2. Present situation of water resources and water related disasters and the role of agro-environmental education in Indonesia

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Introduction and Some Background

Most recent flood events in Indonesia were occurring in all over the country taking death tolls of 155 souls, 13 missing, and some 383 900 people were forced to leave their homes as the floods damaged more than 3 100 of their houses and inundated another 94 600 houses (Soenarno, 2002). These floods just occurred in the middle of rainy season since November 2001 and intensifying during February 2002. Initiated in North Sumatra Province, the floods first inundated and halted the operation of Polonia Airport of Medan, the Capital City of the Province, and then spread out to other parts of Indonesia, not less than 23 provinces, including landslides and flooding many areas in Java, such as: Kebumen, Banyuwangi, Bandung, and also Jakarta. Rainfall intensity in Jakarta area during a five-day event at the end of February 2002 was recorded at 425 mm, causing extensive floods in Jakarta and paralyzing the City's socio-economic activities for several days. Inundated roads had caused serious traffic jams and public anxieties. Some economists gave an estimated loss of this recent Jakarta flood of about 5 ~ 6.7 trillion rupiahs (more than half a billion USD), accounting direct material damages and indirect losses as impacts of the flood. These disasters had awaken awareness of the decision makers in Indonesia on the strong influence of water resources and water related disasters to the national economy that open new challenges and opportunities to natural scientists, especially meteorologists, hydrologists, and climatologists, to contribute professionally to the society. This is due to the impacts of these natural disasters such as floods, droughts and wild forest fires, and their great economic consequences. In 1991's drought, about one million hectares of the second season rice paddy were affected and some 30% was completely loss (harvest failures), and this is as much as ten time of normal year losses which is reaching 100 000 hectares/year. In 1994 and 1997 droughts, the affected rice areas were about half a million hectares. So, during severe droughts, about 10% to 25% of planting rice areas were affected by droughts. I reckon that if we understood more of the climate behaviors and can anticipate its seasonal patterns better, we can suppress these losses much lower, even during normal years. And this certainly will help the farmers, who are still the majority of the Indonesian population, approximately 60% of presently 220 million Indonesian population, and the country as to ensure the food security.

The present paper concerns the issues of water resources and water related disasters that affected the environment and society more in natural context where vegetative or non-

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structural approach is prevalence, therefore exclude any discussion of water related disasters in urban build up areas. The environmental problems generated by water related disasters in agricultural and forestry lands are vast and far ranging in consequences as will be presented and discussed briefly.

Anthropogenic influences: in the past century land use changes from forest cover to agricultural uses, but in the last few decades land use conversion in Java is from agricultural to non-agricultural uses. Population pressure with intensive agriculture and rapid recent industrial development implied extensive land use changes and increased water demand, and suspected to cause this long term changes, in addition to global climatic change. *From four million to forty million people in Java and Madura* was the title of Boeke report (1941) indicating the population increase from 1800 to 1930, when the first Sensus was conducted. It was reported that since old days, population density in Java had been very diverse, from 9 persons/km^2 to 880 person/km^2 in 1815 with average 35 person/km^{2,} and this average increased to 330 (1930) and 1000 (2000). This increase of population has severely affected the land uses and continuous changes in vegetation covers, with consequences in land degradation, soil erosion, and changes in hydrologic regimes and environmental qualities.

Status of Indonesia water resources can be examined from primary water availability by major islands as given on Table 1 indicating a total water available of 2110 mm/year or 127 775 m3/s which is equivalent to four million MCM/year (MCM= mega cubic meter). Dividing this regional water availability by population of the region give water availability index that ranges from 0.15 m^3/cap./day for metropolitan areas like Jakarta to 1480 m^3/cap./day for West Papua or approximately 50 m^3/cap./day for a national average. This water availability is relatively abundance, however un-equal distribution in time and space in many cases has caused serious problems to the environment and society. Monsoon rains drop 80% of the annual total during rainy season, and severe droughts with wide spread impacts occur almost periodically. Figure 1 illustrates the typical seasonal pattern of rainfall in Indonesia that is recognized of three types and the characteristics of Java major river basins and their stream flows are as given on Tables 2 and 3 below with the average minimum and maximum discharges indicating extreme conditions.

