Session 2

“Histories of Developments , Land Use Changing along the Brantas River Basin.”

Rainfall and Sediment runoff in the Lesti River Basin, Tributary of the Brantas River, Indonesia

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Rainfall and Sediment runoff in the Lesti River Bain, Tributary of the Brantas River, Indonesia

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Intensive and continuous observations on sediment yield and transport are conducted in the Lesti River Basin (625 km^2), a tributary of the Brantas River(11,800 km^2), Indonesia (see Figure 1)[1]. This report presents the observation results of raindrop characteristics investigated with Micro Rain Radar (MRR), seasonal and inter-annual land cover change detected by remotely sensing, soil erosion measurements with staves installed at different land covers, and sediment turbidity measurements at the outlet of the Lesti River. Our motivation of these integrated observations is to understand all the processes from sediment yield to transport with the consideration of human impact such as cultivation, deforestation, and sand mining. By referring these observation data, we newly developed two models which can reproduce observed rainfall and sediment runoff processes by introducing the NDVI (Normalized Difference Vegetation Index) values that can express land cover changes [2].

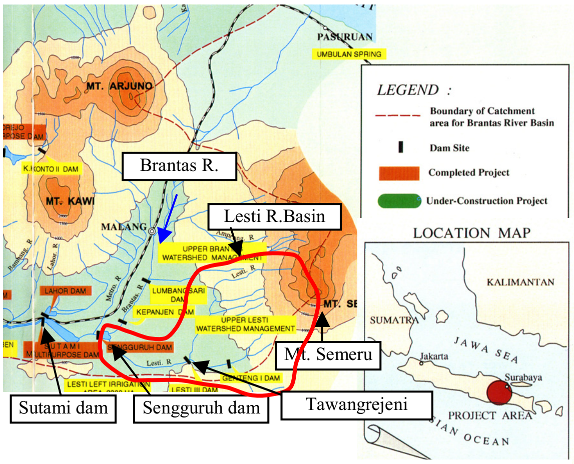

Fig. 1 Lesti River basin

Those models, named as “ST Model” and “RH Model”, respectively, are both in the kinematic wave runoff models and are rather similar. The important difference in those models comes from treatment of effects of NDVI on the erodibility of the topsoil. In the ST Model, erosion velocity of the topsoil, D_r (kg/hr/m^2), by the impacts of raindrops is expressed as;

$$D_r = \gamma K_1 K_e \quad , \quad K_e = 56.48r \qquad (1)$$

where, γ =erodibility of the topsoil as shown in Fig. 2, K_1 =coefficient of the erodibility (kg/J), K_e =impact energy of a raindrop (J/m^2)[3], and r=rainfall intensity (mm/hr).

On the other hand, in the "RH Model", NDVI is not considered in evaluating the topsoil erosion by the rain drop impact, but is considered in the flow resistance, i.e., Manning's roughness coefficient. This is because that when NDVI value is large, i.e., vegetation on the land-surface is very active, the flow resistance due to vegetation becomes large. The relationship between NDVI value and Manning's roughness coefficient is established as;

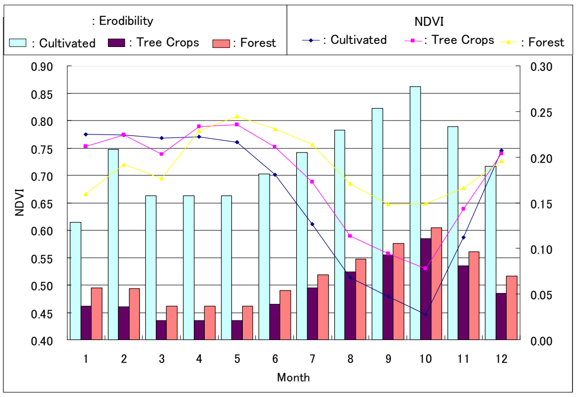

Fig. 2 Seasonal change of the erodibility of the top soil (right) and NDVI (left)

$$n = 0.0713\exp(2.8p) \qquad (2)$$

where, n=Manning's roughness coefficient ($m^{-1/3}s$), and p=NDVI value.

Figure 3 shows comparisons between calculated and observed long term water discharges and turbidity at Tawangrejeni from October 2004 to October 2006 in case of "ST Model". Figure 4 shows comparisons between calculated and observed water discharge and turbidity at Tawangrejeni in the period from 0:00, Nov. 21, 2003 to 0:00, Nov. 24, 2003 in case of "RH Model". Calculated water discharges and turbidities by using each model agree fairly well with observed data.

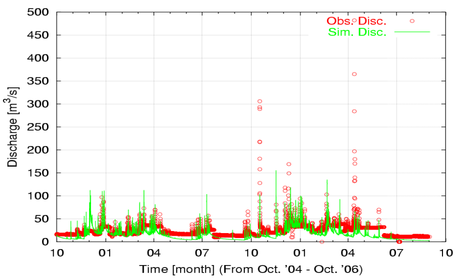

Fig. 3(a) Comparison between calculated and observed long term water discharges at Tawangrejeni from October 2004 to October 2006

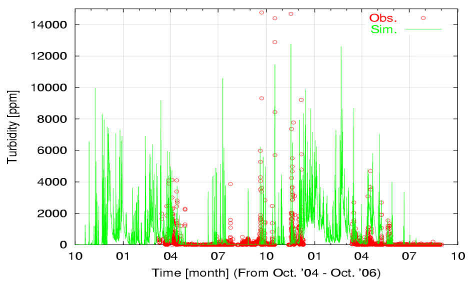

Fig. 3(b) Comparison between calculated and observed long term turbidity at Tawangrejeni from October 2004 to October 2006

References

[1] Nakagawa, H.,Satofuka, Y., Muto, Y., Ohishi, S., Sayama, T. and Takara, K.: On sediment yield and transport in the Lesti River basin, a tributary of the Brantas River, Indonesia,-Experiences from field observations and remotely sensed data-, Proc. of the International Symposium on Fluvial and Coastal Disasters, CD-ROM (2005).

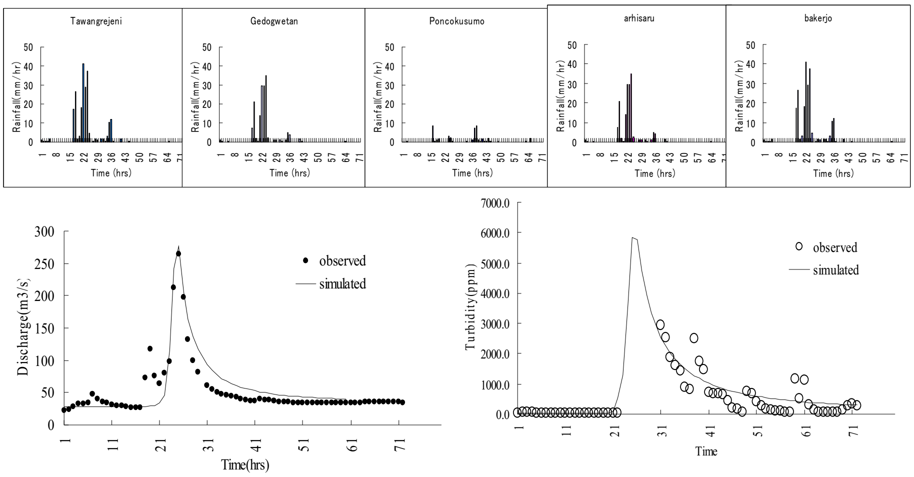

Fig. 4 Comparisons between calculated and observed water discharge and turbidity at Tawangrejeni in the period from 0:00, Nov. 21, 2003 to 0:00, Nov. 24, 2003

[2] Nakagawa, H., Satofuka, Y., Oishi, S., Muto, Y., Sayama, T., Takara, K. and Sharma, R. H. : Rainfall and sediment runoff in the Lesti River basin, tributary of the Brantas River, Annuals, Disa. Prev. Res. Inst., Kyoto Univ., Vol. 50B (in printing)(2007).

[3] Oishi, S., Sayama, T., Nakagawa, H., Satofuka, Y., Muto, Y., Dian, S. and Sunada, K.: Development of estimation method for impact energy of raindrop considering raindrop size distribution and the relationship between the impact energy and local sediment yield, Annual Journal of Hydraulic Engineering, JSCE, Vol. 49, pp.1087-1092 (in Japanese)(2005).

Brantas River Workshop in Malang
November 22-23, 2007
At Hotel Santika Malang

Rainfall and Sediment runoff in the Lesti River Basin, Tributary of the Brantas River, Indonesia

INDONESIA SIDE:

SOEKISTIJONO, Aris HARNANTO and Fahmi HIDAYAT

JAPAN SIDE

Hajime NAKAGAWA[1], Yoshifumi SATOFUKA[2], Satoru OISHI[3], Yasunori MUTO[1], Takehiro SAYAMA[1],Kaoru TAKARA[1], and Raji Hari SHARMA[4]

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This project was done under the main theme of
"System Modeling Approaches for Assessment of Interaction between Social Changes and Water Cycle"
(Project Leader : Prof. Kaoru Takara, DPRI, Kyoto Univ.)

and under the sub-theme of
"Development of the Water Cycle Model in the Asian Monsoon Area"

conducted under CREST (Core Research for Evolutional Science and Technology) Program by the Japan Science and Technology Agency

(Period: 2001-2006)

Objectives

Recently, reservoir sedimentation becomes a big problem to flood control, water utility, and river environment. Sediment management in the basin is a very important matter. So that, we want

- to elucidate basin-scale rainfall and sediment runoff processes, and
- to consider the human impacts (agricultural activity) on the rainfall and sediment runoff phenomenon in the model.

Study Area and Hypothesis

- The Lesti River basin where the sediment yield due to eruption of Mt. Semeru is very active, was selected as a study area.
- We suppose that the main sediment source is from the slope surface erosion due to rain drop impact and surface flow, and riverbed erosion is not so important.
- Sand mining may effect a lot on the sediment yield but we neglect this effect due to difficulty of evaluation.

