巻末資料１

Erosion and Sedimentation in Brantas Upper Reach

and Its Countermeasures

First International Workshop on Water and Sediment Management in Brantas River Basin

Batu, 28-29 July 2005

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JASA TIRTA I

Certificate No. ID03/0127

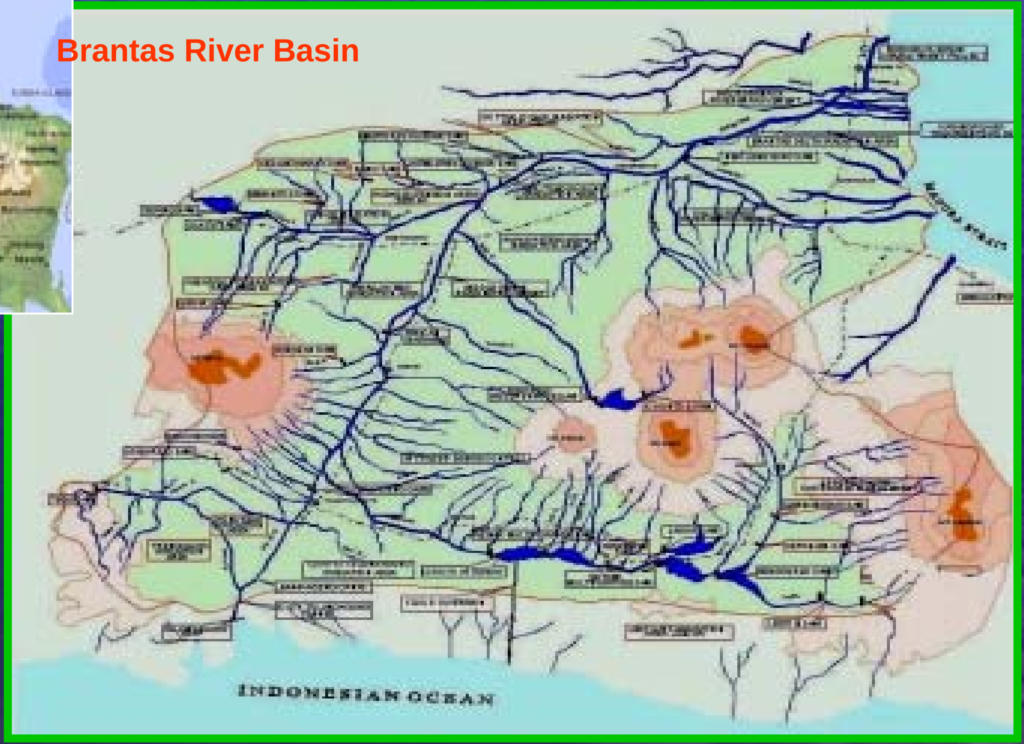
Facts about Brantas River Basin

- One of developed river systems 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 – 59% GRDP E. Java – 8% GRDP National (as of 2003)

Description 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

Brantas River Basin

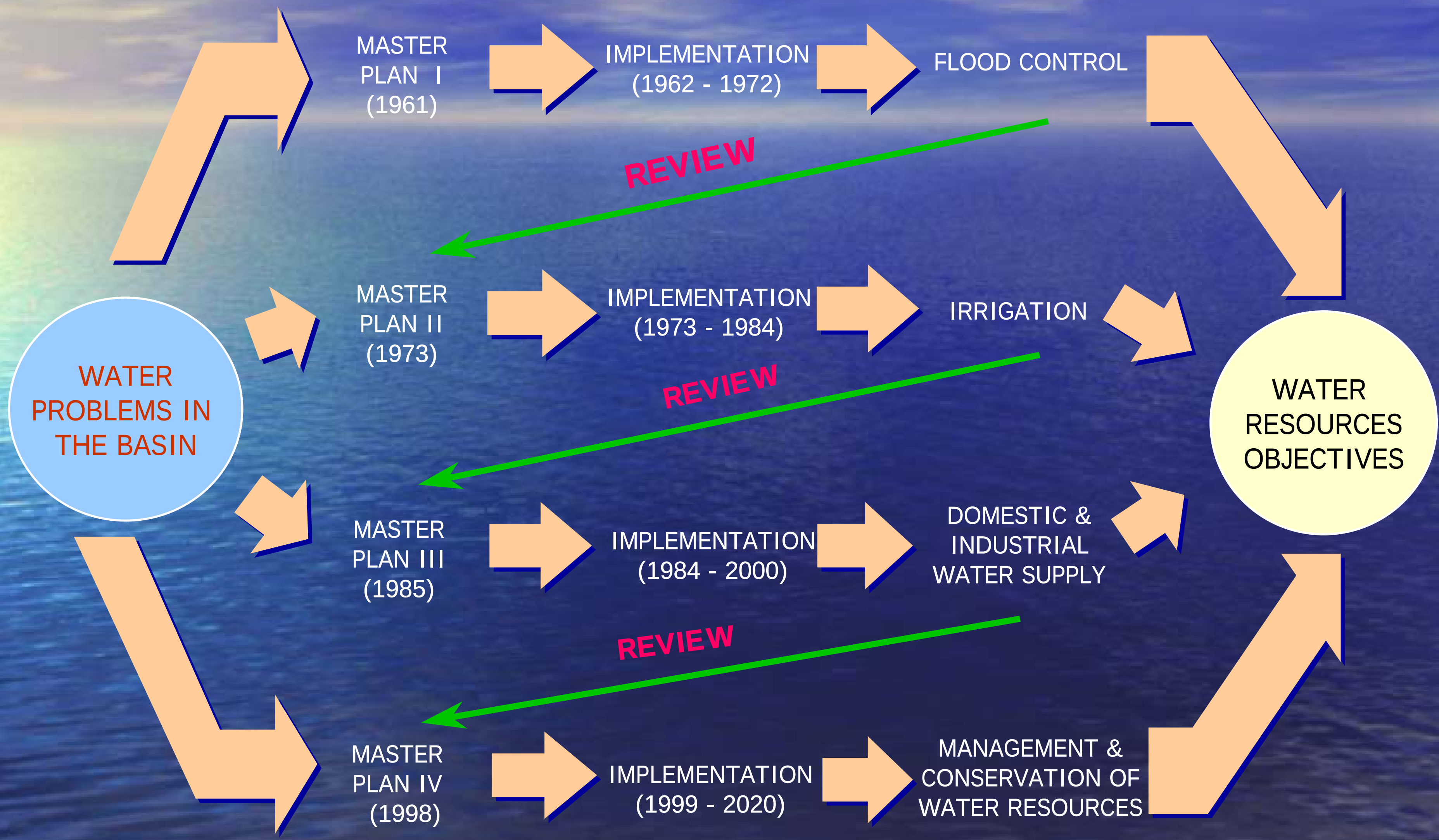


- Active volcanoes : Mt. Kelud & Mt. Semeru
- Land Use (2004) :
  - paddy field 39.0%
  - dry land 12.0%
  - plantation 22.0%
  - forest 11.0%
  - settlements 12.0%
  - others 4.0%

Background of Integrated Development Concept

- Some area in the Brantas basin had been severely hurt by flooding in rainy season and drought in dry season
- Construction of several water resources infrastructures has lead to the necessity to develop an overall plan for the Brantas basin
- Water resources development in the Brantas basin is decided to be conducted at a basin-wide level with integration of various aspects

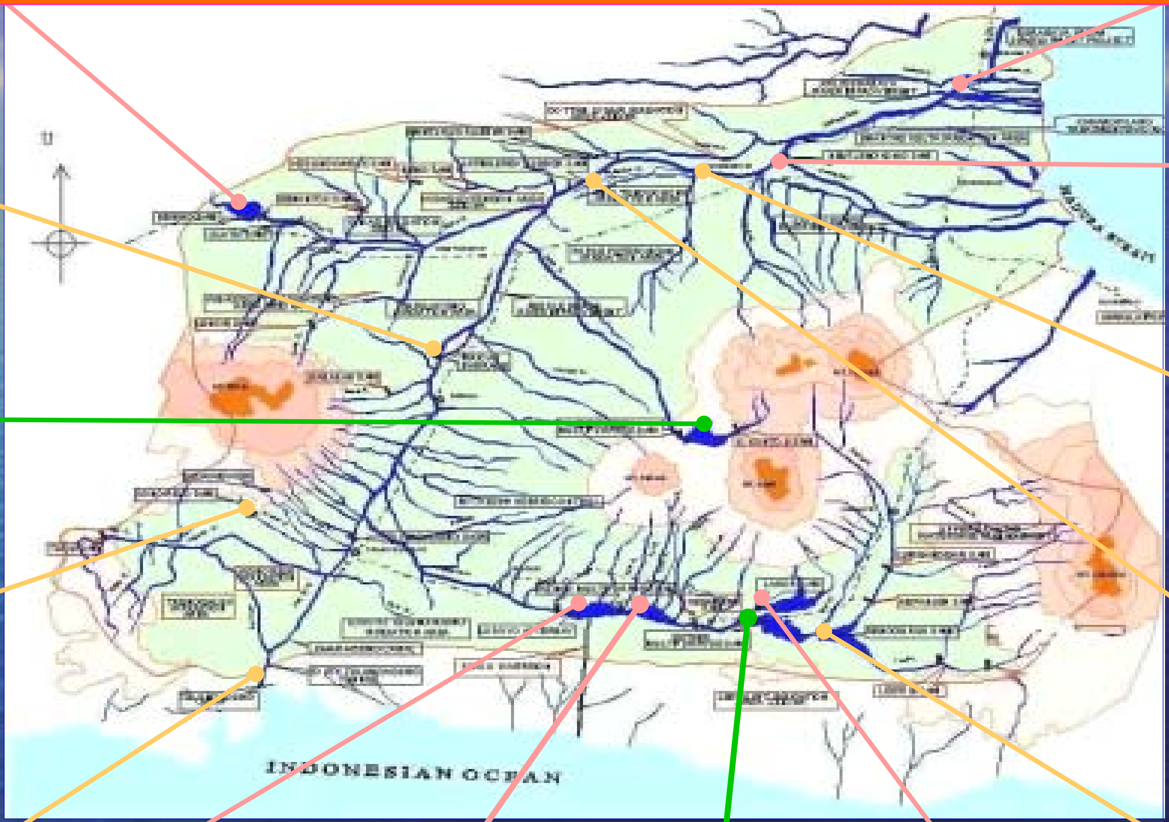
The Brantas River Basin's Master Plans

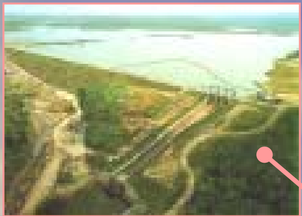


Development of Brantas Basin

Master Plan I (1961 - 1973) | **Master Plan II (1974 - 1985)** | **Master Plan III (1986 - 2000)**

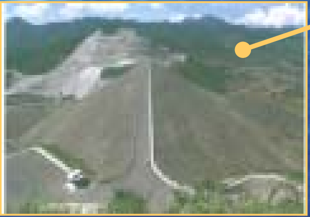
Total investment (1960-2001) : 7.3 trillions Rp.
(US $ 0.097 billions, ¥ 78,8 billions, 258.9 billions Rp.)