Table 1. Water availability in Indonesia by major islands.

Island	**Area [10^3 km^2]**	**Rainfall [mm/yr]**	**Runoff**		**Groundwater**		**Total Water Available**	
			[mm/yr]	**[m^3/s]**	**[mm/yr]**	**[m^3/s]**	**[mm/yr]**	**[m^3/s]**
Sumatra	477.4	2801	1848	27 962	280	4 236	2 128	32 198
Java	121.3	2555	1658	6 378	255	982	1 915	7 360
Bali&NT	87.9	1695	997	2 779	170	472	1 167	3 251
Kalimantan	534.8	2956	1968	33 359	296	5 010	2 264	28 369
Sulawesi	190.4	2156	1352	8 157	216	1 301	1 564	9 458
Maluku	85.4	2218	1400	3 785	222	600	1 621	4 385
W.Papua	413.9	3224	2175	28 524	322	4 229	2 497	32 754
Indonesia	**1911.1**	**2779**	**1832**	**110 944**	**278**	**16 831**	**2 110**	**127 775**

Source: Pawitan (1999)

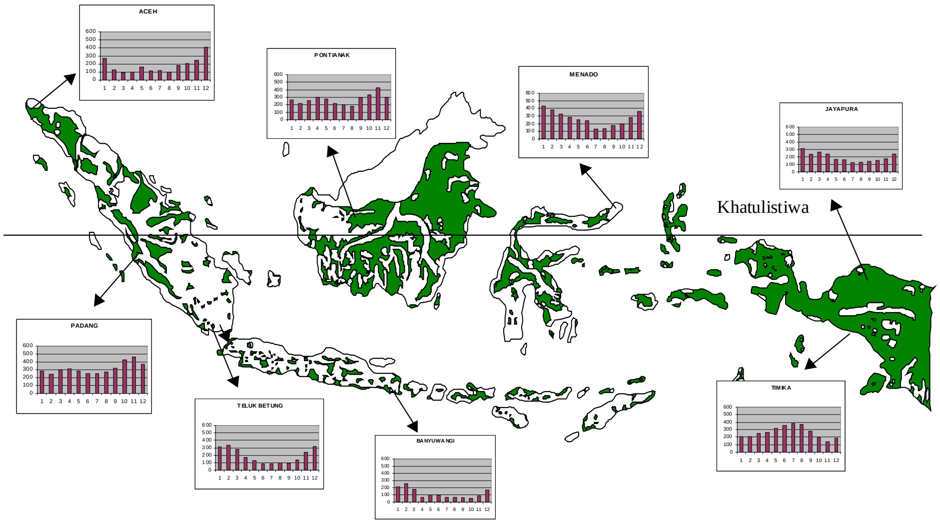

Figure 1. Seasonal patterns of Indonesia rainfall.

Table 2. Characteristics of Java Major River Basins.

No.	Name of River	Length [km] Catchment area [km^2]	Highest peak [m] Lowest point [m]	Main cities Population (year)	Land use[1)] [%]				
					F	L	A	P	U
1.	**Citarum**	269 6 080	1 700 0	Bandung 2 513 000 (1992)	20	2.5	18	30	29.5
2.	**Cimanuk**	230 3 600	3 078 0	Cirebon 256 134 (1995)	22.8	0.01	29.8	36	6.6
3.	**Citanduy**	170 4 460	1 750 0	Tasik 187 609 Ciamis 145 406 Banjar 130 197 (1995)	9.3	0.08	48	24	16.6
4.	**Serayu**	158 3 383	2 565 0	Purwokerto 209 005 -	17	-	35.6	24.6	22.7
5.	**Progo**	140 2 380	1 650 0	Magelang 116 468 (1995)	4	-	32	45	19
6.	**Bengawan Solo**	600 16 100	3 265 0	Solo: 525 371 Ngawi:829 726 (1993)	3.0	.5	24.5	66	6.0
7.	**Brantas**	320 12 000	3 369 0	Surabaya 2 270 081 (1990)	22.1	-	19.8	29.2	28.9

1). F: forest**; L**: lakes, rives, marshes; **A:** agriculture fields; **P:** paddy fields; **U:** urban areas.
Source: Catalogue of Rivers, Vol. 1,2,3.