Methodology

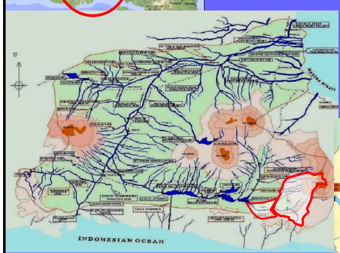
We took following two actions;

- Understanding of the characteristics of the rainfall and sediment runoff by carrying out the observations on
  - characteristics of the topsoil erodibility due to rainfalls
  - characteristics of temporal and spatial distributions of turbidity in the river
  - characteristics of amount of rainfall, raindrops, and river water discharge, and
  - landuse and condition of land surface cover (by remote sensing technique)
- Modeling based on the observed data and information

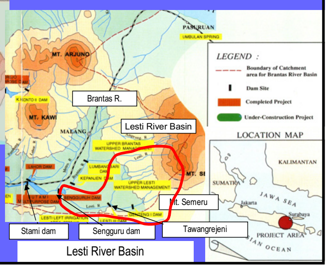
Outline of Brantas River Basin

- Basin Area : 11,800 km^2 (25% of E. Java)
- Population (2003) : 15.5 million (43% of E. Java)
- Average Rainfall : 2,000 mm/year
- Water Potentials : 12 billion m^3/year
- River Length : 320 km

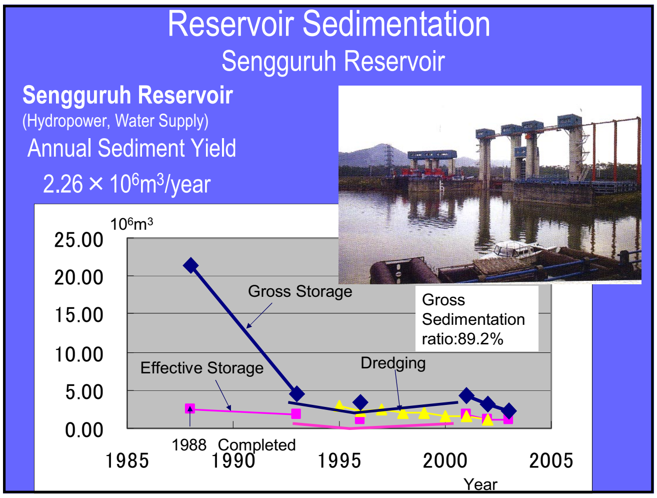
Lasti River Bain 625 km^2

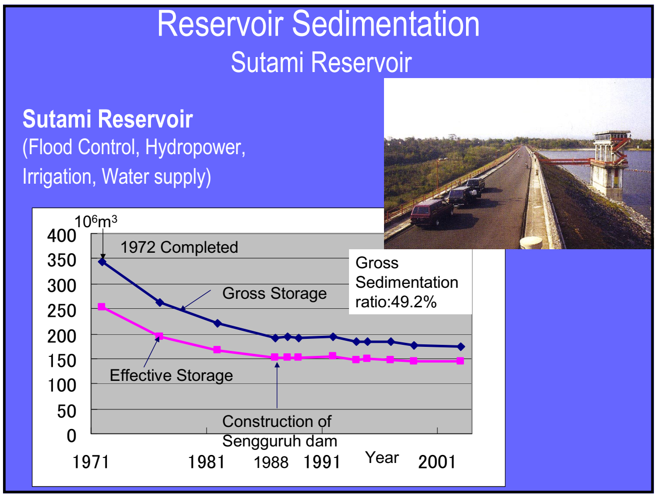


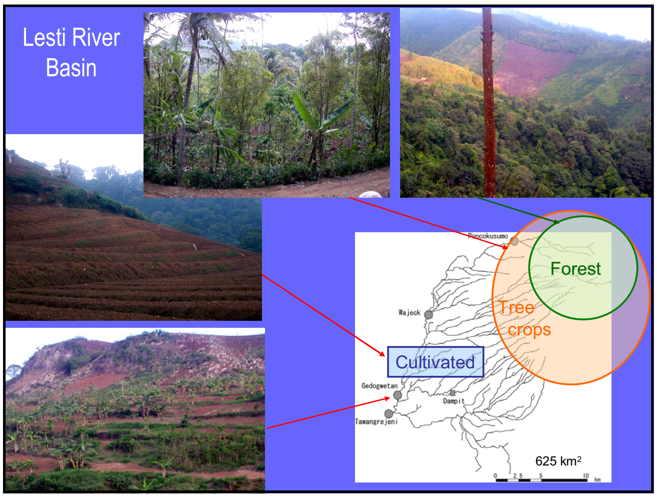
- Land Use (2004) :
  - paddy field 39.0%
  - dry land 12.0%
  - plantation 22.0%
  - forest 11.0%
  - settlements 12.0%
  - others 4.0%

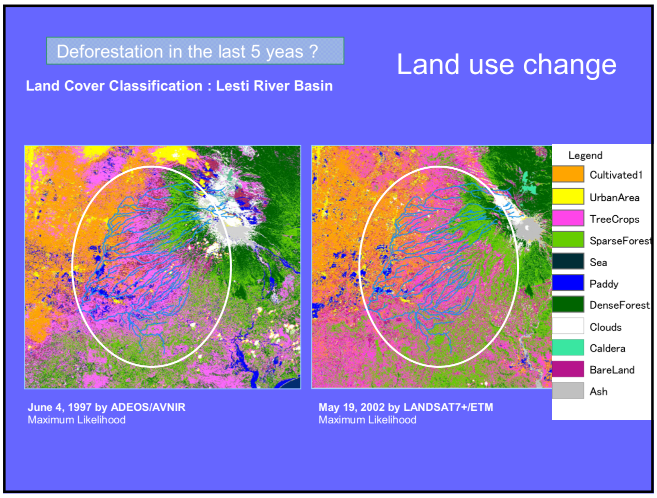


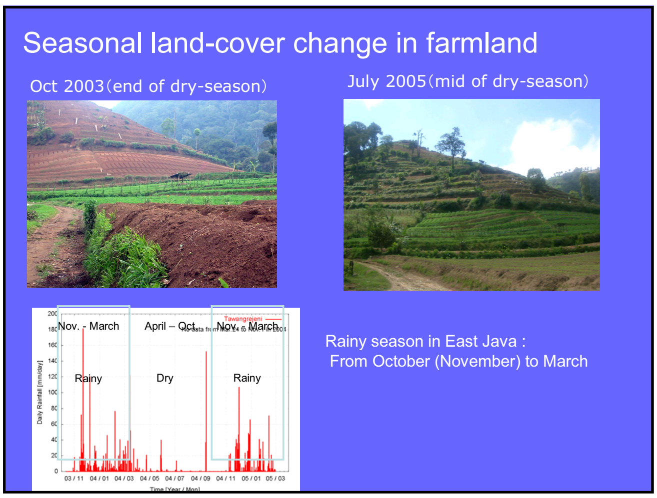
Lesti River Basin

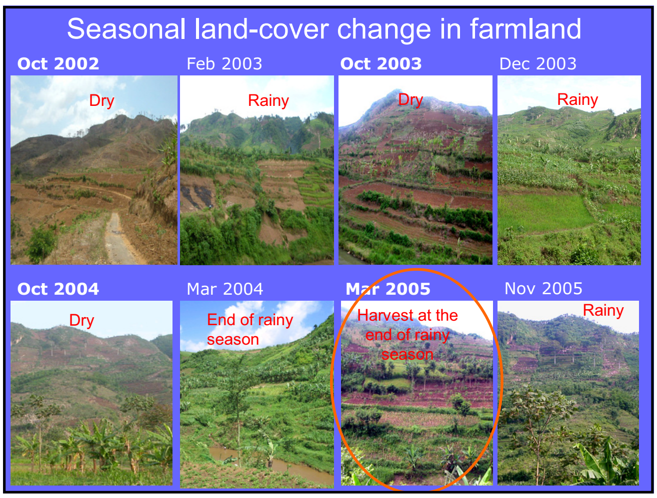

Reservoir Sedimentation
Sengguruh Reservoir
Sengguruh Reservoir
(Hydropower, Water Supply)
Annual Sediment Yield
2.26 × 10⁶m³/year
10⁶m³
25.00
20.00
15.00
10.00
5.00
0.00
Gross Storage
Gross Sedimentation ratio:89.2%
Effective Storage
Dredging
1988 Completed
1985
1990
1995
2000
2005
Year

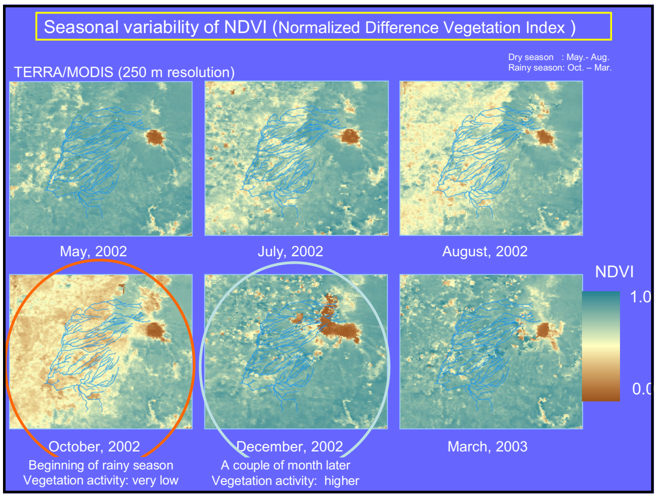

Reservoir Sedimentation
Sutami Reservoir
Sutami Reservoir
(Flood Control, Hydropower, Irrigation, Water supply)
10⁶m³
400
350
300
250
200
150
100
50
0
1972 Completed
Gross Storage
Gross Sedimentation ratio:49.2%
Effective Storage
Construction of Sengguruh dam
1971
1981
1988
1991
Year
2001