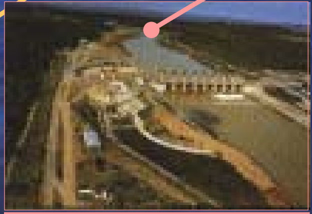

Bening Dam (84)

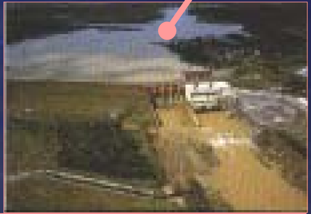

Waru-Turi B. (92)


Selorejo Dam (72)

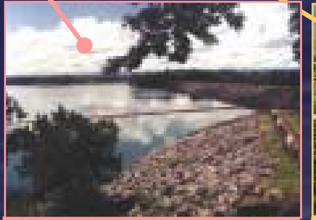

Wonorejo Dam (00)

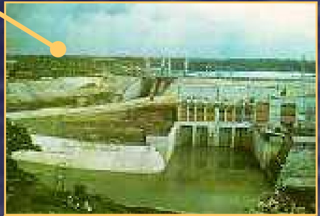

T.Agung Tunnel (91)


Lodoyo Dam (83)


Wlingi Dam (78)


Sutami Dam (72)


Lahor Dam (77)


Sengguruh Dam (88)


Gunungsari B. (81)


New Lengkong B (74)


Menturus R.D (93)


Jatimlerek R.D (93)

Sengguruh Dam

- Type of Dam : *Center core rock fill*
- Basin Area : 1,659 km^2
- Height : 33 m
- Crest Length : 378 m

- Initial Storage
  - Total : 21.5 million m^3
  - Effective : 2.5 million m^3
  - Sediment : 19 million m^3
    (erosion rate : 0.58 mm/year)
- Design Flood Discharge (inflow) : 2,950 m^3/s
- Water Surface Elevation
  - HWL : + 292.50
  - LWL : + 291.40
  - FWL : + 293.10
- Purpose
  - Power Generation of 29,000 kW
  - Sediment trap of Sutami Dam

Sutami Dam

- Type of Dam : *Inclined core rock fill*
- Basin Area : 2,052 km^2
- Height : 100 m
- Crest Length : 750 m

- Initial Storage
  - Total : 343 million m^3
  - Effective : 253 million m^3
  - Sediment : 90 million m^3
    (erosion rate : 0.88 mm/year)
- Design Flood Discharge (inflow) : 2,580 m^3/s
- Water Surface Elevation
  - HWL : + 272.50
  - LWL : + 246.00
  - FWL : + 276.00
- Purpose :
  - Power Generation of 105,000 kW
  - Flood Control
  - Raw Water Supply

Lahor Dam

- Type of Dam : *Center core rock fill*
- Basin Area : 170 km^2
- Height : 74 m
- Crest Length : 446 m

- Initial Storage
  - Total : 36.1 million m^3
  - Effective : 29.4 million m^3
  - Sediment : 6.7 million m^3

  (erosion rate : 0.79 mm/year)
- Design Flood Discharge (Inflow) : 415 m^3/s
- Water Surface Elevation
  - HWL : + 272.50
  - LWL : + 253.00
  - FWL : + 274.50
- Purpose :
  - Flood Control
  - Raw Water Supply

Lahor supply water to Sutami via tunnel

Selorejo Dam

- Type of Dam : *Zone type rock fill*
- Basin Area : 236 km^2
- Height : 49 m
- Crest Length : 450 m

- Initial Storage :
  - Total :62.3 million m^3
  - Effective :54.6 million m^3
  - Sediment :7.7 million m^3
    (erosion rate : 0.65 mm/year)
- Design Flood : 720 m^3/s
  Discharge (inflow)
- Water Surface Elevation
  - HWL : + 620.00
  - LWL : + 598.00
  - FWL : + 622.60
- Purpose
  - Power generation of 5,600 kW
  - Flood Control
  - Raw Water Supply

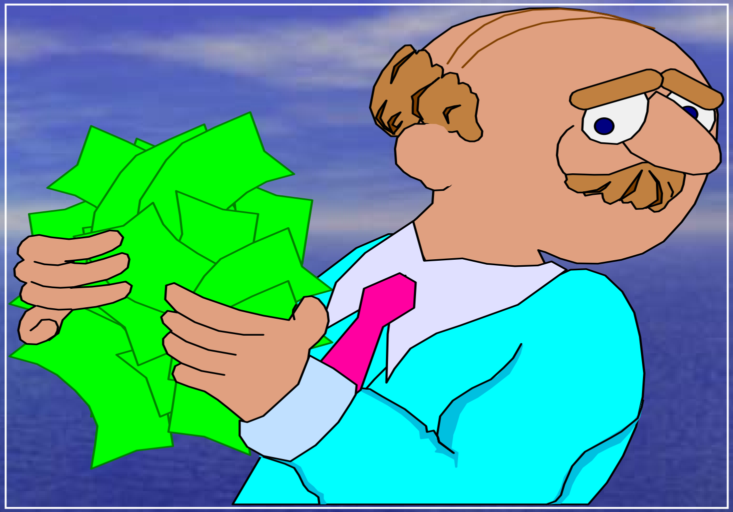
Development Benefits

Beneficiaries	Unit	1960	2004
- Flood Control	Inundated areas	Flooding every year (60.000 ha)	None (main stream)
- Irrigation	Cropping Intensity	0.8 x / year	2.2 x / year (244%)
- Hydropower	Million kWH/year	170 a)	1.000 (588%)
- Raw Water for Domestic	Million m^3/year	73 b)	245 (305%)
- Raw Water for Industries	Million m^3/year	50 c)	135 (270%)

Note:

a) Mendalan and Siman HEPP,
b) Ngagel I dan II Domestic Water Treatment Plants,
c) Sugar factories

Post Construction Problems (1990)



1. No Permanent **Institution** for O&M

2. Limited **Budget** available for O&M

3. W/R. Infrastructures **Degradation**

Corporatization
Jasa Tirta I Public Corporation

Main Tasks

- ✓ Performing operation and maintenance activities of water resources infrastructures.
- ✓ Economic dealings in water utilization.
- ✓ Conducting river basin management including water resources conservation, development and utilization.
- ✓ Conducting rehabilitation of water resources infrastructures according to capability of the corporate body.

Erosion and Sedimentation Problem in Brantas Upper Reach

Calculation on Sutami and Sengguruh Sedimentation (1/2)

Karangkates Dam

Original	Gross Storage	343	million cu.m
	Effect. Storage	253	million cu.m

Sengguruh Dam

Original	Gross Storage	21,5	million cu.m
	Effect. Storage	2,5	million cu.m

Note:

Calculation were made both on primary (PJT) and secondary (PKB) collected data

Reservoir survey for Karangkates Dam in 1988, 1989 and 1992 was omitted due inconsistencies

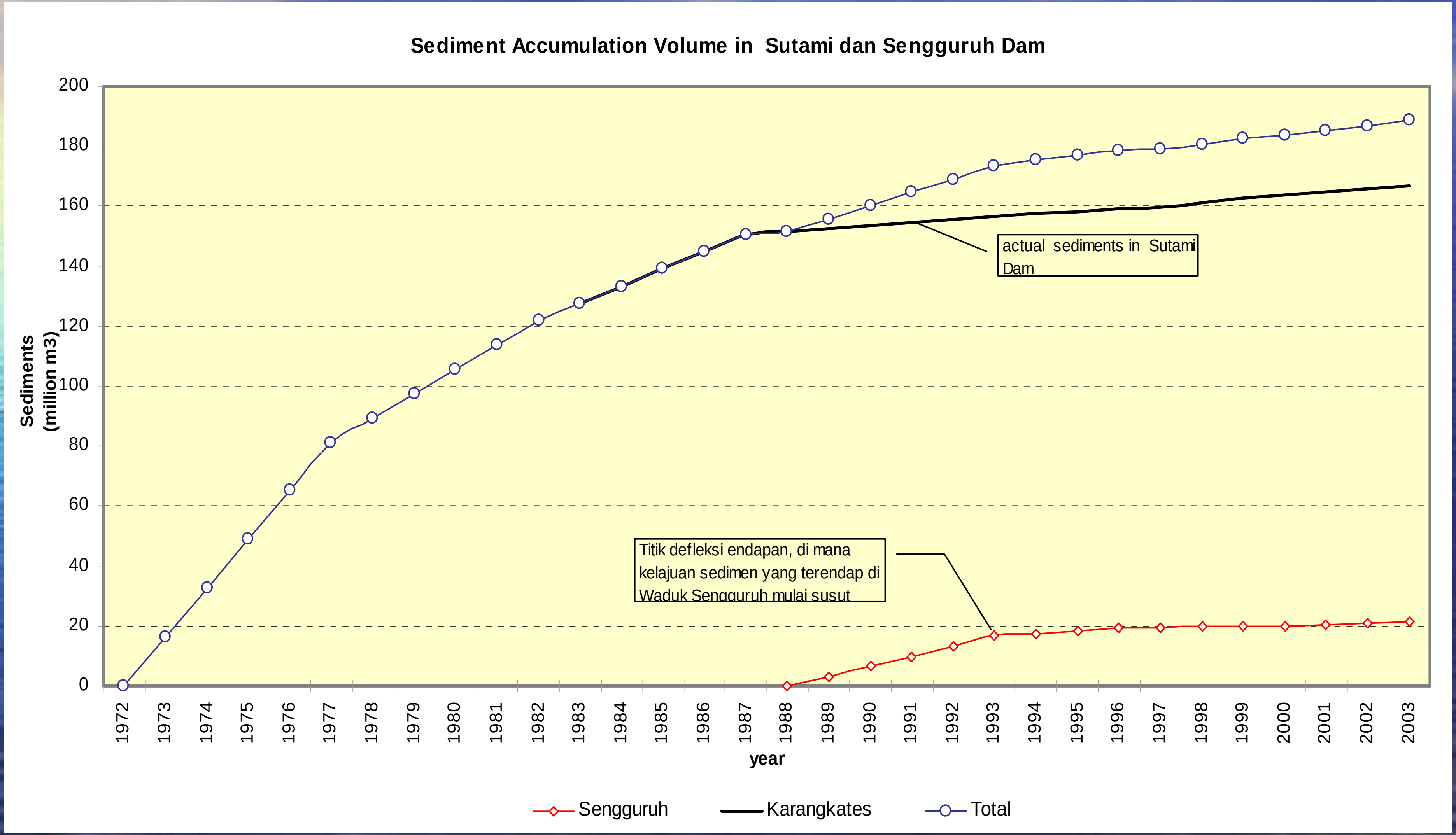
Latest sedimentation rate for Sengguruh Dam (1996) was extrapolated to the following years

Name of Reservoir	Period	Years	Average Annual Sediment		Remarks
			Volume mill cu.m/year	Specific cu.m/km^2/year	
Sengguruh (A=1,659 km^2)	1988-1993	5	3,37	2.029,47	
	1993-1996	3	0,86	516,44	
	1996-2001	5	0,17	102,90	
	2001-2003	2	0,69	417,95	
	1988-2003	15	1,44	869,81	
Karangkates (A=2050 km^2)	1972-1977	5	16,26	7.933,66	
	1977-1982	5	8,08	3.941,46	Prior to Sengguruh Reservoir
	1982-1987	5	5,78	2.819,51	construction sediment yield of
	1987-1994	7	1,02	497,56	Karangkates =6,93 mill cu.m/year
	1994-1995	1	0,68	331,71	Post construction of Sengguruh
	1995-1997	2	0,59	287,80	(1988-2003) it was reduced to
	1997-1999	2	3,56	1.736,59	3,40 mill cu.m/year
	1999-2003	4	0,48	234,15	
	1977-1987	10	6,93	3.379,02	
	1988-2003	5	3,07	1.496,68	
	1977-2003	26	6,42	3.132,29	
Sengguruh & Sutami	1988-2003	15	4,51	2.200,59	