Table 3. Discharge characteristics of Java Major Rivers.

No.	Name of River	Station	Catchment area(A) [km^2]	$\bar{Q}$ [m^3/s]	$\bar{Q}$max [m^3/s]	$\bar{Q}$min [m^3/s]	Qmax/A [m^3/s/100km^2]
1	**Citarum**	Nanjung	1 675	68.7	455.0	5.4	27.1
2	**Cimanuk**	Rentang	3 003	134.7	305.6	19.9	14.6
3	**Citanduy**	Cikawung	2 515	204.0	710.6	16.3	39.2
4	**Serayu**	Rawalo	2 631	273.4	1 497	58.8	76.8
5	**Progo**	Bantar	2 008	89.3	596.0	9.0	29.8
6	**Bengawan Solo**	Bojonegoro	12 804	362.9	2 127	19.0	17.0
7	**Brantas**	Jabon	8 650	258.7	866.1	46.6	10.0

Source: Catalogue of Rivers, Vol. 1,2,3.

Water Resources and Water Related Disasters: Floods and Droughts

Water resources and water related disasters in the forms of floods and droughts can be recognized from their direct impacts as indicated by harvest failures, especially of rice crops, as given on Tables 4, 5 and 6. Other significant impacts can be observed on land and forest fires as indicated on Tables 7 and 8. Briefly these are described below.

Impacts on Rice Crops: Indonesia agricultural production system is characterized by small scale land tenure ship and intensive cultivation almost all year round that proved to be very prone to climate anomalies such as floods and droughts. The impacts of severe droughts were indicated by harvest failures for extended paddy areas, even under technical irrigation facilities. Compare the affected areas of the years 1991, 1994, and 1997 which were approximately ten times those of normal years. Typically 20% of the affected areas fail totally to harvest and the remaining areas only produced about 50% of normal yields. Table 5 indicates that Sumatra and Java are the most drought's affected areas.

Table 4. Estimates of annual yield losses caused by floods and droughts on Indonesia rice fields, 1988~2001.

Year	Floods			Droughts		
	Area Affected [Ha]	Total Damage [Ha]	Yield Loss [Tons]	Area Affected [Ha]	Total Damage [Ha]	Yield Loss [Tons]
1988	130 375	28 934	311 087	87 373	15 115	200 131
1989	96 540	13 174	221 329	36 143	2 116	77 181
1990	66 901	9 642	156 412	54 125	9 521	130 057
1991	38 006	5 707	90 239	867 997	192 347	2 188 921
1992	50 360	9 615	123 781	42 409	7 267	102 525
1993	79 480	26 844	218 876	66 992	20 415	181 643
1994	132 973	32 881	342 302	544 422	161 144	1 456 200
1995	218 144	46 957	547 639	28 580	4 614	68 571
1996	107 385	38 167	305 379	59 560	12 482	151 150
1997	58 974	13 787	153 177	504 021	88 467	1 247 306
1998	158 737	34 701	385 633	183 464	32 681	430 901
1999	188 655	42 087	466 029	104 417	12 619	236 377
2000*	34 493	10 097		60 367	4 715	
2001*	10 224	3 687		73 460	5 271	

Note: * Taken from Baharsjah (2002).

Table 5. Drought Impacts over major islands of Indonesia Rice Fields (Ha) during Dry Season of 1989-1997.

Area	Year:						
	1989	**1990**	**1991**	**1992**	**1993**	**1994**	**1997**
1. Sumatra	9 867	12 545	100 018	2 983	1 063	72 844	138 295
2. Java	456	2 618	591 098	7 363	7 912	322 655	148 815
3. Kalimantan	94	4 503	76 828	141	12 627	51 271	66 267
4. Sulawesi	513	14 442	83 990	79	30 820	14 879	65 886
5. Bali-NTT	764	27	20 343	6 714	916	7 508	1 705
6.Maluku-Irja	3	4	21	279	104	20	283
INDONESIA	**11 697**	**34 139**	**872 298**	**17 559**	**53 442**	**469 177**	**421 251**

Source: Directorate of Food Crop Protection, Ministry of Agriculture –RI, 1998.