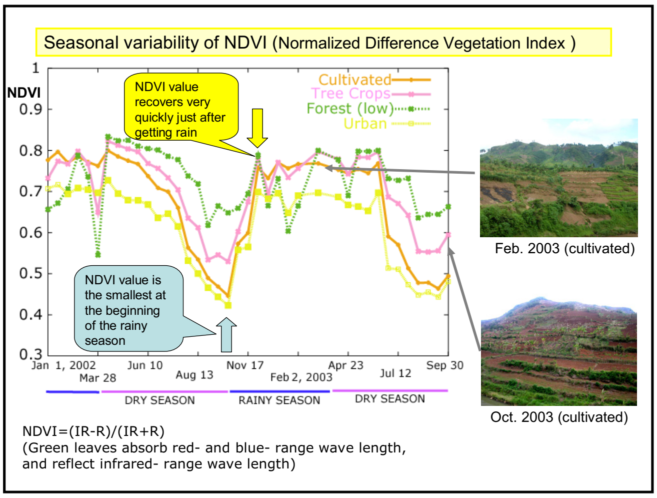

Lesti River Basin
Forest
Tree crops
Cultivated
625 km²

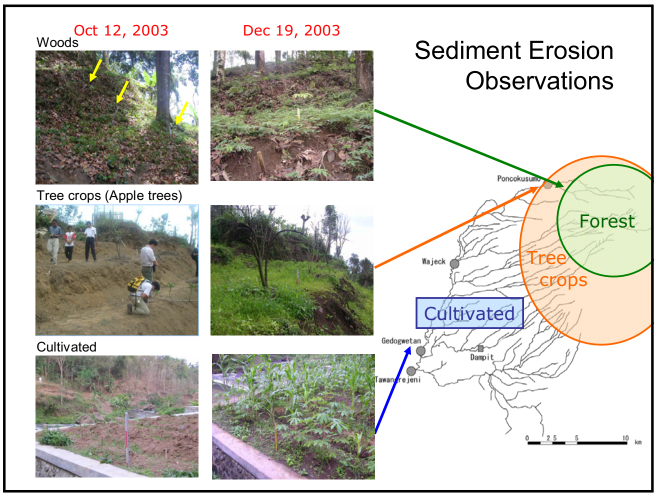

Deforestation in the last 5 yeas ?
Land Cover Classification : Lesti River Basin
Land use change
June 4, 1997 by ADEOS/AVNIR
Maximum Likelihood
May 19, 2002 by LANDSAT7+/ETM
Maximum Likelihood
Legend
Cultivated1
UrbanArea
TreeCrops
SparseForest
Sea
Paddy
DenseForest
Clouds
Caldera
BareLand
Ash

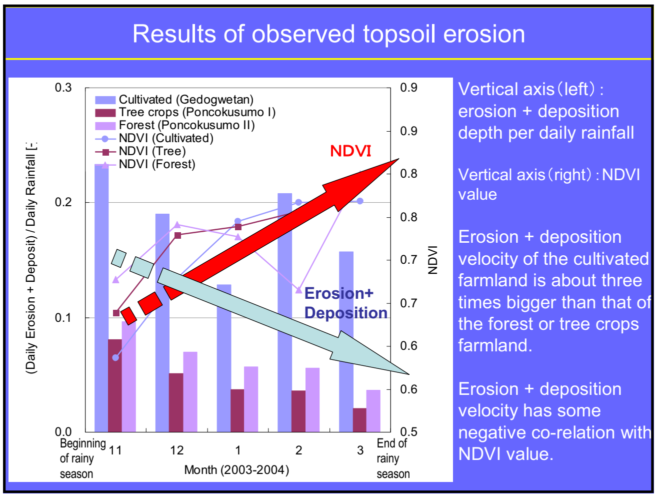

Seasonal land-cover change in farmland
Oct 2003(end of dry-season)
July 2005(mid of dry-season)
Nov. - March
April – Oct
Nov. – March
Rainy
Dry
Rainy
Rainy season in East Java :
From October (November) to March

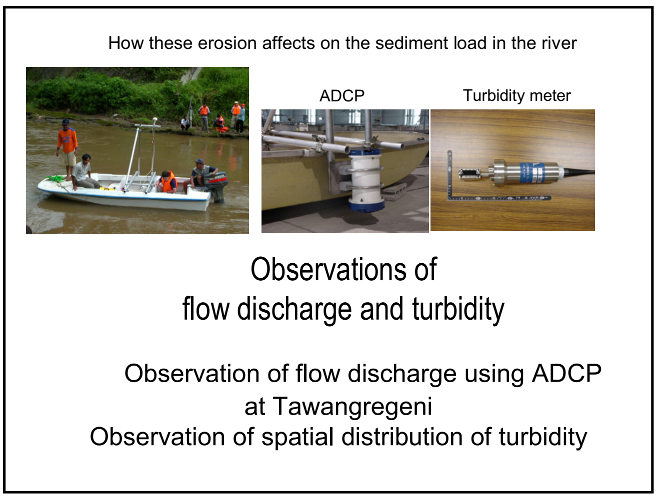

Seasonal land-cover change in farmland
Oct 2002
Feb 2003
Oct 2003
Dec 2003
Dry
Rainy
Dry
Rainy
Oct 2004
Mar 2004
Mar 2005
Nov 2005
Dry
End of rainy season
Harvest at the end of rainy season
Rainy

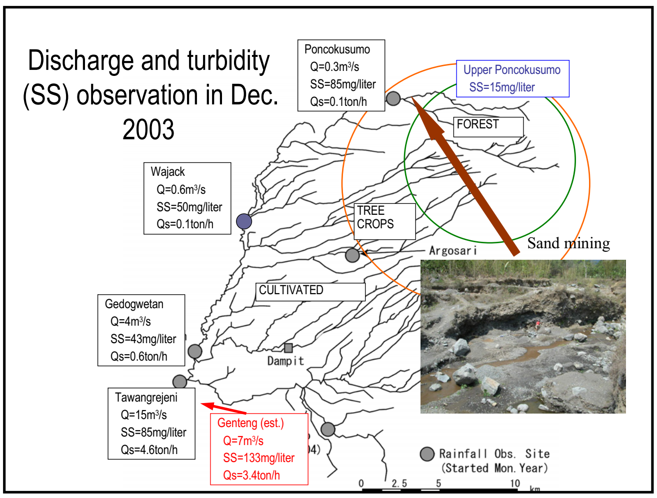

Seasonal variability of NDVI (Normalized Difference Vegetation Index)
TERRA/MODIS (250 m resolution)
Dry season : May.- Aug.
Rainy season: Oct. – Mar.
May, 2002
July, 2002
August, 2002
NDVI
1.0
October, 2002
Beginning of rainy season
Vegetation activity: very low
December, 2002
A couple of month later
Vegetation activity: higher
March, 2003

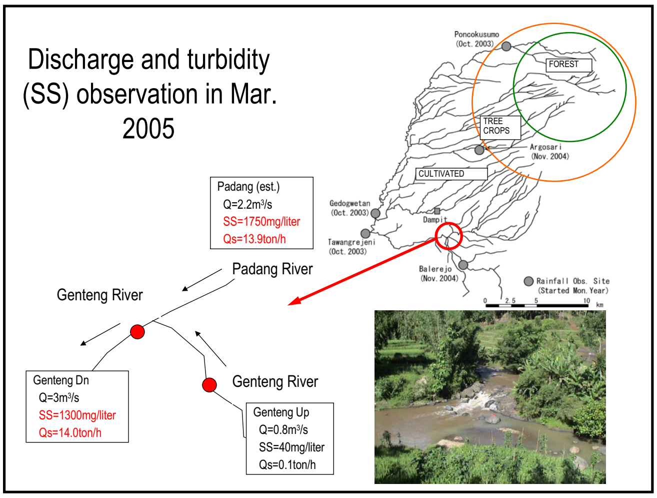

Seasonal variability of NDVI (Normalized Difference Vegetation Index)
NDVI
NDVI value recovers very quickly just after getting rain
NDVI value is the smallest at the beginning of the rainy season
Cultivated
Tree Crops
Forest (low)
Urban
Jan 1, 2002
Mar 28
Jun 10
Aug 13
Nov 17
Feb 2, 2003
Apr 23
Jul 12
Sep 30
DRY SEASON
RAINY SEASON
DRY SEASON
Feb. 2003 (cultivated)
Oct. 2003 (cultivated)
NDVI=(IR-R)/(IR+R)
(Green leaves absorb red- and blue- range wave length,
and reflect infrared- range wave length)

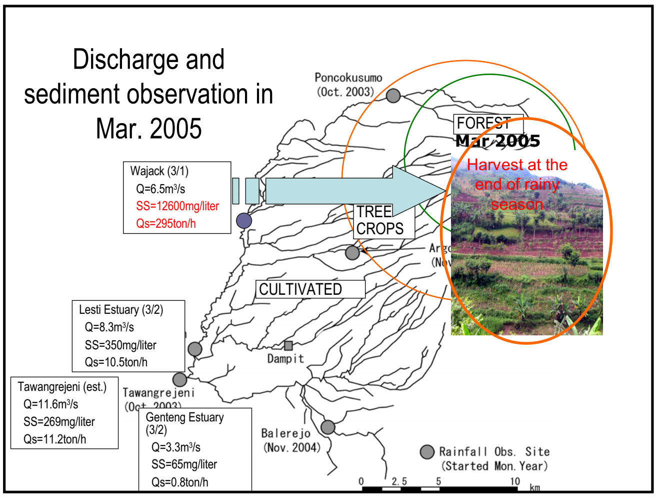

Oct 12, 2003
Dec 19, 2003
Woods
Tree crops (Apple trees)
Cultivated
Sediment Erosion
Observations
Forest
Tree
crops
Cultivated

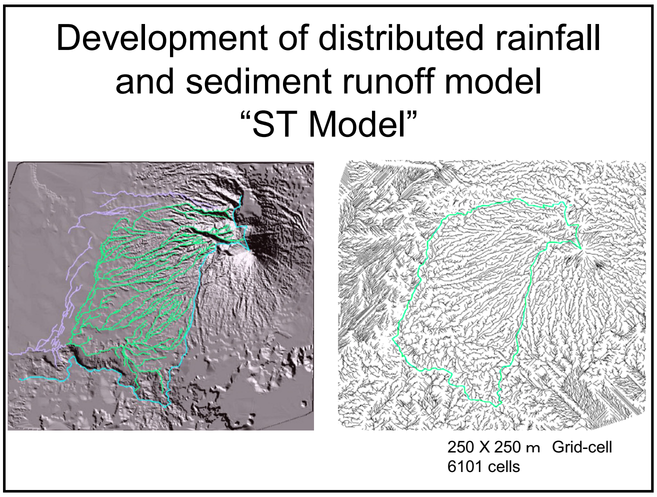

Results of observed topsoil erosion
Cultivated (Gedogwetan)
Tree crops (Poncokusumo I)
Forest (Poncokusumo II)
NDVI (Cultivated)
NDVI (Tree)
NDVI (Forest)
NDVI
Erosion+
Deposition
Month (2003-2004)
Beginning of rainy season
End of rainy season
Vertical axis (left) : erosion + deposition depth per daily rainfall
Vertical axis (right) : NDVI value
Erosion + deposition velocity of the cultivated farmland is about three times bigger than that of the forest or tree crops farmland.
Erosion + deposition velocity has some negative co-relation with NDVI value.