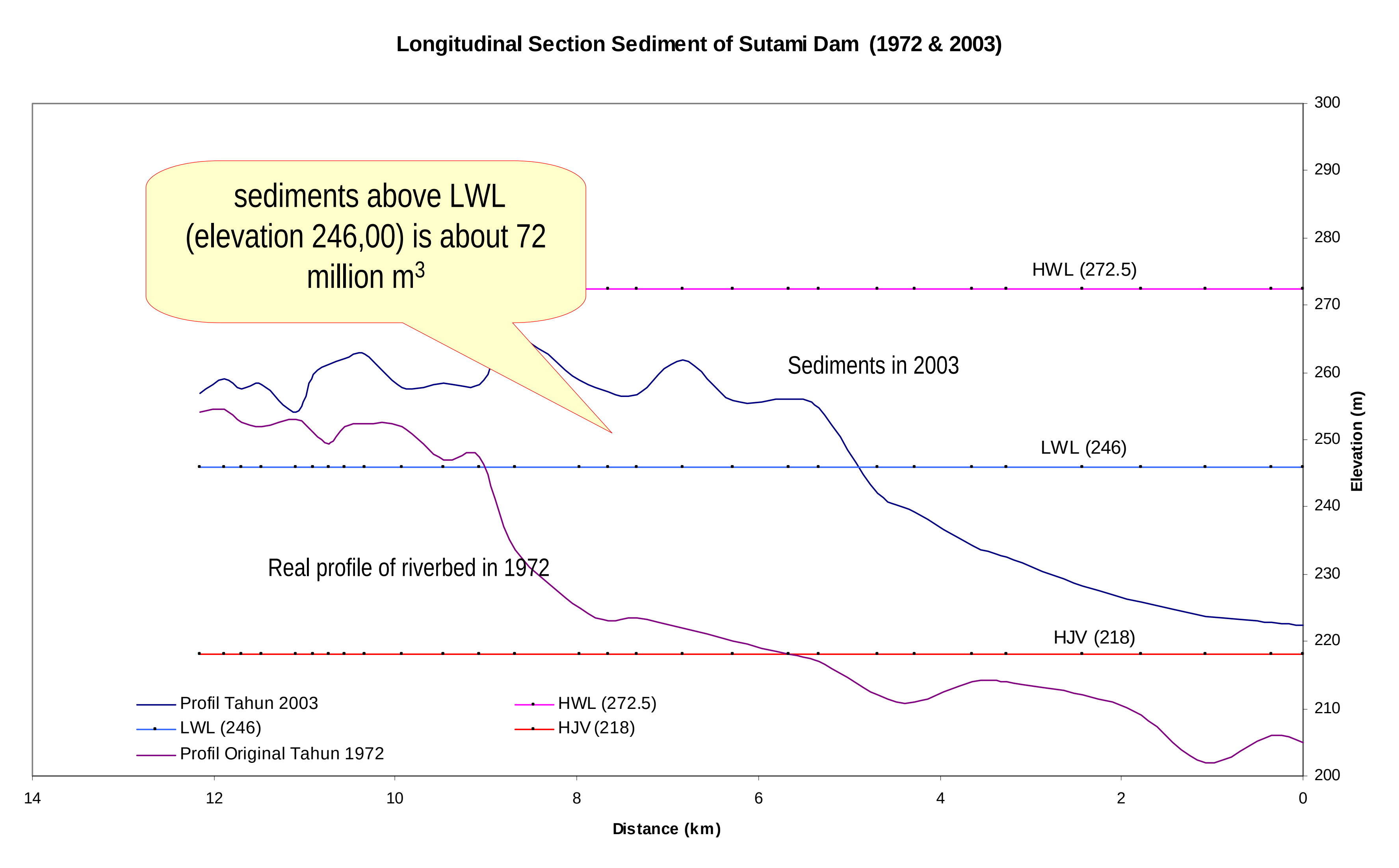
Calculation on Sutami and Sengguruh Sedimentation (2/2)

Year	Accumulated Sediment Volume (Survey)				Rated Sediment Volume						Accumulated Rate	
	Sengguruh			K. Kates	Sengguruh			K. Kates	Sengguruh	K. Kates	Sengguruh	K. Kates
	Reservoir	Dredged	Sabo Dam	Reservoir	Reservoir	Dredged	Sabo Dam					
	million cu.m	million cu.m	million cu.m	million cu.m	mill cu.m/year	mill cu.m/year	mill cu.m/year	mill cu.m/year	mill cu.m/year	mill cu.m/year	million cu.m	million cu.m
1972								-		-		-
1973								16,26		16,26		16,26
1974								16,26		16,26		32,53
1975								16,26		16,26		48,79
1976								16,26		16,26		65,06
1977				81,32				16,26		16,26		81,32
1978								8,08		8,08		89,40
1979								8,08		8,08		97,48
1980								8,08		8,08		105,55
1981								8,08		8,08		113,63
1982				121,71				8,08		8,08		121,71
1983								5,78		5,78		127,49
1984								5,78		5,78		133,26
1985								5,78		5,78		139,04
1986								5,78		5,78		144,81
1987				150,59				5,78		5,78		150,59
1988	-							1,02	-	1,02	-	151,61
1989				150,61	3,22			1,02	3,22	1,02	3,22	152,63
1990					3,22			1,02	3,22	1,02	6,45	153,65
1991					3,22		0,22	1,02	3,44	1,02	9,89	154,67
1992				153,03	3,22		0,22	1,02	3,44	1,02	13,33	155,69
1993	16,12	0,07	0,65		3,22	0,07	0,22	1,02	3,51	1,02	16,83	156,71
1994		0,06		157,73	0,66	0,06		1,02	0,72	1,02	17,56	157,73
1995		0,30		158,41	0,66	0,30		0,68	0,96	0,68	18,51	158,41
1996	18,10	0,23			0,66	0,23		0,59	0,89	0,59	19,40	159,00
1997		0,25		159,58	(0,03)	0,25		0,59	0,22	0,59	19,63	159,58
1998		0,20			(0,03)	0,20		1,48	0,17	1,48	19,79	161,06
1999		0,20		162,55	(0,03)	0,20		1,48	0,17	1,48	19,96	162,55
2000		0,19	0,17		(0,03)	0,19		1,10	0,16	1,10	20,12	163,65
2001	17,95	0,17			(0,03)	0,17		1,10	0,14	1,10	20,26	164,75
2002	18,30	0,11			0,36	0,11		1,10	0,47	1,10	20,72	165,85
2003	19,18	0,04		166,95	0,88	0,04		1,10	0,92	1,10	21,65	166,95

Sediment Accumulation in Sutami and Sengguruh Dam



Prediction of Sediment Deposit in Sutami Dam

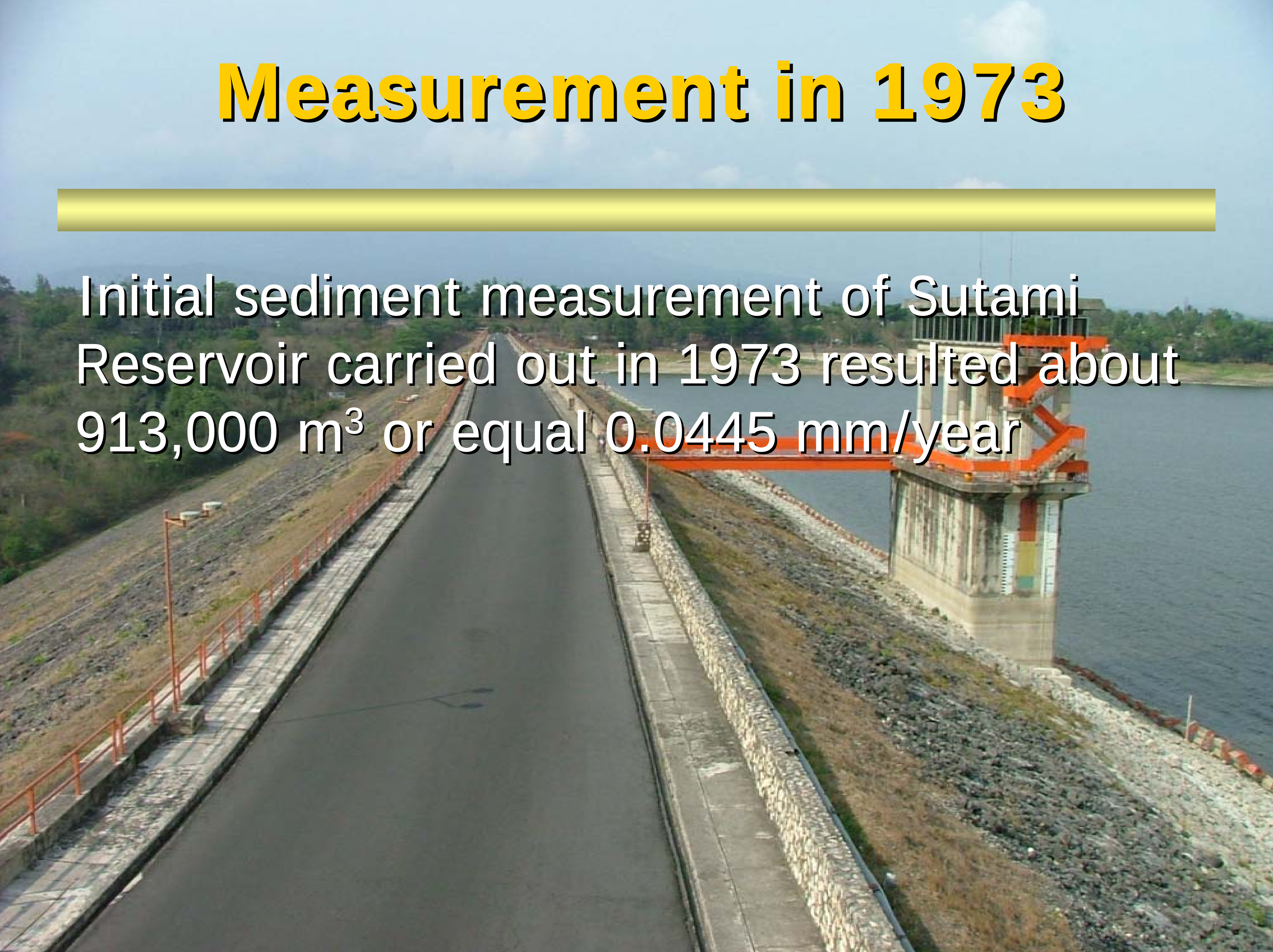


Research on Erosion and Sedimentation Brantas Upper Reach

- Measurement in 1973
- Measurement done by HRS 1980
- BATAN (National Atomic Energy Agency) 1983
- Brantas Master Plan 1985
- Brawijaya University 2003
- Brantas Rehabilitation 2004

Measurement in 1973

Initial sediment measurement of Sutami Reservoir carried out in 1973 resulted about 913,000 m^3 or equal 0.0445 mm/year



Measurement done by HRS 1980

- Based on the research done by Hydraulic Research Station (HRS) in 1971, the sediment volume was 256 million m^3 (1973-1977). It means that the average sediment volume per year is 6.29 million m^3 or equal to 3.41 mm/year with the assumption of trapping efficiency is 90 %.
- Based on the measurement of sediment concentration in Gadang and Sengguruh, could not show real condition but could be concluded that sediment transport in Lesti River was greater than Brantas River.
- The sediment measurement in Selorejo Reservoir (1982) showed that the total sediment volume was 1,162,000 m^3 (including sediment deposited in Tokol dam of about $\pm$ 80,000 m^3), so the average of erosion rate is 1,00 mm/year.

The measurement done by Nippon Koei in 1980

By comparing in more cross section measurement, the total sediment in Sutami Dam from 72 to 80 is only 12.86 million m^3 or equal to 0.78 mm/year. The result of study assumed that sediment storage will be full in 1977.

The Study of Erosion Rate by BATAN in 1983

- By analyzing the content of Cesium 137, one of Radioactive component which was produced by nuclear explosion started from 1945 and continued until 1963.
- By comparing the content of Cesium 137 in some places, it could be concluded that the erosion rate average was 1.35 mm/year or the sediment yield was about 2,777,000 m^3 . The biggest erosion rates resulted in Lesti sub basin was 1.56 mm, Amprong sub basin was 0.96 mm, Upper Brantas sub basin was 1.46 mm.

The Result of Computation in Brantas River Basin Master Plan of 1985

The computation on soil loss based on USLE by considering the results of demo plots done by Brawijaya University for about 2-4 years, it was resulted an improvement of erosive index by Utomo.

The sediment yield rates results :

- Brantas River : 3.94 mm/year.
- Lesti River : 8.72 mm/year.

The Study of sediment done by Engineering Faculty, Brawijaya University

According to result analysis using USLE assumption on topographic map and the used of sediment field, the sediment which flow to Sengguruh Dam is 2,147,659 ton/year and in Sutami Dam is 1,492,278 ton/year or 3,639,937 ton/year or equal to 3,193,000 m^3 .

- These are the volume of erosion in several places :
- Amprong River : 29.35 ton/Ha 3 mm/year
- Bango River : 61.42 ton/Ha 5.4 mm/year
- Lesti River : 45.86 ton/Ha 4.0 mm/year
- Metro River : 28.06 ton/Ha 2.46 mm/year
- Upper Brantas : 63.07 ton/Ha 5.5 mm/year

From those result, it can be concluded that the biggest erosion is happened in the Upper Brantas.