Table 6 indicates that dry seasonal flood damage was 10 to 20 percent of those of rainy season floods. The frequencies of floods by region were found in 15 provinces and 115 districts in ten years with few experienced 6 to 8 times in ten years. The areas affected were few hundreds of thousand hectares per district.

Table 6. Recent Flood Impacts on Indonesia Rice Fields by seasons (Ha).

Budget Year	April-September		October-March		Total:	
	Area Affected	Total Damaged	Area Affected	Total Damaged	Area Affected	Total Damaged
Prev.Average*	15 348	4 015	71 687	14 922	87 035	18 937
1994/95	7 822	4 840	75 980	16 062	83 802	20 902
1995/96	**44 236**	**7 359**	**179 462**	**54 968**	**223 698**	**62 327**
1996/97	7 543	1 042	74 090	18 633	81 633	19 584
1997/98	6 230	459	45 993	11 657	52 232	12 116

Note: * Previous five year average (1989/90 – 1993/94).
Source: Directorate of Food Crop Protection – Ministry of Agriculture – RI, 1998.

Impacts on Forest Fires: Forest fires were first included as part of Indonesian Forest Statistics in 1978/1979, though it was first recorded in 1882 when Michielsen conducted a survey in Central Kalimantan. He reported that forest fire had damaged a number of sites in 1877. A first comprehensive record of major forest fire was made after the 1982-1983 fires in East Kalimantan that devastated over 3.5 million hectares of forest lands, the greatest forest fire in recorded history. A fact finding team investigated the vegetation affected by the fires and concluded that the fires destroyed 800 000 ha of primary forest, 1 400 000 ha of logged over forest and 750 000 ha of secondary forest, and 550 000 ha of peat swamp forest. Economic losses due to the fires were estimated at USD 9. Billion as indicated on Table 7 below.

The Directorate General of Forest Protection and Nature Conservation of the Ministry of Forestry – RI reported that a minimum of 25 000 ha of forest fires annually, and between 1988 and 1992 at least 190 884 ha were on fire – an average of 47 721 ha per year. The scale of forest fires increased significantly with the onset of prolonged droughts such as those associated with the recurrent ENSO events known as El Nino years: 1982-83; 1987; 1991; 1994; and 1997. Extent of forest fires in Indonesia, broken down by major islands, since 1984 to present years is given on Table 8 that indicated the recurrence major fires in relation to severe drought years, and the dominant regions of Sumatra and Kalimantan. These fires also known for their negative impacts on transportation and health sectors, primarily due to wide spread haze that also affected Singapore and Malaysia (Trans-boundary haze problems).

Table 7. Estimated economic losses from forest fires in East Kalimantan 1982-1983.

Source of Loss	Value (Million USD)
Timber from natural forest	7 981
Timber from swamp forest	348
Non-timber forest products	373
Rehabilitation expenses	352
Total	**9 054**

Sources: Warta Ekonomi, No.19, October 7, 1991.

Table 8. Forest fires in Indonesia, 1984~2000 (Ha).

Year	Sumatra	Java+Bali	Kalimantan	Sulawesi	Maluku+ West Papua	Indonesia
1984	4 808	10 265	0	0	0	15 079
1985	17 748	5 214	0	1 516	6 100	42 570
1986	10 236	5 773	4 689	879	250	22 038
1987	12 583	18 685	2 367	9 761	0	49 323
1988	6 123	10 398	745	28	0	17 661
1989	6 123	10 398	745	28	0	15 885
1990	13 929	5 443	1 314	1 454	623	25 573
1991	25 686	35 843	29 901	8 501	265	118 881
1992	2 912	5 904	3 526	0	0	14 532
1993	27 244	4 704	352	6	0	40 897
1994	32 054	96 108	18 292	4 521	1 132	161 798
1995	304	6 198	75	56	0	6 705
1996	2 280	5 523	1 102	442	0	10 356
1997	72 376	24 225	86 622	25 850	30 294	263 991
1998						
1999						
2000						

Source: Ditjen Perlindungan Hutan dan Pelestarian Alam, 1997.