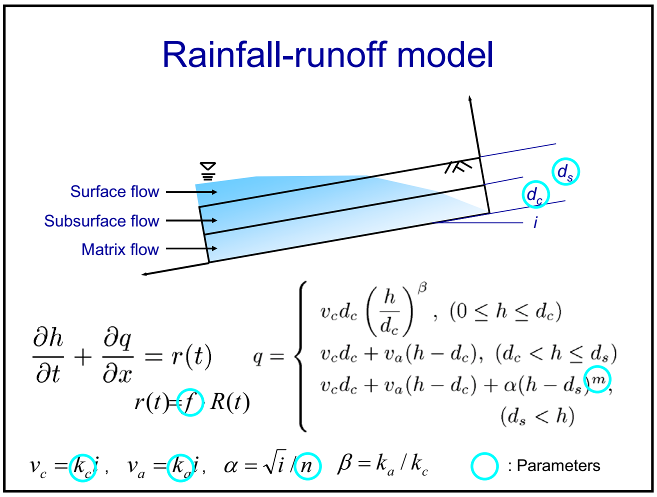

How these erosion affects on the sediment load in the river
ADCP
Turbidity meter
Observations of
flow discharge and turbidity
Observation of flow discharge using ADCP
at Tawangregeni
Observation of spatial distribution of turbidity

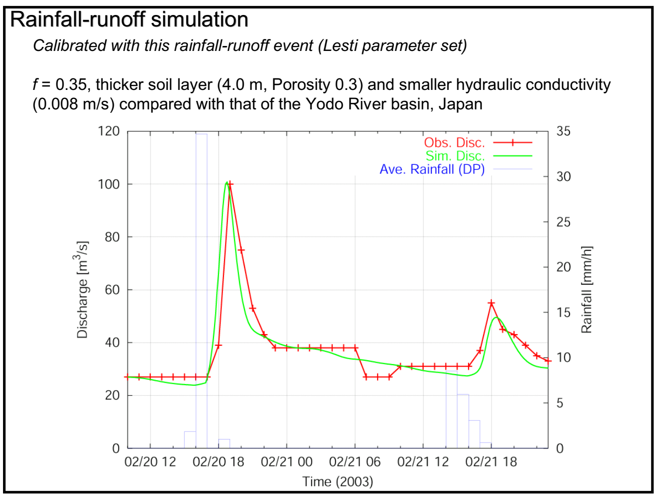

Discharge and turbidity (SS) observation in Dec. 2003
Poncokusumo
Q=0.3m³/s
SS=85mg/liter
Qs=0.1ton/h
Upper Poncokusumo
SS=15mg/liter
FOREST
Wajack
Q=0.6m³/s
SS=50mg/liter
Qs=0.1ton/h
TREE
CROPS
Sand mining
Argosari
CULTIVATED
Gedogwetan
Q=4m³/s
SS=43mg/liter
Qs=0.6ton/h
Dampit
Tawangrejeni
Q=15m³/s
SS=85mg/liter
Qs=4.6ton/h
Genteng (est.)
Q=7m³/s
SS=133mg/liter
Qs=3.4ton/h
Rainfall Obs. Site
(Started Mon. Year)

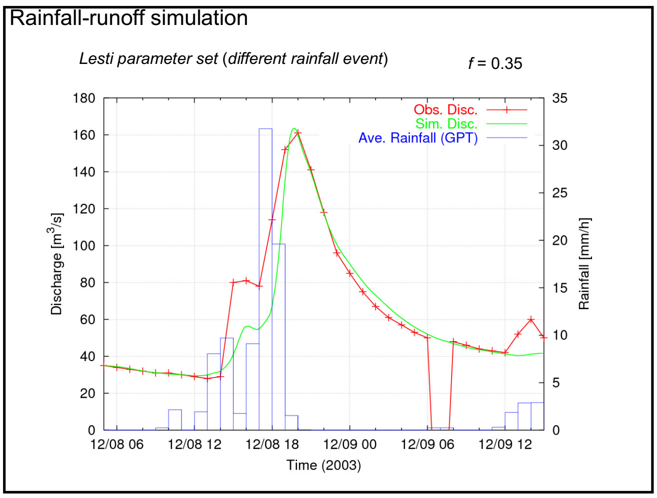

Discharge and turbidity (SS) observation in Mar. 2005
Padang (est.)
Q=2.2m³/s
SS=1750mg/liter
Qs=13.9ton/h
Padang River
Genteng River
Genteng Dn
Q=3m³/s
SS=1300mg/liter
Qs=14.0ton/h
Genteng River
Genteng Up
Q=0.8m³/s
SS=40mg/liter
Qs=0.1ton/h
FOREST
TREE CROPS
CULTIVATED
Dampit
Rainfall Obs. Site (Started Mon. Year)

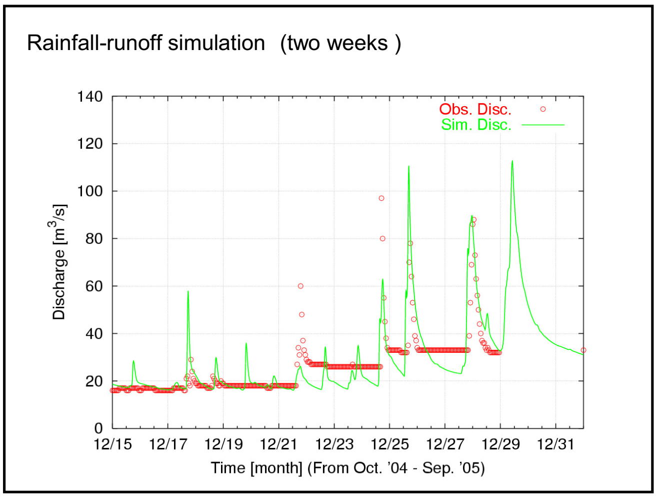

Discharge and sediment observation in Mar. 2005
Poncokusumo (Oct. 2003)
FOREST
Mar 2005
Harvest at the end of rainy season
Wajack (3/1)
Q=6.5m³/s
SS=12600mg/liter
Qs=295ton/h
TREE CROPS
CULTIVATED
Lesti Estuary (3/2)
Q=8.3m³/s
SS=350mg/liter
Qs=10.5ton/h
Dampit
Tawangrejeni (est.)
Q=11.6m³/s
SS=269mg/liter
Qs=11.2ton/h
Tawangrejeni
Genteng Estuary (3/2)
Q=3.3m³/s
SS=65mg/liter
Qs=0.8ton/h
Balerejo (Nov. 2004)
Rainfall Obs. Site (Started Mon. Year)
0 2.5 5 10 km

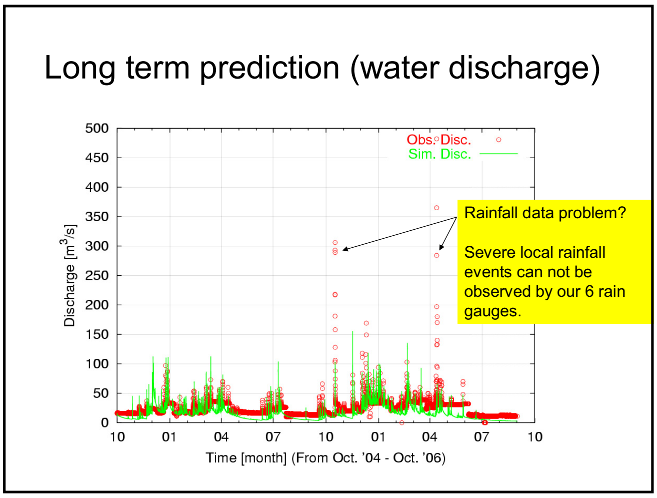

Development of distributed rainfall and sediment runoff model "ST Model"
250 X 250 m Grid-cell
6101 cells

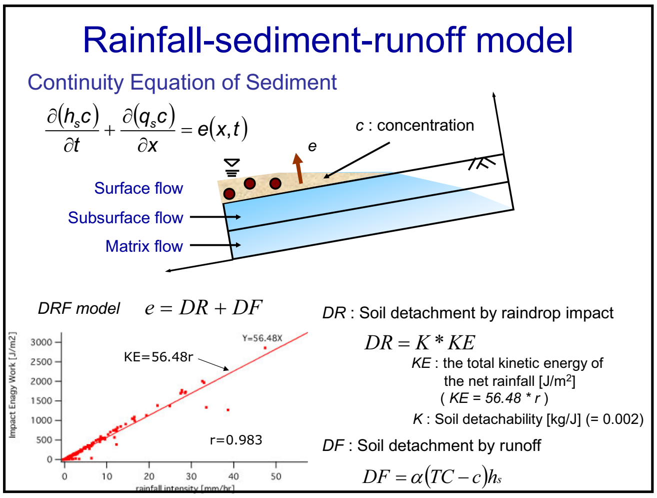

Rainfall-runoff model
Surface flow
Subsurface flow
Matrix flow
d_s
d_c
i
$\frac{\partial h}{\partial t} + \frac{\partial q}{\partial x} = r(t)$
$r(t) = f\, R(t)$
$q = \begin{cases} v_c d_c \left(\frac{h}{d_c}\right)^{\beta}, & (0 \le h \le d_c) \\ v_c d_c + v_a (h - d_c), & (d_c < h \le d_s) \\ v_c d_c + v_a (h - d_c) + \alpha (h - d_s)^m, & (d_s < h) \end{cases}$
$v_c = k_c i, \quad v_a = k_a i, \quad \alpha = \sqrt{i}/n \quad \beta = k_a / k_c$
: Parameters

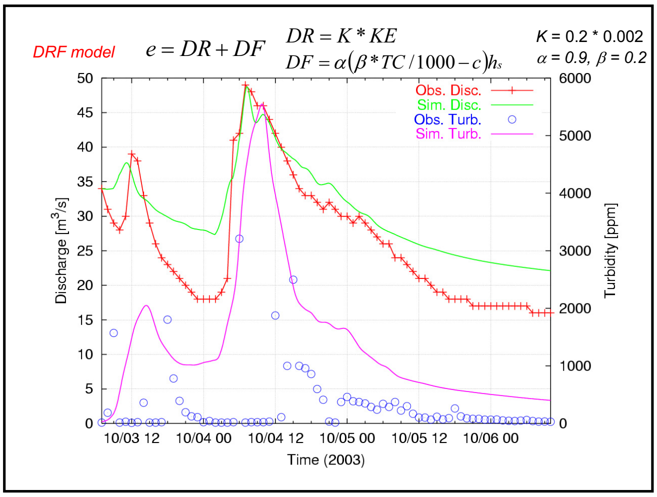

Rainfall-runoff simulation
Calibrated with this rainfall-runoff event (Lesti parameter set)
f = 0.35, thicker soil layer (4.0 m, Porosity 0.3) and smaller hydraulic conductivity (0.008 m/s) compared with that of the Yodo River basin, Japan
Obs. Disc.
Sim. Disc.
Ave. Rainfall (DP)
Discharge [m³/s]
Rainfall [mm/h]
02/20 12
02/20 18
02/21 00
02/21 06
02/21 12
02/21 18
Time (2003)