The Result of Computation in Engineering Studies Brantas River Basin Rehabilitation Works (2004)

By using GIS data analyzing and Aerial Photo Interpretation. The computation of sediment yield based on USLE can be categorized as :

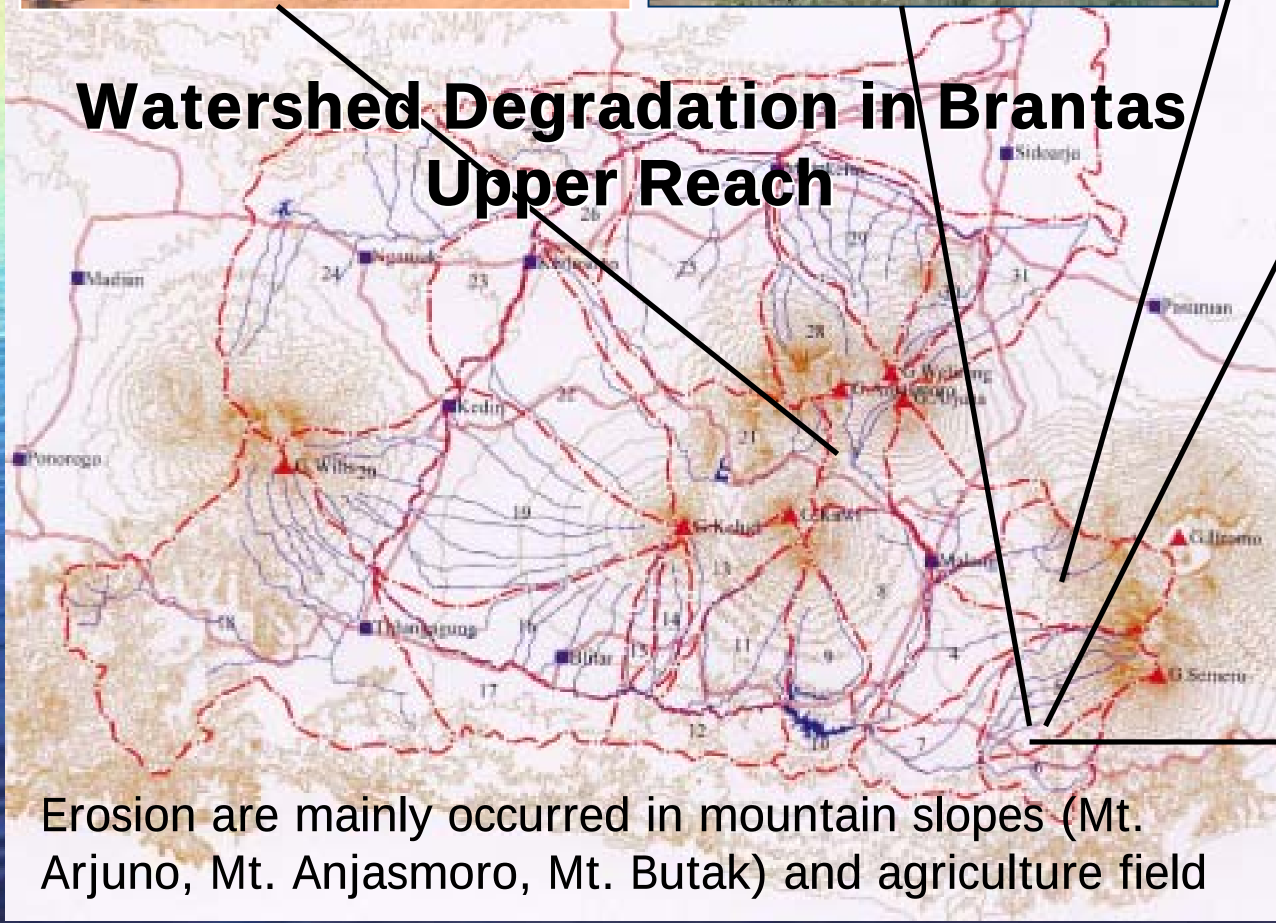
- High yields on water surface erosion > 5.00 mm / year.
- Moderate yield on water surface erosion 2.5-5 mm / year.
- Low yield on water surface erosion 1.0-2.5 mm/year.
- Very low yield on water surface erosion < 0.5 mm/year.

For the whole mountainous area can be categorized as the high yield especially for Amprong River (9.6 mm), Lesti River (10.9 mm), Genteng River (8.50 mm) and Upper Brantas (6.00 mm).

Transition of Storage Capacity - Selorejo Reservoir

Storage Capacity Transition of the Selorejo Dam Reservoir						
Surveyed Year	Gross Storage Capacity		Effective Storage Capacity		Dead Storage Capacity	
	Volume (million m^3)	Percent (%)	Volume (million m^3)	Percent (%)	Volume (million m^3)	Percent (%)
1970	62,30	100,0	50,10	100,0	12,20	100,0
1993	48,87	78,4	44,59	89,0	4,28	35,1
1997	47,61	76,4	44,46	88,7	3,15	25,8
1999	42,70	68,5	39,96	79,8	2,74	22,5
2003	44,01	70,6	41,51	82,9	2,50	20,5

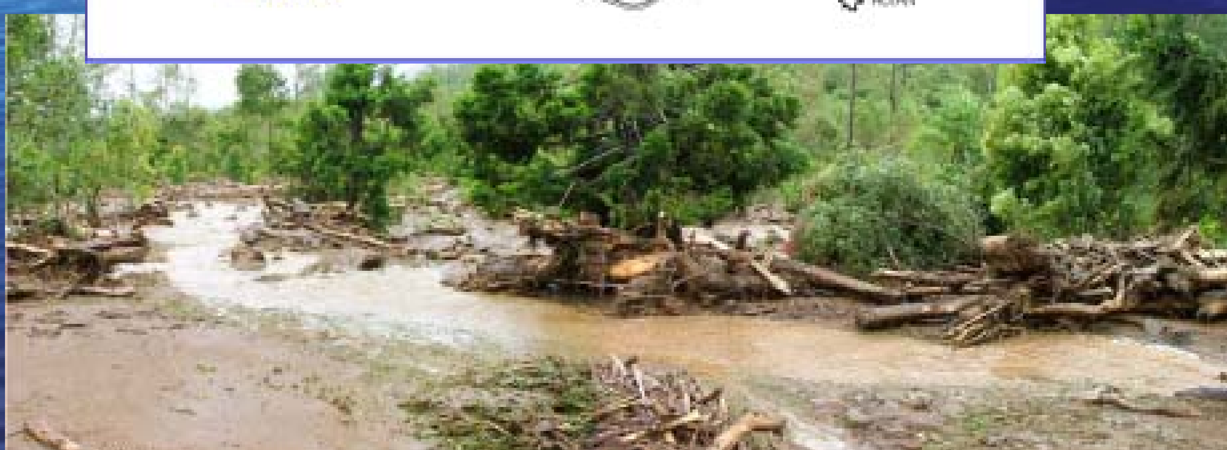
Watershed Degradation in Brantas Upper Reach



Erosion are mainly occurred in mountain slopes (Mt. Arjuno, Mt. Anjasmoro, Mt. Butak) and agriculture field

The Flood Damage in Brantas Spring Water at Batu City on February 3, 2004

Brantas River Spring Water:
It is destroyed by stones,mood,and trees which flew through the flood.



ARBORETUM
A lot of variety plants had been destroyed by the flood.

Some of Flood Damages






Reservoir Condition after Flood






Reservoir Sedimentation

Sengguruh Dam

Sutami Dam

Wlingi Dam

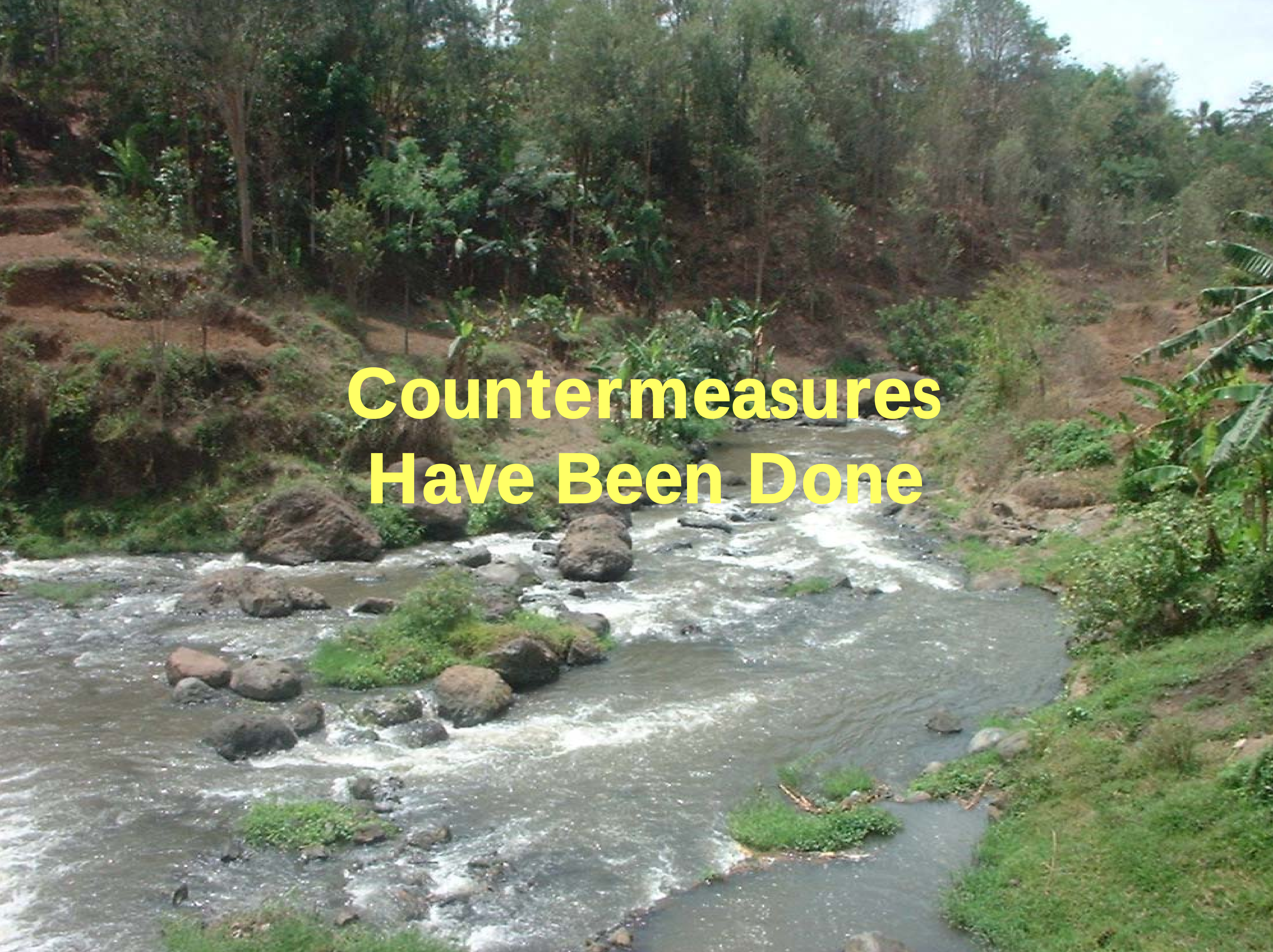
Selorejo Dam

Sengguruh Reservoir

The Effect of Sediment in Sengguruh Reservoir

Sediment deposit covers sand flushing facility

Sediment deposit in front of power generation intake


Countermeasures
Have Been Done

Reservoir Dredging and Flushing

No.	Description	Period	Volume
I	Dredging		
	Sengguruh	1995-2004	1.795.828
	Wlingi	1995-2004	2.024.658
	Selorejo	2001-2004	236.144
	Lodoyo	2003-2004	482.398
II	Flushing		
	Wlingi	1990-2004	4.541.458
	Lodoyo	1999-2004	1.633.410
GRAND TOTAL			10.713.896

Check Dam Construction

Year	Total	Location
1997	10	District of Gedangan, Sumber Manjing
1999	7	District of Bantur, Junrejo, and Dau
2000	5	District of Dampit, Sumbermanjing Wetan, Dau
2001	4	District of Ngantang, Pujon
2002	7	District of Bantur, Pujon dan Batu
2003	7	District of Bumiaji, Sumberpucung
2004	13	District of Bantur, Batu

Terracing and Reforestation

Terracing

Reforestation done by the citizens

Reforestation done by the students

Conclusion

1. The sediment rate measurements in Sutami and Sengguruh Dam showed various results and tend to decrease event though compare to condition of watershed which already devastated.
2. There are also various results about erosion rate based on USLE theory or even BATAN measurement. The sediment transport which occurred, show different condition among sub river basins. All of those could be considered due to watershed degradation in each sub basins which may changed every time. It is very important to understand well in order to determine the priority of area that should be handled first.
3. In fact that Sengguruh and Sutami Dam storage volume are decreased, there should be comprehensive erosion and sediment management by conducting conservation efforts e.g. reforestation or constructing of sabo dams.
4. In order to obtain clear description on erosion rate and sediment source, it is necessary to conduct comprehensive research and need technical assistance from Government of Japan, not only from engineering practitioners but also the scientist from university.