Land Use and Cover Changes

Change of land use has been marked especially during the last three decades, with extensive physical development and urbanization. Deterioration of land and water resources in many of Indonesia's watersheds is widespread. Erosion hazards have reached the point where some upland areas have to be abandoned due to lack of productivity. It is believed that these land use and cover changes have had direct impacts on hydrologic regimes. Conservative estimate came to about 80 million ha of derelict land in the year 2000. Recent conditions of Java hydrology and water resources were characterized by occurrences of extreme floods and droughts with high pollutant contents of water bodies. And water crisis is anticipated as real threat to satisfy Java increasing water demands.

The Case of Java Island: Java is the most densely populated island in the world and has been known as an island village. The whole island has become almost completely inhabited at about 1000 inhabitants per square kilometer, which causes high pressure to land. The population increase was obvious in the last two centuries, from only about four million people at the beginning of the nineteenth century, about forty million at the beginning of the twentieth century, and to the present population of about 130 million. This population increase had caused a drastic change in Java land uses, with obvious desertification at some places in Java, although the forest land coverage is still recorded at 20%. Pawitan (1999) did a trend analysis for the rainfall data over the period of 1896 to 1994 for Citarum river basin, and it was found that consistent decline of annual rainfall occurred with approximately 10 mm/year reduction and accompanied with 3 mm/year reduction of runoff. Evaluation of more rainfall series over the South Java areas also gave the same trend of reduction of annual rainfall and stream flow. However, more intensive droughts and floods were experienced also with increased frequencies. Therefore, possible impact of climate change was considered and relationship with ENSO phenomena was evaluated. From long term SOI series it was found that dramatic change of the SOI patterns for the past two decades was reflected by seasonal changes of Java rainfalls. Severe droughts were characterized by drops of total annual rainfall by 100 % that was distributed by reduction up to 300 % during dry season and 50 % reduction during wet season rainfalls. These have been associated strongly to recent increase of El Nino events.

The Case of Sumatra Island: Syam et al.(1997) examined the land use changes in the study site in Lampung province, from 1970 to 1990, considering the national policy, transmigration, and the agro-economical circumstances. Fifty seven percent of the study site was covered with primary forest in 1970,against 13% in 1990. Areas under plantation which were not recorded in 1970, increased to 60% in 1990. In addition, the change from monoculture plantations (mostly coffee) to mixed plantations was noticeable from 1984 to 1990. Total upland areas, including area under shifting cultivation and upland fields with crops and vegetables only with fruit trees, decreased from 21% in 1970 to 0.1% in 1990, clearly suggesting the establishment of plantation agriculture, mainly coffee plantation, in hilly areas, and the conversion of areas for crop and vegetable production to the middle terraces in Lampung Province.

Soil Erosion and Critical Lands

Before the turn of the 20th century there had been little research on the environmental problems in Indonesia, however with increasing deforestation with recent un-controlled illegal logging and its negative impacts, investigations were carried out on some river basins. Earliest study was by Mohr (1906) who found detrimental effects of irrigating rice fields. Erosion rates of parts of Serayu basin were estimated from suspended loads of over 5 700 tons/km^2 at Sojokerto to over 24 600 tons/ km^2 at Pekacangan river. Rutten (1917) concluded that denudation rates were highly dependent on lithological characteristics. Volcanic material had less erosion rate (0.1~0.4 mm/yr) compared to marl (1.6~5.0 mm/yr). Van Dijk and Vogelzang (1948) compared the sediment yields in West Java for the years 1911-1912 and 1934-1935: 900 m^3/km^2 at annual rainfall 1797 mm and 1 900 m^3/km^2 at annual rainfall 1941 mm, respectively. Erosion measurements in Central Java was done by van der Linden (1983) giving an annual estimate of 177 tons as bedload and

