysis in this paper gives an obvious support to the argument that without the presence of significant attention on "ecohydrological" consideration, the adverse impacts of extreme climate events and deterioration of watershed simultaneously, will become phenomenal to any WRDM program, without exception.

With regards to the extreme clime events and the magnitude of flood incidents, the study has not given a strong evidence of positive causal relationship between the micro-climatic trend and the noticeable contribution of the La Nina and El Nino phenomenon. There are, however, a number of reasons to believe that the successful effort to minimize the adverse impacts of the extreme flood and drought events have been contributed by the early warning that have been obtained from a number of macroclimatic predictions.

From the records of past experiences, the analysis also gives an obvious indication that there has been a significant micro-climatic change, which was explained by the apparent shift of pattern from the normally statistically predictable tendency to extremely highly unpredictable flood and drought incidents, The conventional practices on statistical probability prediction concepts have been tended to be transformed into more locally specific characteristics. The aggravated watersheds have been contributing significantly to the flood occurrences that are more frequently occurred with the characteristic of a short term duration but high intensity runoff. Thus, the trend of flood occurrence has shifted from a more gradual characteristic to be highly fluctuated ones as a result of the extremely high intensity of rainfall with relatively shorter duration of interval.

To address these problems, the Indonesia's policy in terms of a realistic policy action plan on WRDM with a systematical strategy has been reformulated to an emphasis on operation and management of the water resources infrastructures based on integrated river basin management approach, aiming for sustainable management of water resources as the ultimate goal. This policy review is based among others on water resources management, environmental management, legal and administrative aspects, as well as socio-economics as well as financial matters. The policy also gives a special focus on the "structural" as well as the "non-structural" aspects of flood and drought mitigations toward an appropriate balance of WRDM and impacts on "ecohydrology" The subsequent policy implementation has been based on consistent effort for dissemination of knowledge and technology pertaining to sustainable management of water resources by virtue of "ecohydrological" approach toward reducing of the environmental pressures resulted from inappropriate natural resources exploitation.

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