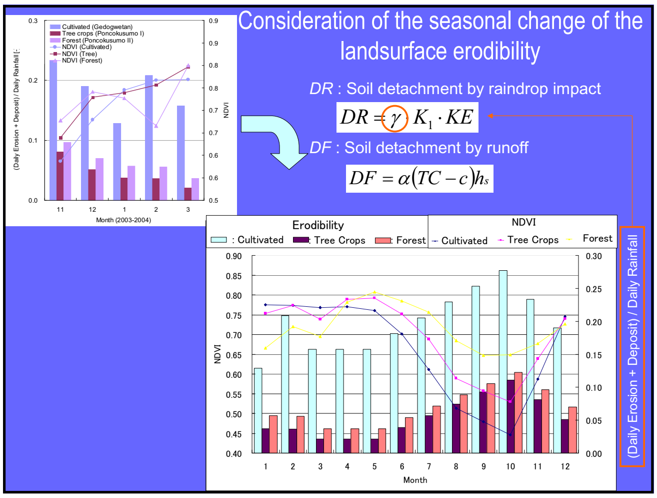

Rainfall-runoff simulation
Lesti parameter set (different rainfall event)
f = 0.35
Obs. Disc.
Sim. Disc.
Ave. Rainfall (GPT)
Discharge [m³/s]
Rainfall [mm/h]
12/08 06
12/08 12
12/08 18
12/09 00
12/09 06
12/09 12
Time (2003)

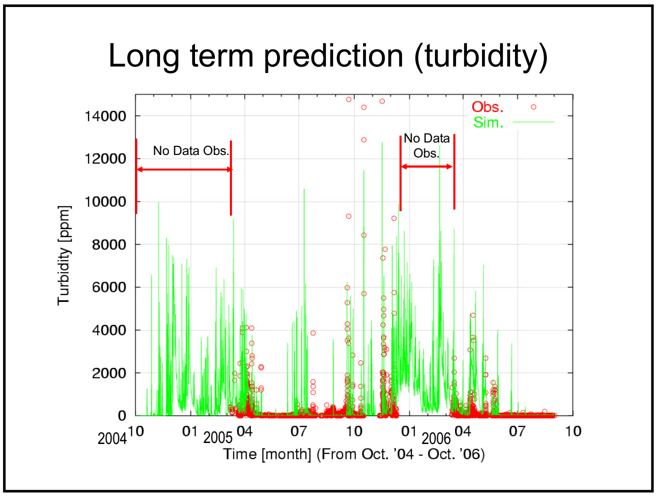

Rainfall-runoff simulation (two weeks)
Obs. Disc.
Sim. Disc.
Discharge [m3/s]
Time [month] (From Oct. '04 - Sep. '05)
12/15 12/17 12/19 12/21 12/23 12/25 12/27 12/29 12/31


Long term prediction (water discharge)
Obs. Disc.
Sim. Disc.
Rainfall data problem?
Severe local rainfall events can not be observed by our 6 rain gauges.
Discharge [m3/s]
Time [month] (From Oct. '04 - Oct. '06)

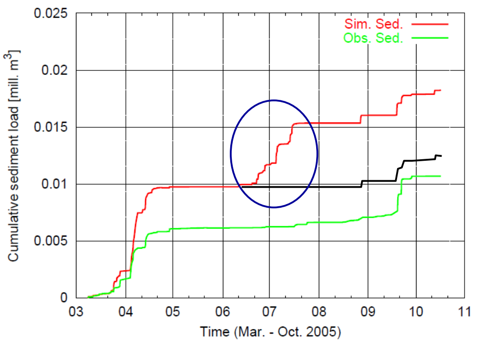

Rainfall-sediment-runoff model
Continuity Equation of Sediment
$\frac{\partial(h_s c)}{\partial t} + \frac{\partial(q_s c)}{\partial x} = e(x,t)$
c : concentration
e
Surface flow
Subsurface flow
Matrix flow
DRF model $e = DR + DF$
DR : Soil detachment by raindrop impact
$DR = K * KE$
KE : the total kinetic energy of the net rainfall [J/m2]
(KE = 56.48 * r)
K : Soil detachability [kg/J] (= 0.002)
DF : Soil detachment by runoff
$DF = \alpha(TC - c)h_s$
KE=56.48r
r=0.983
Impact Enagy Work [J/m2]
rainfall intensity [mm/hr]


DRF model $e = DR + DF$
$DR = K * KE$
$DF = \alpha(\beta * TC / 1000 - c)h_s$
K = 0.2 * 0.002
α = 0.9, β = 0.2
Obs. Disc.
Sim. Disc.
Obs. Turb.
Sim. Turb.
Discharge [m3/s]
Turbidity [ppm]
10/03 12 10/04 00 10/04 12 10/05 00 10/05 12 10/06 00
Time (2003)


Consideration of the seasonal change of the landsurface erodibility
DR : Soil detachment by raindrop impact
$DR = \gamma K_1 \cdot KE$
DF : Soil detachment by runoff
$DF = \alpha(TC - c)h_s$
Erodibility
NDVI
Cultivated
Tree Crops
Forest
Month
(Daily Erosion + Deposit) / Daily Rainfall

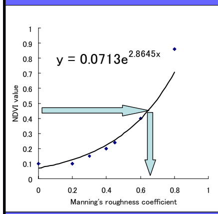

Long term prediction (turbidity)
Obs.
Sim.
No Data Obs.
No Data Obs.
Turbidity [ppm]
2004 2005 2006
Time [month] (From Oct. '04 - Oct. '06)

Cumulative sediment volume



流量・濁度観測データが得られる期間のみ積算

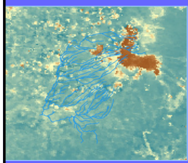
"RH Model"



Landuse	NDVI value	Typical Manning's roughness coefficient
Water body	0	0.1
Paddy field	0.2	0.1
Bare land	0.3	0.15
Cultivated land	0.4	0.2
Cultivated land (dense)	0.45	0.24
Pasture land	0.6	0.4
Dense forest	0.8	0.86

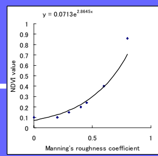
n for channel =0.05

Higher NDVI → Higher vegetation cover → Higher roughness



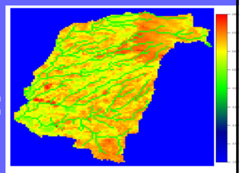
NDVI Value

+



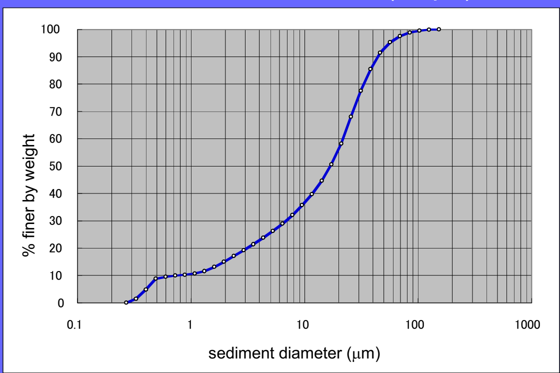
Conversion rule

=



Manning's roughness coefficient

Grain size distribution (slope)

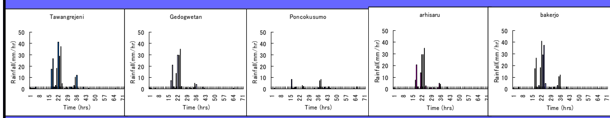


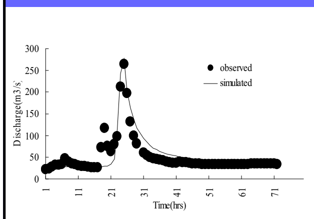
Mean diameter :20mm
Maximum diameter :100mm

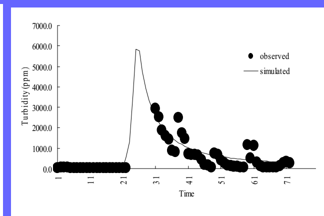
⇒ sediment eroded on the slope can be treated as a washload

Results

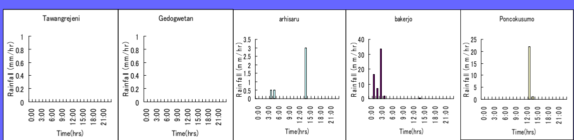
Simulated and observed discharge and turbidity
2003-11-21 to 2003-11-23

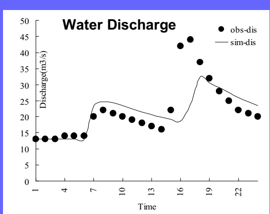


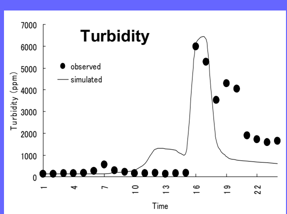




Simulated and observed discharge and turbidity
2005-09-19







Error comparison

Error comparison of observed and simulated values of discharge and turbidity was done using root mean square error (RMSE)

In case of NDVI-n, n=0.1, 0.5, 0.8

RMSE for different Manning's roughness coefficient

$$RMSE = \sqrt{\frac{1}{N}\sum_{i=1,N}[(Q_0)_i - (Q_e)_i]^2}$$

	NDVI-n	n-0.1	n-0.5	n-0.8
Discharge	19.9	35.9	20.1	47.5
turbidity	550.1	1860	1458.3	1315.4

RMSE in case of using Manning's n from NDVI index gives better result for discharge and turbidity both

Conclusions

1. We carried out the various analyses of data obtained by field observations and remote sensing to understand the basin-wide rainfall and sediment runoff processes.
2. Sediment yield on the slope was found to happens due to heavy rainfall just beginning of the rainy season in the volcanic river basin such as the Lesti River basin.
3. At the beginning of rainy season, as the vegetation activity is low yet, a large amount of sediment were easily yielded by the raindrop shower, resulting in the high turbidity in the river.
4. The distributed rainfall and sediment runoff models, that are based on the erodibility variation due to landuse change, seasonal change of the vegetation, and raindrop impacts, were developed and long- and short-term predictions of sediment runoff phenomenon could be reproduced fairly well.
5. Model refinement and calibration of parameter set are necessary much more.