Table 9. Critical land (1988) and Annual Rehabilitation Rate (1976-87)

Island(s)	Critical Lands			Annual Rehabilitation Rate		
	Inside Forest	Outside Forest	Total	Inside Forest	Outside Forest	Total
Sumatra	1405900	2298600	3704500	37651	103503	141154
Java & Bali	97700	1262900	1360600	1148	223650	224798
NusaTenggara	1025100	1151500	2176600	7900	22764	30654
Kalimantan	1798300	1165300	2963600	16860	10438	27298
Sulawesi	1099300	965200	2064500	30263	64293	94556
Maluku	305400	330400	635800	54	408	462
Irian Jaya	186800	95800	282600	0	0	0
Indonesia	**5918500**	**7269700**	**13188200**	**93876**	**425046**	**518922**

another 44.5 tons as suspended loads. According to Thijsse (1974, 1976) approximately 40 % of the total up land area in Indonesia of about 100 million ha was already in

deteriorated state ("desert land"). Table 9 indicates the status of critical lands in 1988 and the national capacity in rehabilitating the land during 1976~1987 period. Present rate of deforestation is approximated at two million hectares annually and unfortunately it can be said that there is no significant improvement in the capacity of land rehabilitation.

Role of Agro-environmental Education

Present education institutional capacity of Indonesia in agro-environmental matters is mostly centered around the Public Universities with Agricultural Faculties in the wide sense, including fisheries, forestry, and some environment and natural sciences. Recent national development in the past decades has shown the important roles of the agro-environmental scientists and engineers not only in safe guarding the environment for future generation, but also to ensure better societal welfare and economic conditions and national food security. Obvious constraint that presently limit in realizing this role is the lack of data on water resources and water related observations, including hydro-climate data. Sufficient climate observations in Indonesia now are only limited to small number of agricultural research stations, especially in Java at approximately 100 stations on in Indonesia at some 250 stations, and hydrometry stations that are operated on yearly basis subject to availability of hydrologic 'projects'. Therefore, to fulfill present needs of hydro-climate information, a network of climate 'centers' will be required and to be well attended by skillful managers and operators, which are now still lacking. The present National Task Force on Climate Anomalous to Ensure Food Security to deal with droughts and floods disasters that is being set up by the Ministry of Agriculture, is in the process of recruiting necessary personals at the national and regional levels from various sectoral agencies. The present target was in drought anticipation of El Nino 2002, therefore to secure food supply. At national level, some 15 inter-departmental agencies have been identified for participation, in addition to the internal working units within the Ministry of Agriculture. And at the provincial level, approximately 10 technical service agencies will be coordinated. The first program of the Task Force would be to train these people on hydro-climate matters and how to socialize the information to the society (farmers) with the consequences on plan of planting seasons. So, the role of agro-environmental education includes communicating the hydro-climate information to the society with real actions.

Concluding Remarks

1. Population pressure with intensive agriculture and rapid recent industrial development implied extensive land use changes and increased water demand, generated degraded land and soil erosion, and was suspected to cause long term changes in regional hydrologic regimes in Indonesia.
2. The impacts of severe droughts were indicated by harvest failures for extended rice areas, even under technical irrigation facilities that approximately can reach ten times those of normal years. Typically 20% of the affected areas fail totally to harvest and the remaining areas only produced about 50% of normal yields. The frequencies of floods by region were found in 15 provinces and 115 districts in ten years with few

experienced 6 to 8 times in ten years. The areas affected were few hundreds of thousand hectares per district.

3. Typically there is a minimum of 25 000 ha of forest fires annually, and between 1988 and 1992 at least 190 884 ha were on fire – an average of 47 721 ha per year. The scale of forest fire increased significantly with the onset of prolonged droughts such as those associated with the recurrent ENSO events known as El Nino years: 1982-83; 1987; 1991; 1994; and 1997.
4. The important role of agro-environmental education in practice is curbed by the lack of necessary hydro-climatic information from actual observations.

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