Thank you very much

Integrated River Basin Management in Humid Asia

Katumi Musiake

Professor, Fukushima University

Professor Emeritus, University of Tokyo

Secretary General, Asia Pacific Association of Hydrology and Water Resources

Awareness of the Issue

- **Physical, chemical and biological principles governing the hydrological phenomena are general and common in the world. However, hydrological and water resources issues appear very differently in different regions, and are strongly affected by geographical, socioeconomic and cultural conditions in the region.**
- **Methodologies of hydrology and water resources management technology have been developed and formulated mainly in Europe and North America of which major parts are composed of inactive old geology and undulating topography under temperate humid or semi-humid climates.**
- **Some of them are useful and applicable in the world, but some of them are not necessarily applicable to other regions like monsoon Asia where the conditions are remarkably different from the Western world.**

Awareness of the Issue (contd.)

- **In our region, we have hydrological conditions very different from those in Western countries, for instance, rainfall with a large seasonal fluctuation, mountain areas composed of fragile geology, alluvial plains where human activities are concentrated, and so on. These conditions give rise to various water issues specific to the monsoon Asia.**
- **Problem is that hydrology and water issues in the monsoon Asia have not necessarily been recognized adequately even in the region and also in world-wide international societies.**
- **We have to identify them more systematically and to address them more adequately in the world.**

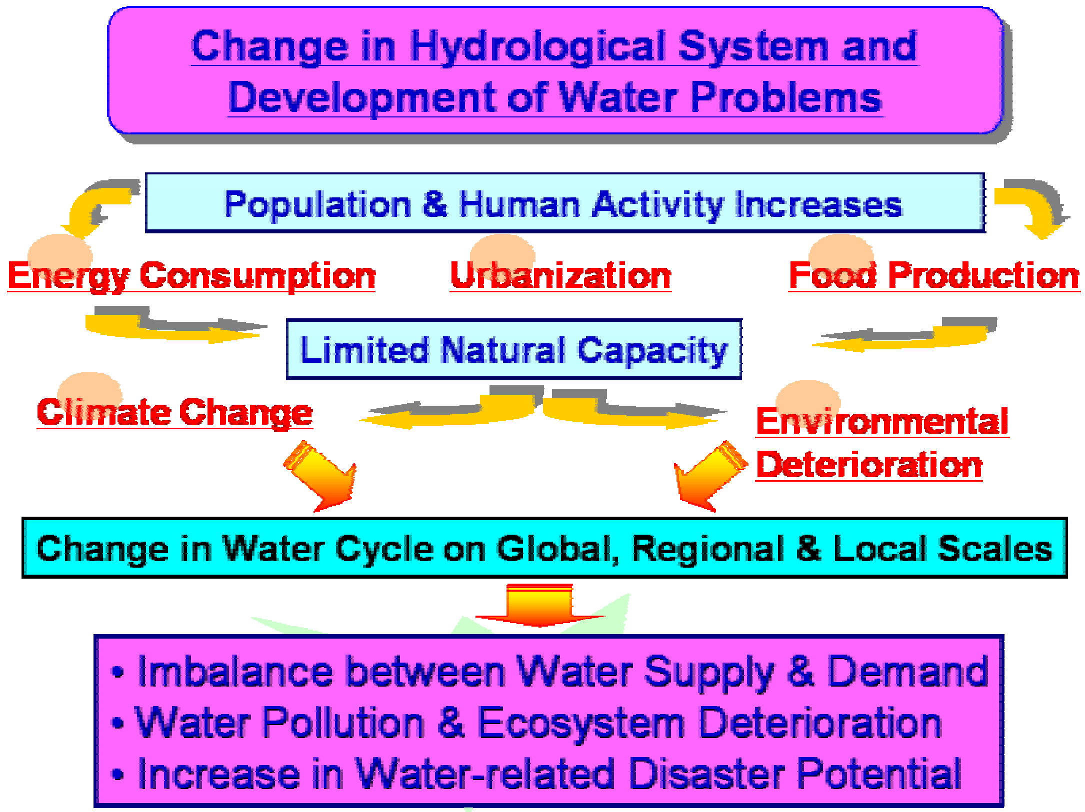
Purpose of my talk: to make clear regional characteristics of hydrology and water resources in monsoon Asia,
and then to discuss IRBM issues in relation to the regional characteristics.

Contents of My Talk

- **To make an overview of "Asian water issues" in a context of "global water issues"**
- **To try to make clear the concept of IRBM**
- **To clarify what characterizes hydrology and water issues in monsoon Asia, especially in humid Asia.**
- **To describe water issues particular to IRBM in humid Asia.**

An Overview of "Asian Water Issues" in a Context of "Global Water Issues"

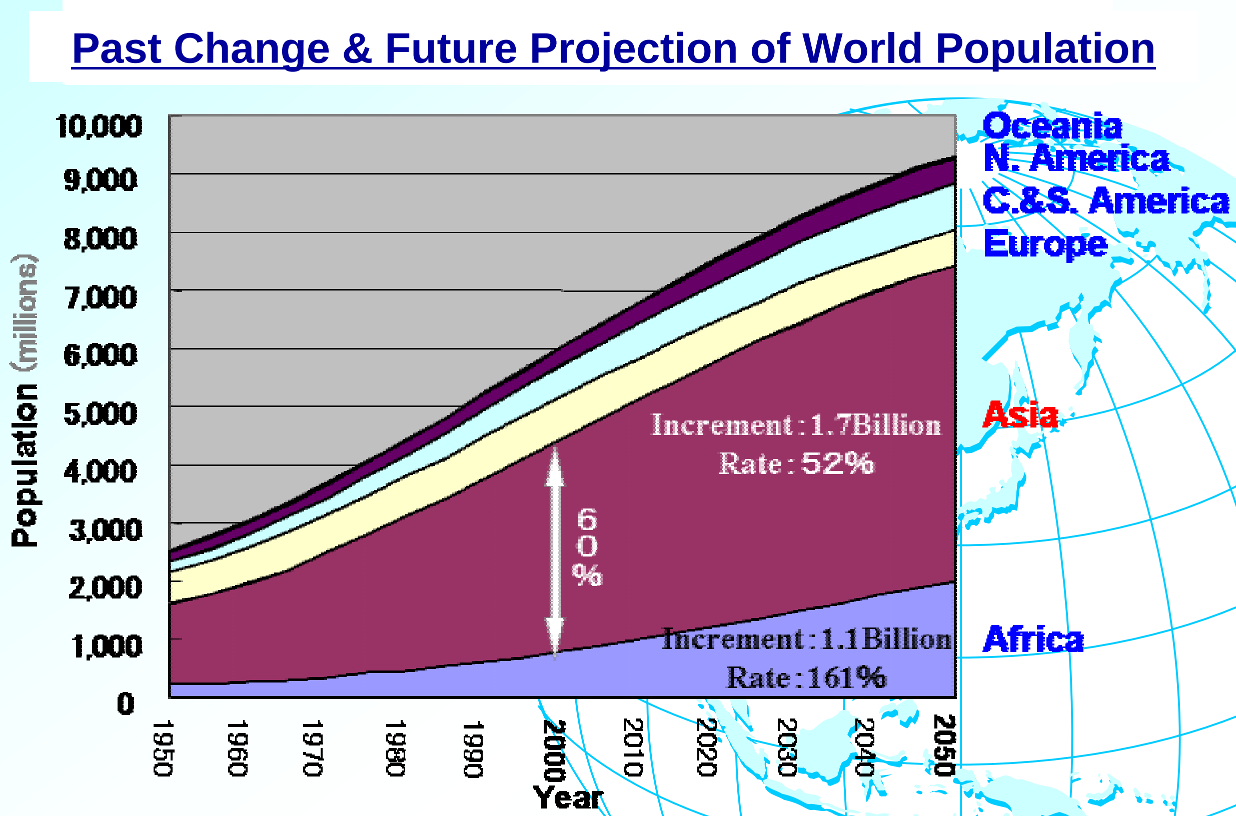
Development of "Global Water Problems"



Rapid population growth and expanding human activities such as increases in energy consumption, food production and urbanization are the most important causes that have brought about remarkable changes in water cycle at global, regional and local levels since the latter half of the 20th century.

These changes have given rise to serious water problems as shown at the bottom in the above figure.

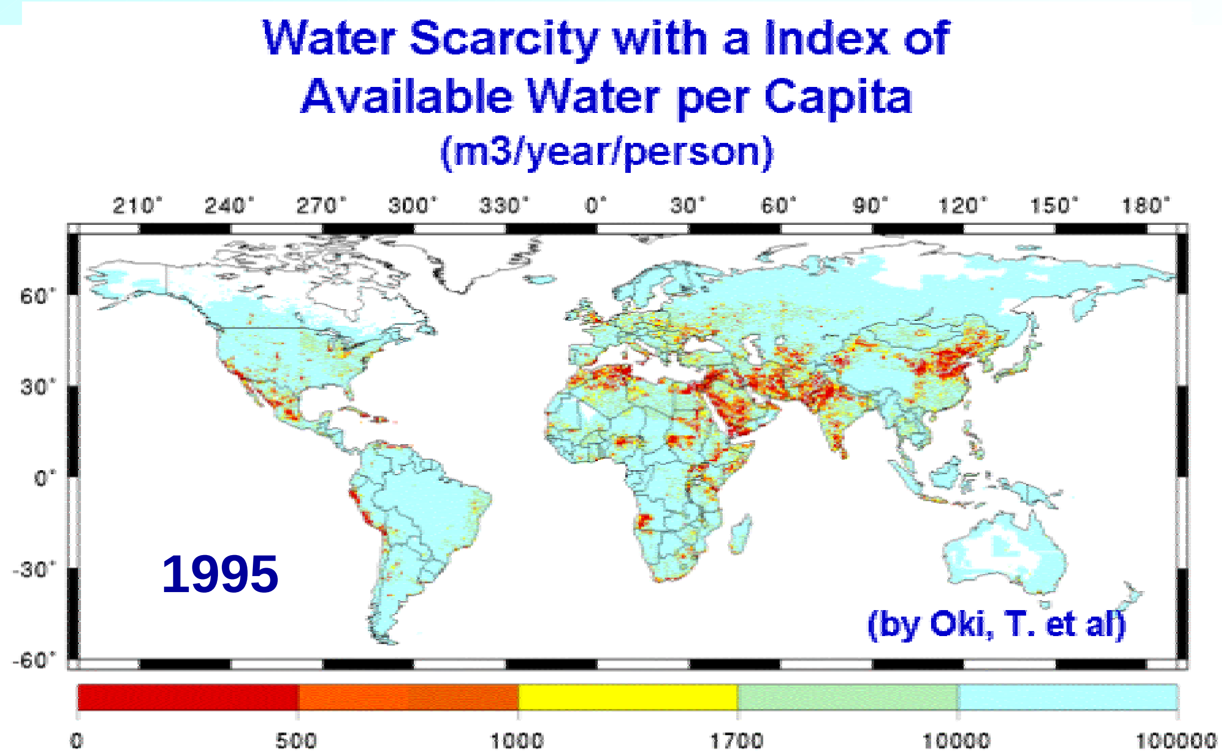
Continuing Population Growth in Asia



Rapid growth since the latter half of the previous century has made Asia the most densely populated region in the world.