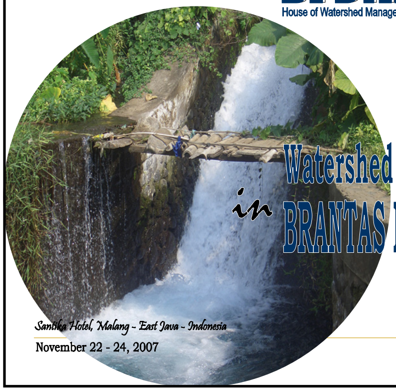
Expected effects in future

1. Highly accurate prediction for the inflow sediment volume into reservoirs may be possible.
2. Highly accurate prediction for the amount of sediment volume by erosion corresponding to the surface cover condition (human impact) with vegetation by using NDVI values from satellite image can be possible
3. Suggestions to the farmers for the deliberate land use and development of agronomical technologies can be possible.

Watershed Management in Brantas river basin

Mr.Eddy

Brantas Watershed Management Agency (BP-DAS Brantas), Ministry of Forestry



THE MINISTRY OF FORESTRY
GENERAL DIRECTORY OF LAND REHABILITATION AND SOCIAL FORESTRY

BPDAS *Brantas*

House of Watershed Management

Watershed Management *in* BRANTAS RIVER BASIN

Santika Hotel, Malang - East Java - Indonesia

November 22 - 24, 2007

VISION and MISSION

VISION

- As the land and forest information and services center for Watershed Management

MISSION

- Provide Watershed Management's plan for stakeholders;
- Develop the model of Watershed Management;
- Develop the model system of Watershed Management's Institution and Partnership;
- Watershed Management evaluation;
- Provide data and information about Watershed Management;
- Create an efficient and effective supporting system;

FUNDAMENTAL DUTY AND FUNCTION

FUNDAMENTAL DUTY AND FUNCTION **(Minister of Forestry's Letter of Appointment Number : 665/Kpts-II/2002 on 7 March 2002, about Organization and Administration of Office of Watershed Management)**

FUNDAMENTAL DUTY

- **Planning, Institution Development and Evaluation**

FUNCTION

- **Organize the Watershed Management's Plan**
- **Organize and Present the Watershed Information**
- **Develop the Watershed Management's Model**
- **Develop the Watershed Management's Institution and Partnership**
- **Monitor and Evaluate the Watershed Management**
- **Organize the Administration and Internal Affair**

JURISDICTION of BPDAS BRANTAS

Watershed			Sub Watershed			DISTRICT / CITY
NO	NAME	AREA	NO	NAME	AREA	NAME
1	BRANTAS	1.188.559	1	Ngrowo Ngasinan	145.198	I. REGENCY /
2	REJOSO	63.369	2	Lesti	58.384	DISTRICT
3	GEDANGAN DLODO	87.140	3	Melamon	78.089	1 Malang
4	WELANG. Ds	67.458	4	Ambang	101.675	2 Blitar
5	PASIRAMAN. Ds	50.889	5	Widas	151.532	3 Tulungagung
6	BAREK GLIDIK. Ds	117.870	6	Lahar	258.796	4 Trenggalek
			7	Brangkal	96.097	5 Kediri
			8	Konto	50.764	6 Nganjuk
			9	Bluwek	21.482	7 Jombang
			10	Maspo	226.542	8 Mojokerto
			11	Rejoso	63.369	9 Pasuruan
			12	Pasiraman	50.889	10 Sidoarjo
			13	Gedangan Dlodo	87.140	
			14	Barek Glidik	117.870	II. CITY
			15	Welang	67.458	1 Batu
						2 Malang
						3 Blitar
						4 Kediri
						5 Mojokerto
						6 Pasuruan
						7 Surabaya
	TOTAL	1.575.285			1.575.285	

AUTONOMIC SERVICE AREA (REGENCY / DISTRICT)

No.	REGENCY/DISTRICT	AREA (Km²)	RESIDENT (Person)	DENSITY (Person/ Km²)
1	2	3	4	5
1.	Malang	2.977,05	2.264.757	761
2.	Blitar	1.588,79	1.102.006	694
3.	Tulungagung	1.131,67	984.730	870
4.	Trenggalek	1.261,40	677.237	537
5.	Kediri	1.386,05	1.415.500	1.021
6.	Nganjuk	1.224,33	1.024.691	837
7.	Jombang	1.159,50	1.155.449	997
8.	Mojokerto	692,15	903.317	1.305
9.	Pasuruan	1.474,02	1.428.530	969
10.	Sidoarjo	634,39	1.682.280	2.652
	TOTAL	13.529,35	12.638.497	934

AUTONOMIC SERVICE AREA (CITY)

No.	CITY	AREA (Km²)	RESIDENT (Person)	DENSITY (Person/ Km²)
1	2	3	4	5
1.	Malang	110,06	780.863	7.095
2.	Blitar	32,58	124.328	3.816
3.	Kediri	63,40	240.979	3.801
4.	Mojokerto	16,46	112.547	6.838
5.	Pasuruan	36,58	162.293	4.437
6.	Surabaya	326,36	2.640.564	8.091
7.	Batu	92,78	177.210	1.910
	TOTAL	678,22	4.238.784	6.249

BRANTAS WATERSHED'S FOREST ZONE (HA)

No	REGENCY /DISTRICT	PRODUCTION FOREST	PROTECTION FOREST	NATURAL PRESERVE	NATIONAL PARK	SOCIAL FOREST PARK	TOTAL
1.	Malang	43.421,7	38.179,1	877,0	19.005,1	8.909,2	110.392,1
2.	Blitar	22.808,4	11.900,4	-	-	-	34.708,8
3.	Tulungagung	34.712,7	5.523,6	-	-	-	40.236,3
4.	Trenggalek	47.204,4	14.114,2	-	-	-	61.318,6
5.	Kediri	14.465,3	7.940,6	19,0	-	-	22.424,9
6.	Nganjuk	44.396,1	6.515,1	-	-	-	50.911,2
7.	Jombang	19.208,3	294,2	-	-	2.864,7	22.367,2
8.	Mojokerto	15.712,2	4.101.9	-	-	-	19.814,1
9.	Pasuruan	-	-	50,4	5.553,6	6.129.7	11.733.7
10.	Kota Batu	3.366,1	8.028,1	-	-	-	11.394,2
	TOTAL	245.295.2	96.777,2	946.4	24.558,7	17.903,6	385.481,1

SUB WATERSHED'S HEALTHNESS MONITORING

NO.	SUB WATERSHED	SCORE			AVERAGE
		HIDROLOGY	LAND	SOCIAL ECONOMY	
1.	Lesti	2.66	1.71	1.92	2.14
2.	Konto	2.18	1.82	1.95	2.04
3.	Barek	2.32	1.56	1.82	1.92

CRITICAL LAND in BRANTAS WATERSHED

No	REGENCY / DISTRICT	FOREST ZONE				OUTSIDE FOREST ZONE				Total
		Very Critic	Critic	Rather Critic	Potential Critic	Very Critic	Critic	Rather Critic	Potential Critic	
1	2	3	4	5	6	7	8	9	10	11
1	Malang	4,789	5,404	280	-	809	5,500	14,095	16,247	47,124
2	Batu	235	690	-	-		-	1,152	747	2,824
3	Blitar	5,510	3,589	-	-	722	13,647	4,801	113	28,382
4	Tulungagung	1,536	6,792	-	-	136	3,230	9,082	3,025	23,801
5	Trenggalek	4,314	4,924	-	-	-	11,530	11,894	301	32,963
6	Kediri	1,404	1,337	-	-	388	4,485	4,245	7,818	19,677
7	Nganjuk	728	2,314	4,238	-	140	2,770	2,887	5,665	18,742
8	Jombang	124	2,716	-	-	1,159	4,028	4,379	2,168	14,574
9	Mojokerto	1,526	3,437	3,650	-	401	2,110	4,510	450	16,084
10	Pasuruan	1,311	3,298	-	-	-	4,735	25,453	2,326	37,123
	GRAND TOTAL	21,477	34,501	8,168	-	3,755	52,035	82,498	38,860	241,294

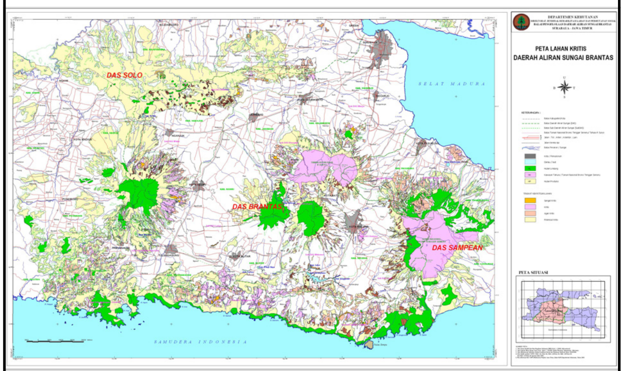
Source : BPDAS Brantas's Critical Land Inventory, 2004

Critical Land in City Area

No.	CITY	URBAN AREA				Total
		Very Critic	Critic	Rather Critic	Potential Critic	
1	2	3	4	5	6	7
1	Malang City	-	1,014	598	-	1,612
2	Blitar City	-	281	150	8	439
3	Kediri City	-	-	1,325	-	1,325
4	Mojokerto City	-	-	400	-	400
5	Pasuruan City	-	500	565	85	1,150
6	Sidoarjo City	1,113	3,247	9,129	1,000	14,489
7	Surabaya City	-	2,805	8,265	8	11,078
	JUMLAH	1,113	7,847	20,432	1,101	30,493

Source : BPDAS Brantas's Critical Land Inventory, 2004

CRITICAL LAND MAP of BRANTAS WATERSHED



CRITICAL LAND in BRANTAS WATERSHED

POTENCY, PROBLEMS AND SOLUTION

BRANTAS WATERSHED'S POTENCY

- Take place 34 % from The East Java Province area
- 45 % East Java's resident live in Brantas Watershed area
- 30 % agriculture area placed in Brantas Watershed
- Brantas Watershed's state forest are 26 %
- Own 8 (eight) dam for flood control
- Good infrastructures (road network, airport, port and telecommunication network)
- The central of education in East Java

ISSUE / PROBLEMS

LAND and HIDROLOGY

- Critical Land : 271.787 Ha in and outside forest zone which cause the decrease of rainfall percolation as the source of groundwater that enlarge the surface flow.
- Threat of flood disaster in Brantas watershed.
- High sedimentation in Karangkates Dam and Sengguruh Dam.

SOCIAL ECONOMY

- Crop cultivation at high oblique land
- People awareness for environment still lower
- Crop's yield market system is not optimal
- Watershed autonomy is not set up yet (contribution between up and downstream).

Land and Forest Rehabilitation Activity

Cultivation

- People Forest
- People garden
- Re plantation :
  - Conservation Forest
  - Protection Forest
  - Production Forest
- Mangrove Forest
- The city green plantation

Multi Forestry Effort

- Fruit Plantation
- Bee Development
- Agro Forestry
- Village Seed Garden

Conservation Technique

- Controller DAM
- Defender DAM
- Gully Plug
- Diffusion Well
- Terrace Rehabilitation



Cultivation



Conservation Technique

Institution Development Activity

- Partnership Provisioning
- Farmer Training
- Workshop
- Dissemination
- Develop People Forest's Model
- Develop Micro Watershed's Model
- Develop Mangrove Forest's Model
- Develop City Forest's Model
- Worker Training

Farmer Group Activity

Training

Watershed Monitoring and Evaluation

- Watershed Management's Monitoring and Evaluation
- River Current Observation Station's Monitoring and Evaluation
- Land Use Monitoring and Evaluation
- Social Economic Monitoring and Evaluation
- Monitoring and Evaluation of Land Rehabilitation and Soil Conservation
- Monitoring and Evaluation of Land and Forest Rehabilitation
- Monitoring and Evaluation of The National Action of Land and Forest Rehabilitation (GERHAN)
- Natural Disaster Monitoring and Evaluation
- Forest and Land Rehabilitation Areal Model Activity
- Evaluation of Watershed's Performance
- Data Base
- KUHR / KUK-DAS Monitoring and Evaluation
- River Current Observation Station Development

River Current Observation Station

Rainfall Gauge

REALIZATION OF GERHAN'S CULTIVATION, 2003 -2004

No	Watershed	2003 (Ha)	2004 (Ha)	2005 (Ha)	2006 (Ha)	2007 (Ha)	TOTAL (Ha)
1	2	3	4	5	6	7	8
1	BRANTAS	12.933,00	33.466,00	18.350,00	7.060,00	31,470.00	103.279,00
	TOTAL	12.933,00	33.466,00	18.350,00	7.060,00	31,470.00	103.279,00

REALIZATION of GERHAN'S CONSERVATION TECHNIQUE, 2003-2007

No	Watershed	2003 (unit)	2004 (unit)	2005 (unit)	2006 (unit)	2007 (unit)	TOTAL (unit)
1	2	3	4	5	6	7	8
1	BRANTAS	253	532	463	376	345	1.969
	TOTAL	253	532	463	376	345	1.969

Cultivation Plan of BPDAS Brantas, 2008

No	Watershed	People Forest (Ha)	Mangrove Forest (Ha)	City Green (Ha)	Re plantation (Ha)	TOTAL (Ha)
1	2	3	4	5	6	7
1	BRANTAS	23,100.00	650.00	2,155.00	1,075.00	50,905.00
	TOTAL	23,100.00	650.00	2,155.00	1,075.00	50,905.00

Conservation Technique's Plan of BPDAS Brantas, 2008

No	DAS	Controller DAM (unit)	Defender DAM (unit)	Gully Plug (unit)	Diffusion Well (unit)	Pond (unit)	TOTAL (unit)
1	2	3	4	5	6	7	8
1	BRANTAS	49	990	600	2,215	-	3,854
	TOTAL	49	990	600	2,215	-	3,854

.... Thank You ....

River Basin Development and Its Impact to Sediment Balance in the Basin Case Study: the Brantas River Basin

Mr.Ir.Harianto,Indonesia
Jasa Tirta I Public Corporation

River Basin Development and Its Impact to Sediment Balance in the Basin
Case Study: the Brantas River Basin Indonesia [1]

by

Ir. Soekistijono, Dipl. HE

Ir. Harianto, Dipl. HE[2]

The Brantas River basin is located in East Java Province, Indonesia. This river is the second largest river in the Java Island having length of 320 km and catchment area of 11,800 km^2 that is about 25% of East Java's area. Development in the basin commenced in 1960's has resulted 8 reservoirs (Sengguruh, Sutami, Lahor, Wlingi, Lodoyo, Selorejo, Bening and Wonorejo), 4 river-improvement-schemes, four barrages, and three rubber dams. Although the development benefits have been realized as targeted including flood control of 50 years return period, providing irrigation water for 304,000 ha of irrigation area of which 83,000 ha can be secured from the mainstream, production of electricity of about 993 kWh/year, and provision of raw water for industries and municipal drinking water as much as 126,50 million m^3/year and 280,68 million m^3/year respectively etc, nowadays, the Brantas River basin faces serious sediment related issues that affect sustainable water resources managament in the basin.

The unbalanced sediment flow among the upper reach, middle reach and lower reach occurs in the basin that caused by blocking of sediment flow by the dams and sabo facilities, erupted material of Mt. Kelud, and excessive sand mining in the river. These issues were not considered well during planning stage of the basin developments.

In the Brantas River basin, the deposition of sediment in the reservoirs is one of the major sediment issues. Because of a large amount of sediment inflow, the main reservoirs in the basin are rapidly losing their gross storage capacities, ranging from 30-90 percent of the originals gross storage capacities. In some smaller reservoirs such as Sengguruh, Wlingi and Lodoyo, their effective storage capacities were reduced to about 40 percent of original capacities. Most of those dams do not have facilities to remove deposited sediment in the reservoirs.

The other issues are effects of River Improvement Project which is still debateable and excessive sand mining activities in the river. As known that the discharge capacity in the Brantas River reduced due to riverbed aggradations caused by deposition of sediment from eruption of Mt. Kelud. Accordingly the river channel necessary for discharging the flood was proposed to be improved by dredging the river and heightening the existing levee. The Brantas Middle Reach River Improvement Project was proposed in the Second Master Plan in 1972. The project was implemented stage wise that consist of two phases i.e. 1) First Phase (1975-1985): improvement for 10-year flood and 2) Second Phase (1985-1994): improvement for 50-year flood. In the last 1980's, riverbed degradation in the Brantas

[1] Second International Workshop on Water and Sediment Management, Malang, November 22-23, 2007

[2] Director of Technical Affairs, Jasa Tirta I Public Corporation, Jl. Surabaya 2A Malang, 65115 Indonesia, email: mlg@jasatirta1.go.id, birolitbang@telkom.net

River became so remarkable that Watudakon Siphon cropped out from the riverbed and irrigation intake became rather difficult. Responding to these problems, Jatimlerek and Menturus rubber dams and new Watudakon Siphon were constructed under Second Phase Project.

Based on a study conducted in 1996 to investigate sand mining volume and number of workers in the Brantas Middle Reaches and the Porong River, it resulted that annual sand mining volume was estimated to be about 2.12 million m^3. In 2004, it was investigated that annual sand mining volume was estimated to be about 2.92 million m^3. This increasing was caused mainly by expanding utilization of pumping equipment. The annual sand mining volumes above are considered higher than the expected sediment inflows along the stretches. The Brantas River Morphological Studies conducted in 1992 under the Brantas River Rehabilitation Project estimated that the average annual local sediment inflows along the Brantas River upstream of Kertosono were 2,154,000; 1,831,000 and 1,615,000 m^3, respectively, in the first, second and third 5-year periods after the eruption of Mt. Kelud in 1990. According to the surveys conducted in 1991, 1996 and 1997, serious degradation was observed in all the reaches and the deepest degradation from 1996 to 1997 was about 4.5 m. Between 1991 and 2004, the average heights of riverbed degradation of the Brantas and Porong are 2.27 m and 1.95 m respectively. Continuous riverbed degradation has been causing serious bank collapse, destabilization and damage of river and relevant facilities such as rubber dam, bridge pier, weir, ground sill, revetment, water intake etc.

From the situation in the Brantas River basin as explained above, we can learn much that river basin development should be conducted in integrated and comprehensive manners. All aspects consist of technical, economic, social and environmental aspects etc should be taken into account comprehensively during the planning stage of water resources facility development.

River Basin Development and Its Impact to Sediment Balance in the Basin
Case Study: the Brantas River Basin Indonesia

Second International Workshop on Water and Sediment Management

Malang, 22-23 November 2007

Jasa Tirta I Public Corporation

Malang, East Java, Indonesia

http://www.jasatirta1.go.id

1

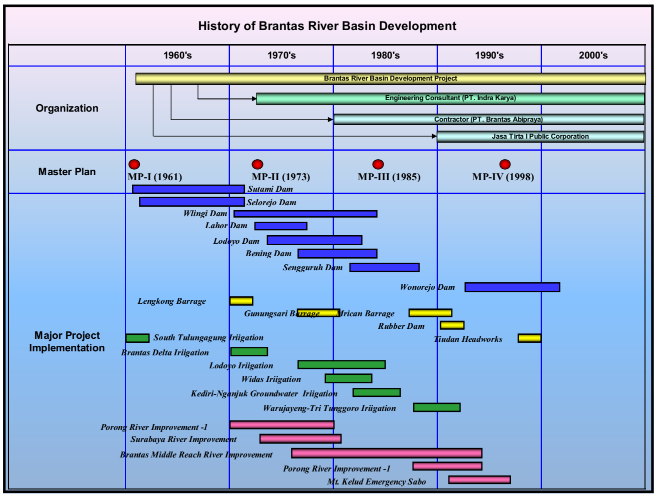
Preface

- This presentation is mainly taken from the author's experience in development and management of water resources in the Brantas River Basin
- The experience shared in this presentation is not viewed from the academic perspective but is more aimed at improving the SIDCOM process of water resources development and management

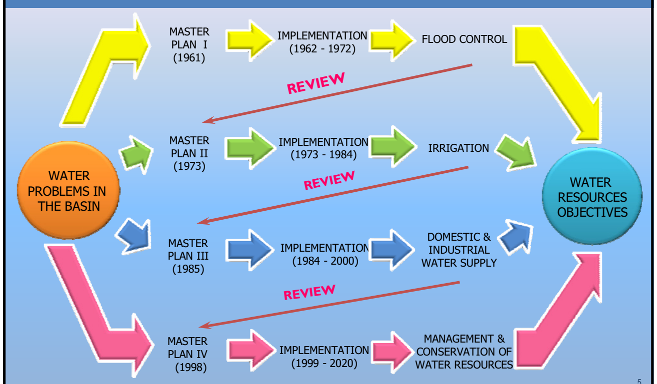
2

Facts of the Brantas River Basin

- Brantas is one of the strategic and important river system in Indonesia
- Functions as the most important source of water supply in East Java Province
- Support regional and national development benefits: GRDP Brantas Rp. 150,630 billion – approx. US$ 17.66 billion – 65.8% GRDP E. Java – 8% GRDP National (as of 2005)

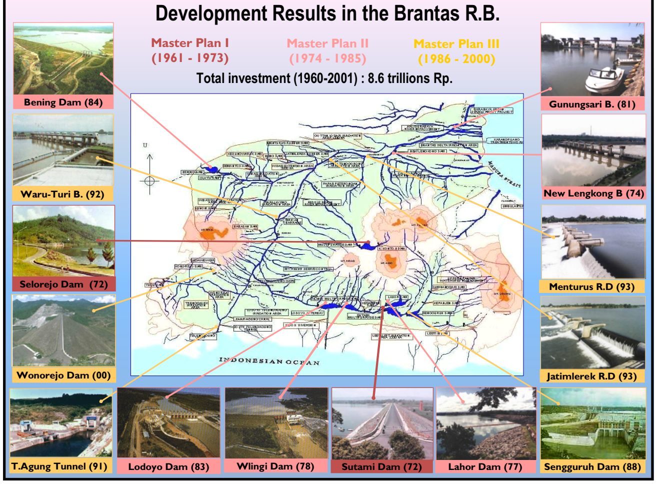


History of the Brantas R.B. Development



5

Development Results in the Brantas R.B.