Asia is currently home to about 60% of the present world population of 6 billion. The Asian population is still growing and is projected to reach about 5.3 billion by the middle of this century. This growth will worsen Asia's water problems.

Water Scarcity: "Too Little Water" Problem



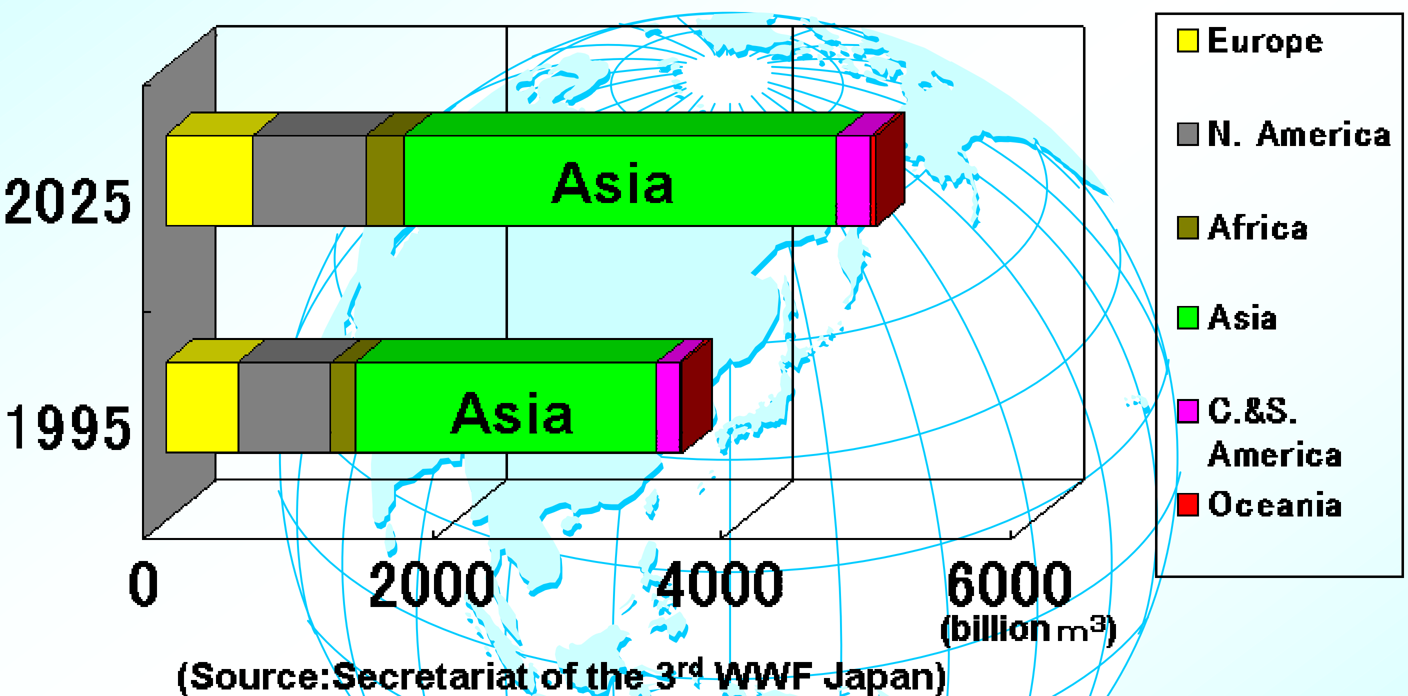
High ← Water Stress → Low

The figure shows the world distribution of water scarcity with a index of available water per capita estimated in 0.5°grid unit in the year of 1995.

Red and orange grids indicate serious water scarcity.

Grids of high water stress appear not only in arid/semi-arid regions, but also in humid region of Asia.

Increasing Water Demand

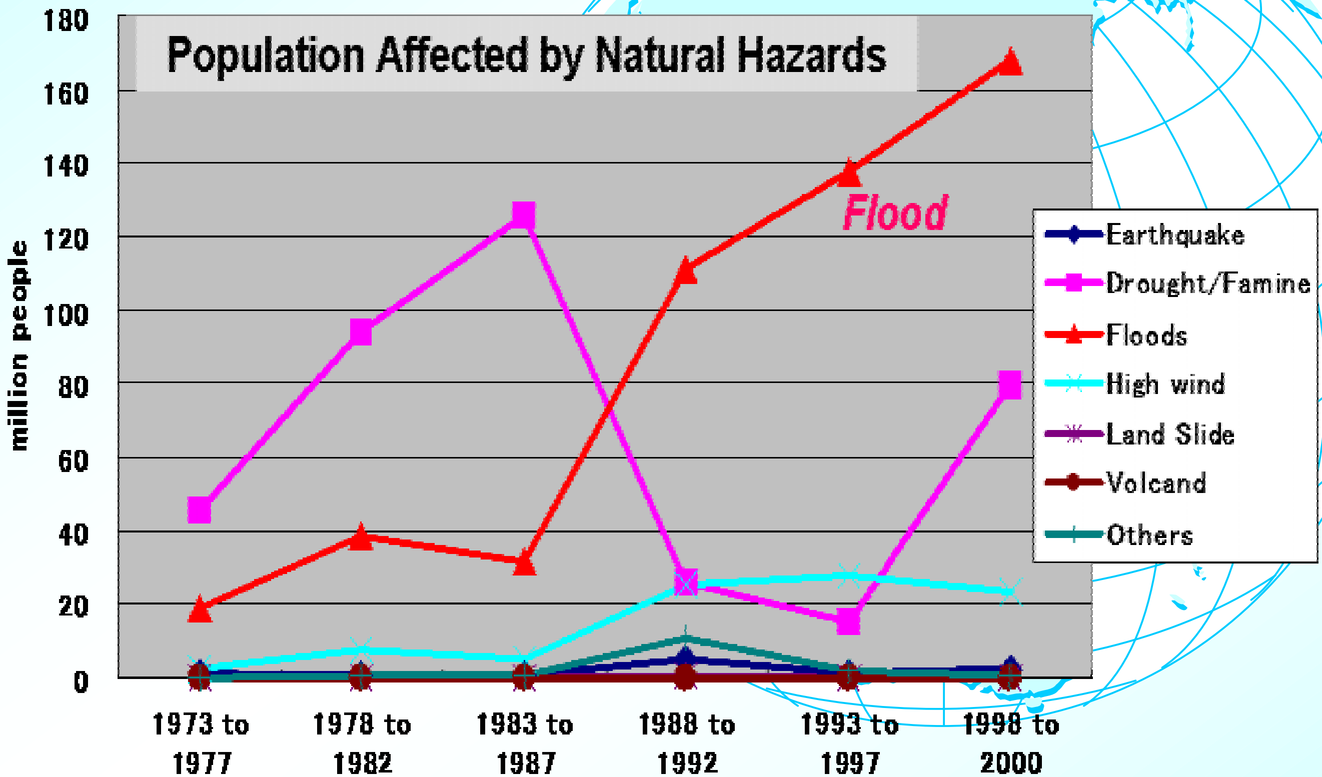


The figure shows the water demand in 1995 and the projected value in 2025, classified by region of the world.

The demand in 2025 in Asia will increase about 1.5 times compared to that in 1995. The degree of increase in the demand is the highest in both absolute value and increasing rate in Asia.

Natural Disasters

Increase in "Too Much Water" Problems



Source: World Disasters Report 1999, 2001

Among the causes of natural disasters, **flood disaster** is remarkably increasing in these two decades in the world.
Especially in humid Asia, flood problems are crucial in their seriousness and frequency.

World Record of Disasters Causing 100 or More of Deaths, 1963~1992, Classified by Region and Cause of Disaster

Cause \ Region	Asia				America				Europe	Mid.East／Africa				Caribbean	Pacific
	Total	EAS	SAA	SAS	Total	NOA	CAM	SAM		Total	MEA	CAF	SAF		
Floods	130	42	10	78	35	5	3	27	10	19	9	1	9	2	6
Tropical Storms	84	41	1	42	13	8	4	1	0	5	1	0	4	11	40
Storms, Other	27	8	0	19	10	9	0	1	1	4	3	1	0	0	4
Landslides	26	9	5	12	20	1	1	18	3	3	0	0	3	1	1
Drought	6	2	4	0	0	0	0	0	0	15	0	11	4	0	0
Food Short -ages/ Famine	1	0	1	0	0	0	0	0	0	3	0	1	2	0	4
Earthquakes	34	10	10	13	20	4	5	11	22	22	19	2	1	0	4
Epidemics	41	4	3	34	16	0	2	14	1	74	3	49	22	0	0
Other	31	6	5	20	21	14	2	5	7	5	2	2	1	1	7

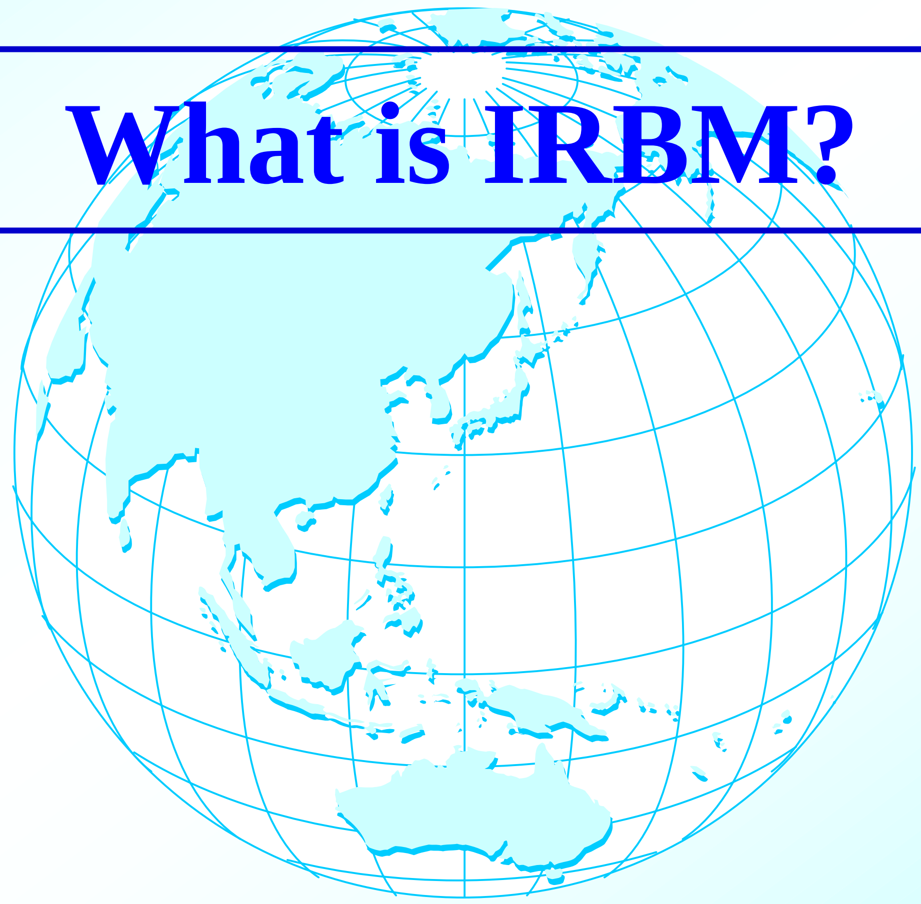
(Source: Disaster around the World – A Global and Regional View, World Conf. on IDNDR, Yokohama, Japan, May 1994)

- The number of disasters which caused 100 or more of deaths in one event
- Aggregated country-base statistics for 30 years from 1963 to 1992
- Pink-shaded portion in vertical column indicates disasters related to "too much water" such as floods, storms and landslides

The "too much water" disasters are much more serious in Asia than in North America/Europe or in Mid. East/Africa.

Roughly speaking, the frequency of serious flood disasters in Asia is one order larger compared to that in other regions.

What is IRBM?



Water management : to apply **structural** and **non-structural** measures to modify natural and man-made water systems for the **enhancement of human welfare** as well as the **conservation of natural environment.**

- water supply
- wastewater treatment
- water quality improvement
- flood disaster mitigation
- debris/sediments control
- hydropower generation
- navigation
- recreation
- conservation/restoration of eco-system

Water has diverse functions, and the water management includes various subjects.

General Characteristics to be Considered in Water Issues and their Management

- Since water issues are too diverse to be solved from a single view-point, the "comprehensive" or "integrated" way of thinking is always required in their management

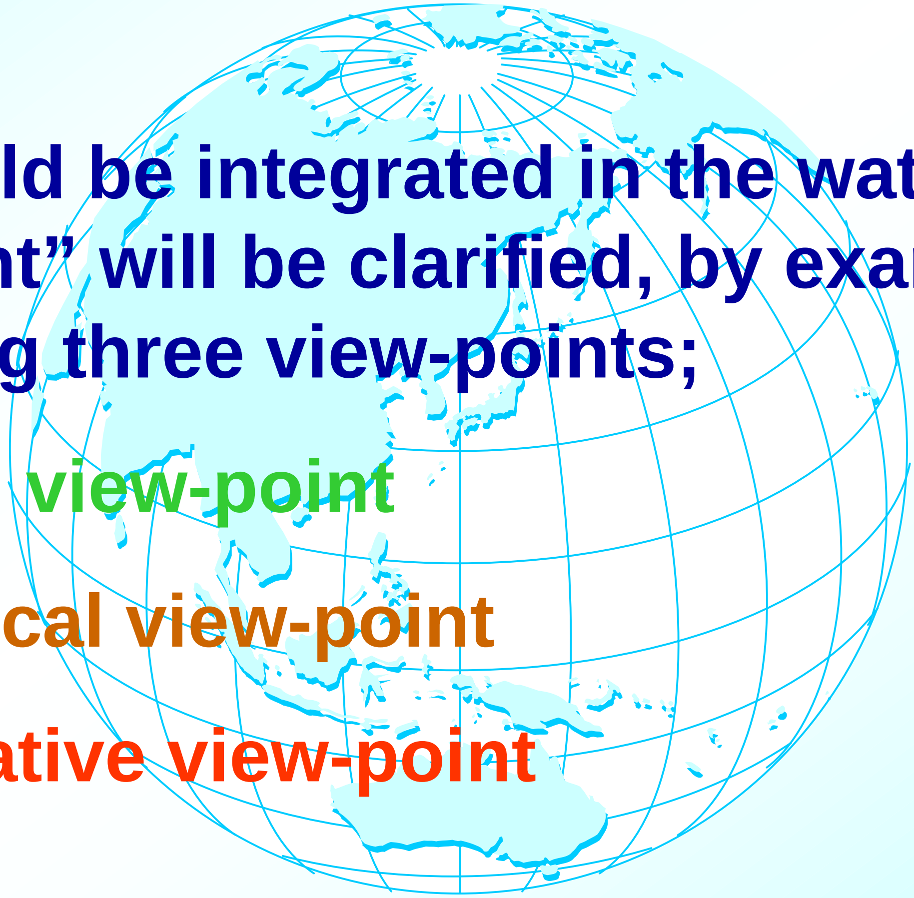
- Water management issues have regional characteristic affected by;
  - natural factors such as meteorology/climates, hydrology, topography/geology, eco-system, etc., and
  - human factors such as historical/cultural backgrounds, socio-economical situations, etc. in the region

- Water issues to be solved and consequently targets of water management are changed with the times.

To Clarify the Concept of “Integrated” “River Basin” Management

“What should be integrated in the water management” will be clarified, by examining from the following three view-points;

- **Functional view-point**
- **Geographical view-point**
- **Administrative view-point**



Functional view-point

***Functions of Water* are divided into the following three major categories;**

- ***Water Utilization***: municipal use(domestic & industrial), agricultural water use, hydropower generation, recreational use, navigation, etc.
- ***Flood Control and Disaster Mitigation***
- ***Conservation and Restoration of Water-related Environment and Eco-system***

(there are many measures under each of three major functions)

Among functions and also among water sub-sectors and areas in each of functions, there are differences in interests and requirements – a sort of conflicts.

Different requirements among functions

- in the operation of multipurpose reservoir between water utilization and flood control purposes, if the capacity is limited.
- between environmental protection and construction of water infrastructure facilities

Conflict among water sub-sectors

- in water allocation among agricultural, domestic and industrial water uses

Conflict among areas

- in the water utilization between up-stream and down-stream areas
- in the flood inundation problem between one side and other side areas of the river
- in the dam construction between dam-site and down-stream beneficiary areas

Integration from Functional View-point

- In planning a water management, the following processes will be taken;

- to identify water issues to be solved, and determine objectives and strategies: In this process, functions to be involved and measures to achieve each function are examined.

- to coordinate different functions and measures and formulate them in an "integrated" way of thinking to meet with the objectives of the water management.

- From this view-point, the degree of "integration" is assessed, based on whether relevant functions and measures are involved adequately to achieve the objectives of the management.

Integration from Geographical View-point

- This view-point is refers to spatial scale and accounting units for the water management, such as global, river basin, groundwater basin, administrative district, water use district, etc.

- In the humid region, the “river basin” is an important unit to analyze hydrological processes / water balance as well as to consider water supply-demand, flood disaster mitigation and conservation of aquatic eco-system.

- Therefore, the “river basin” is taken as an “integrated geographical unit for the water management in the humid region.

(In the arid/semi-arid region, the “groundwater basin” is important)

Integration from Administrative View-point

- The water management is generally enforced by administrative agencies. Water-related agencies are usually fragmented in every country over the world, since water has diverse aspects.

- After objectives and strategies are defined for a water management, we have to assign duties and roles among relevant agencies, and to establish an executive structure which enables to enforce the water management effectively and efficiently in an "integrated" manner.
  The involvement of stakeholder is also included in the administrative view point.

- From this view-point, the degree of integration is assessed, based on whether the established administrative structure has executive capabilities (on financial bases)
  in accomplishing the objectives of the management.

Summary of Consideration on the Concept of “ Integrated” “River Basin” Management

- The “ integrated” way of thinking is crucial in the water management.

- Also, “ river basin” is an important unit for the water management.

- It is easy to say IRBM, but very difficult to realize it.

- In order to realize the IRBM, it is very crucial;
  - whether relevant functions can be adequately incorporated in the IRBM, and
  - whether an executive structure with high capabilities for enforcing the objectives in an integrated manner can be established.

What Characterizes Hydrology and Water Issues in Monsoon Asia, Especially in Humid Asia?

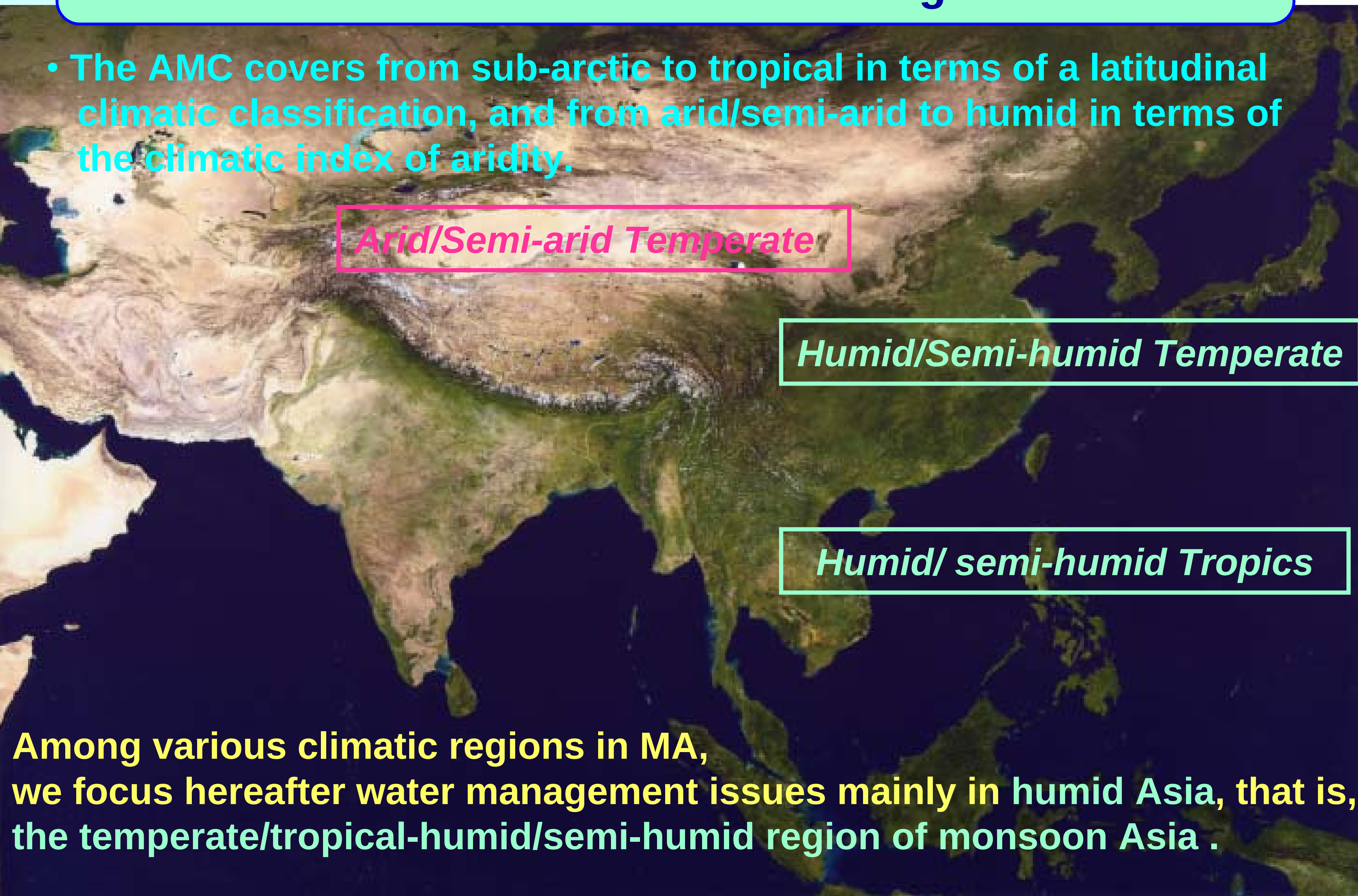
- **Two important factors which characterize regional features of hydrology and water issues:**
  - Climatic factor, and
  - Geomorphologic factor

- **As for the climatic factor characterizing the Asia, the Asian monsoon climate is very important.**

- **As for the geomorphologic factor characterizing the Asia, land conditions formed by the plate tectonic motion, called “tectonic zone or orogenic belt”, are very important.**