Development Benefits

Sector	Unit	1960	2006
Flood Control	Innundated area	60,000 ha (annually)	None for the mainstream
Irrigation	Cropping intensity	0.8 x annually	2.2 x annually
Power Generation	Million kWh/year	170	993
Bulkwater for Industrie	Million m^3/year	73	280.7
Bulkwater for Domestic	Million m^3/year	50	126.5

7

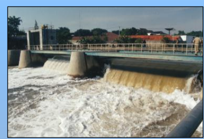
Water Use in the Basin


Electricity = 993 M kWh/year


Irrigation Area= 304,000 ha (83,000 ha from main stream)


Raw Water for Domestic Supply = 280.68 Mm^3/year


Raw Water for Industries Supply =126.50 Mm^3/year


Maintenance flow = 204 Mm^3/year and flood control at 50 years return period = 60,000 ha


Fisheries = 41 Mm^3/year

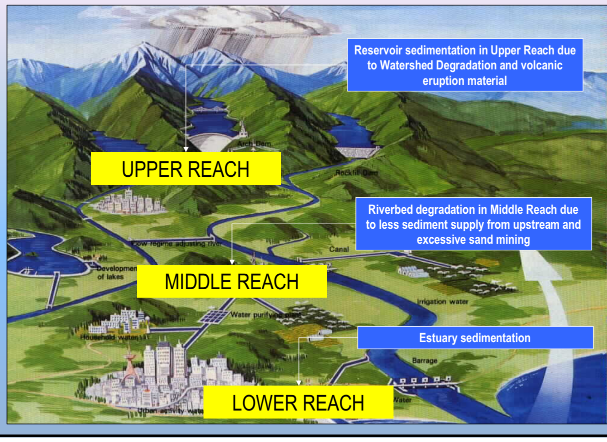
8

Sediment Related Issues in the Basin

- The Brantas River basin faces serious sediment related issues that affect sustainable water resources management in the basin.
- The unbalanced sediment flow among reaches (upper, middle, lower) occurs in the basin that caused by:
  - Blocking of sediment flow by the dams and sabo facilities;
  - Erupted material of Mt. Kelud;
  - Excessive sand mining in the river.
- Although special care has been taken in the past to consider erosion-sedimentation, the recent land use change has led in the increase of erosion-sedimentation within the basin.

9

Sediment Balance in the Basin



Deposition of the Sediment

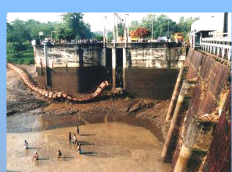
- Sutami Reservoir (completed in 1972), the main reservoir in the basin is rapidly losing their gross storage capacities, remains 50.93% of the originals gross storage capacities.
- In some smaller reservoirs such as Sengguruh, Wlingi and Lodoyo, their effective storage capacities were reduced to about 20-70 percent of original capacities.
- Most of those dams do not have facilities to remove deposited sediment in the reservoirs.

11

Sediment Deposition


Sengguruh Reservoir


Sutami Reservoir


Wlingi Reservoir


Selorejo Reservoir

12

Sediment Deposition

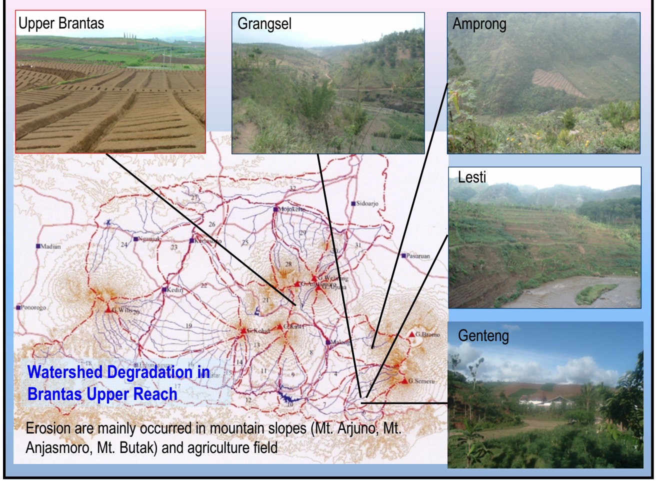
Wlingi Reservoir

13

Transition of Reservoir Storage

No.	Reservoir	Initial Capacity			Current Capacity			Rate of Sediment (mil m^3/year)
		Year	Effective	Total	Year	Effective	Total	
1	Sengguruh	1988	19,0	21,5	2005	0,9	1,5	1,18
2	Sutami	1972	253,0	343,0	2006	146,7	174,7	4,95
3	Lahor	1977	29,4	36,1	2006	25,2	30,6	0,20
4	Wlingi	1977	5,2	24,0	2006	2,1	4,4	0,68
5	Lodoyo	1980	4,2	5,8	2006	2,7	2,7	0,12
6	Selorejo	1970	50,1	62,3	2006	40,8	42,9	0,54
7	Bening	1981	28,4	32,9	2004	26,2	28,7	0,18
8	Wonorejo	2000	99,4	111,0	2005	99,6	110,3	0,14

14



River Improvement Project

- In the past, discharge capacity in the Brantas River reduced due to riverbed aggradations caused by deposition of sediment from eruption of Mt. Kelud. Accordingly the river channel necessary for discharging the flood was proposed to be improved by dredging the river and heightening the existing levee.
- The Brantas Middle Reach River Improvement Project was proposed in the Second Master Plan in 1972. The project was implemented stage wise that consist of two phases
  - First Phase (1975-1985): 10-year flood
  - Second Phase (1985-1994): 50-year flood
- In the last 1980's, riverbed degradation in the Brantas River became so remarkable that Watudakon Siphon cropped out from the riverbed and irrigation intake became rather difficult. Responding to these problems, Jatimlerek and Menturus rubber dams and new Watudakon Siphon were constructed under Second Phase Project.

16

Excessive Sand Mining

- Annual sand mining volume was estimated to be about 2.92 million m^3 (2004). This increasing was caused mainly by expanding utilization of pumping equipment.
- The annual sand mining volumes above are considered higher than the expected sediment inflows along the stretches.
- The Brantas River Morphological Studies (1992) under estimated the average annual local sediment inflows along the Brantas River upstream of Kertosono :
  - First 5-year period Mt. Kelud eruption = 2,154,000 m^3
  - Second 5-year after the eruption = 1,831,000 m^3
  - Third 5-year after the eruption = 1,615,000 m^3

17

Excessive Sand Mining

- Between 1991 and 2004, the average heights of riverbed degradation of the Brantas and Porong are 2.27 m and 1.95 m respectively.
- Continuous riverbed degradation has been causing serious bank collapse, destabilization and damage of river and relevant facilities such as rubber dam, bridge pier, weir, ground sill, revetment, water intake etc.

18

Excessive Sand Mining

19

River Bed Degradation

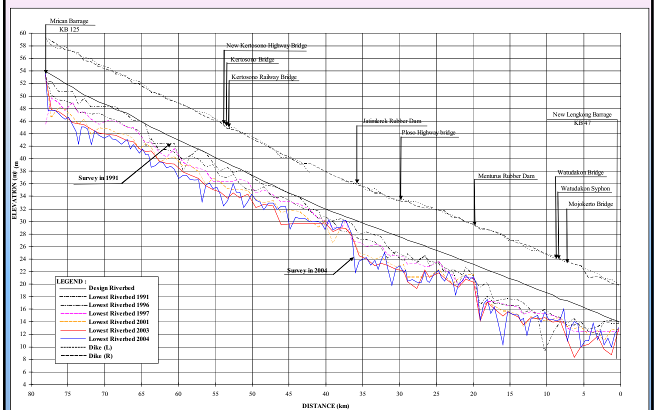
Brantas River

Degradation of riverbed in downstream section of Watudakon Siphon

Porong River

Degradation of riverbed and exposed conduit (old Bangil Tak Siphon)

20



Profile Transition of the Brantas Middle Reaches

Riverbed Profile of the Brantas River (1991-2006)

Collapse and Damage of Structures

Scouring around Bridge Pier
(Kademangan Bridge)

Damaged dike revetment (Right)
(Ngrowo River and Brantas River Confluence)

22

Collapse and Damage of Structures

Damaged Jatimlerek Rubber Dam
Brantas River

Exposed foundation (Cepiples Railway Bridge)
Porong River

23

Conclusion

- From the situation in the Brantas River basin as explained, we can learn much that river basin development should be conducted in integrated and comprehensive manners.
- All aspects consist of technical, economic, social and environmental aspects should be taken into account comprehensively.

24

Conclusion

- Technical:
  - Loss of reservoir's active storage due to sedimentation
  - Water quantity management will endure problems due to the rapid erosion-sedimentation process
  - Unbalanced sediment budget between the upper, middle and lower reaches
- Economic
  - Hazard of floodings and landslide
  - Externalities due loss of reservoir's active storage

25

Conclusion

- Social
  - Population pressure on water resources will deteriorate the resource itself
- Environmental
  - Water quality degradation (including eutrophication at the reservoirs)
  - Degradation of soil fertility leads into agriculture involution and higher use of fertilizers

26