Asian Monsoon Climate
- includes various climatic regions-

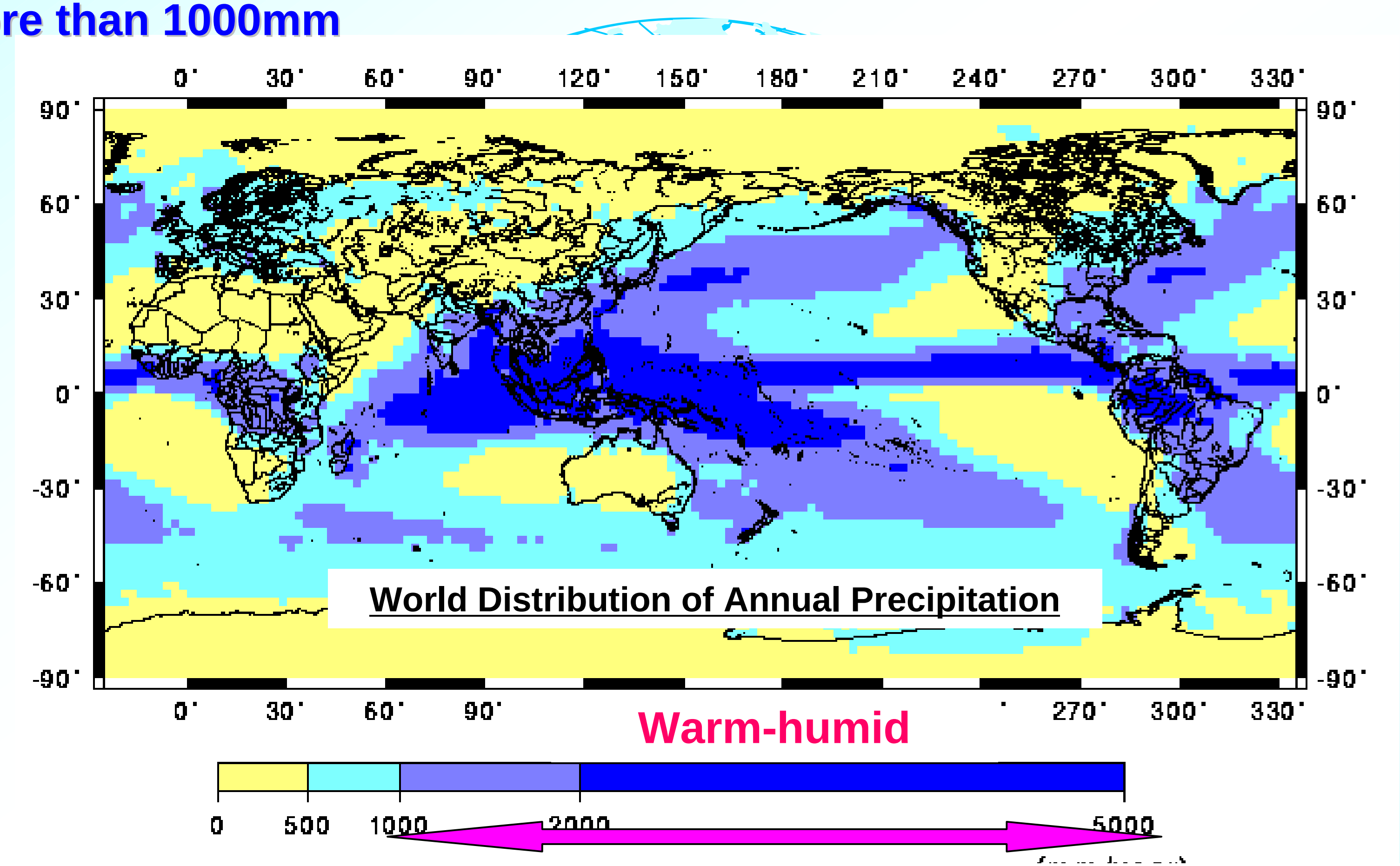
- The AMC covers from sub-arctic to tropical in terms of a latitudinal climatic classification, and from arid/semi-arid to humid in terms of the climatic index of aridity.



Among various climatic regions in MA,
we focus hereafter water management issues mainly in humid Asia, that is,
the temperate/tropical-humid/semi-humid region of monsoon Asia .

Definition of Warm-humid Asia

- **From a macroscopic point of view, we put temperate and tropic together in the same category, which is defined here as "warm" zone**
- **"Humid" climate is tentatively defined as areas with annual precipitation of more than 1000mm**



Roughly speaking, W-H region corresponds to areas with annual precipitation of more than 1000mm, and it covers large part of Asian region.

Hydro-climatic characteristics in Warm-humid Asia

- **The seasonal variation of precipitation is very high corresponding to the seasonal change in monsoon wind system.**
  In other words, there are pronounced dry and rainy seasons in most part of monsoon Asia.
  Also, the inter-annual variation of precipitation is large.

- **The temperate/tropical-humid region of monsoon Asia is one of the most abundant precipitation areas in the world, and there are often torrential rainfalls due to typhoon, tropical cyclone and seasonal rain front during the rainy period, which bring about serous water- related disasters.**

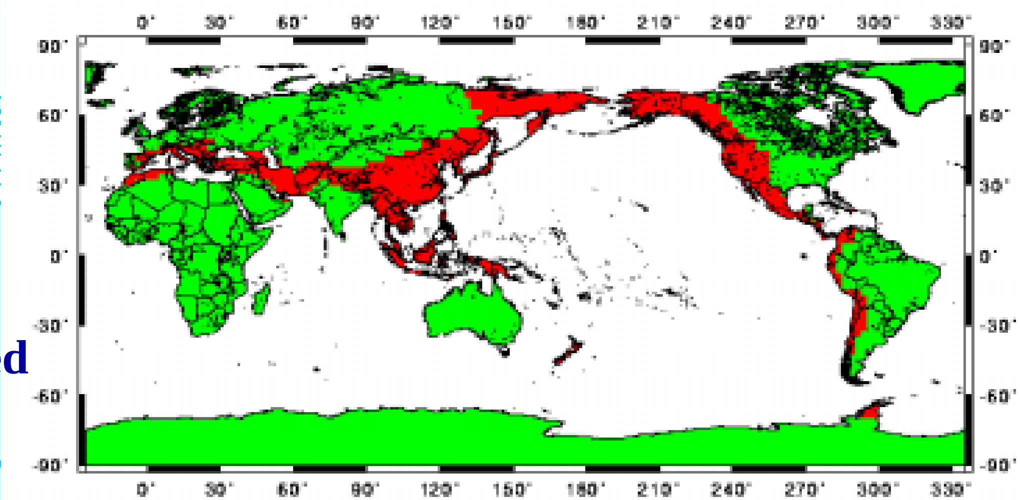
- **In addition to the climatic variation due to the change of natural climate system itself, the climatic change due to the global warming seems to take place in monsoon Asia. The 3rd IPCC Report points out that the annual precipitation and the inter-annual variation of the precipitation as well may increase in large parts of east and south-east Asia during the 21st century.**

(Hydrological conditions in Asia are characterized by Asian monsoon climate, but characteristics of water management issues in Asia are not sufficiently expressed only by the climatic conditions.)

“Tectonic Zone” characterizing land conditions in Asia region

The continent masses are classified into **two major divisions**;

- **Tectonic zones**: zones where mountain-making activities take place due to plate tectonic motion
- **Stable regions**: regions which are composed of old geology and not affected by seismic and/or volcanic activities



World Distribution of Tectonic Zones

There are two tectonic zones in the world:

Alpine-Himalayan Zone and Circum-Pacific Zone

The Asia Pacific region is widely covered by tectonic zones. Land conditions formed by PTM make special characteristics different from stable regions.

Characteristics of Water Issues in Monsoon Asia

- Water issues in monsoon Asia are characterized by **land conditions** formed through **plate tectonic motion**, **climatic conditions** of **Asian monsoon** and **human activities modifying those natural environment**.

- People' life is placed on
  - **fragile mountain areas** affected by seismic / volcanic activities due to plate tectonic motion, and
  - **alluvial flood-risk plains** formed by sediments transported from the upper reaches of fragile mountain areas.

- Owing to these natural conditions, monsoon Asia is the **most densely populated** region in the world, supporting about 60% of world population, and the **population** is **still increasing** in many developing countries.

Water Issues to be Considered in IRBM in Humid Monsoon Asia

- In our region, there are a variety of human activities under land conditions of tectonic zone and climatic conditions of Asian monsoon.

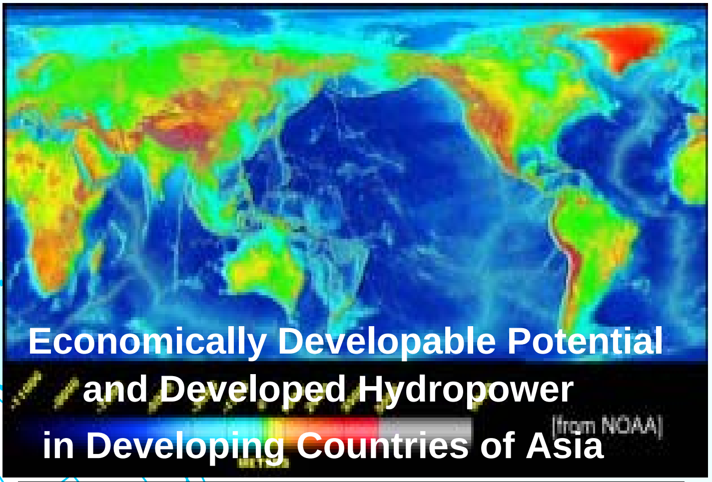
- We can observe many types of human activities particular to Asia monsoon–tectonic zone, which make water issues different from stable regions.

- Some examples of water issues to be considered in the " integrated river basin management (IRBM)" are enumerated below.

Water Issues to be Considered in IRBM in Monsoon Asia

High Potential of Hydro-power Generation

- (High mountains + Abundant Precipitation) provides “high potential of hydro-power”
- In developed countries along tectonic zones, such as France, Italy, Switzerland, Japan, west coast of Canada and USA, etc., almost of economically developable hydro-power potentials had been developed before the middle of 20th century.
- On the other hand, in developing countries of Asia, most of hydro-power potentials are remained for the future energy development.



Economically Developable Potential and Developed Hydropower in Developing Countries of Asia

	Developable H-Power (MW)	Developed H-Power (MW)	Ratio (%)
Indonesia	7500	3012	40
China	378000	70000	19
Thailand	15000	3900	26
Malaysia	29000	2058	7
Philippine	12310	2230	18
Vietnam	9000	3343	37
India	94000	22448	24
Pakistan	33572	4825	14
Sri Lanka	——	1137	——
Bangladesh	600	230	38

（Source: Electric Power Industry in each country (JEPIC 2000)，APEC ENERGY DATABASE ）

Water Issues to be Considered in IRBM in Monsoon Asia

Mountain slope cultivation

- Fragile mountain lands formed up due to mountain making activities, such as slopes of volcanoes, fractured zones, Tertiary formation and weathered granite areas, can be cultivated, if they have necessary temperature and water. → mountain slope cultivation in Asian tectonic zones
- On the other hand, they are disaster-risk areas vulnerable to slope failure, landslide, debris/mud flow, etc..
- “Land productivity” and “Disaster risk” are both sides of coin.


Cameron Highlands, MALAYSIA


Brantas basin, Java, INDONESIA


Chugoku district, JAPAN

Heavy Sediment Yield and Water-related Disasters in Mountain Areas

- The steep slope and fragile geology bring about high sediment yield, slope failure, landslide, volcanic eruption and debris/mud flow in mountainous areas.

- Sabo engineering works (debris control, landslide and slope failure prevention works) are applied to prevent or mitigate damages caused by them.

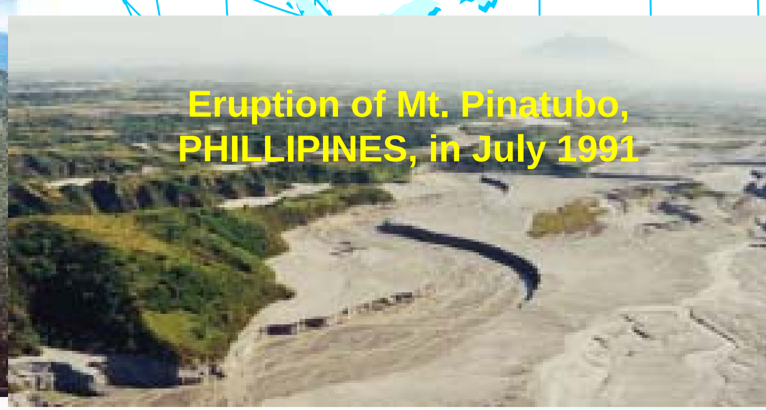
Sabo dam constructed in the upper reaches of Brantas river basin, Indonesia

Water Issues to be Considered in IRBM in Monsoon Asia

Sediment yield and runoff

- The source of sediment yield in stable regions is mainly soil erosion. The soil erosion/runoff processes formulated as Universal Soil Loss Equation (USLE) and Revised Universal Soil Loss Equation (RUSLE).
- We have other major sources of sediment in humid Asia, such as landslide, slope failure, volcanic eruption, debris/mud flow, etc..
- Estimation and prediction of these kinds of sediment yield/runoff are very difficult due to their discontinuous nature, but we have to carry out systematical studies on them.

Landslide due to earthquake. The Abe River Basin, JAPAN



Eruption of Mt. Pinatubo, PHILLIPINES, in July 1991

Debris/mud flow with drifting fallen trees in Ban Nam Kor, Petchaboon, THAILAND, in 11 August 2001.

Water Issues to be Considered in IRBM in Monsoon Asia

Paddy cultivation in the alluvial plain

- Since the alluvial plain is low-lying and wet land, it is used for paddy cultivation if the high temperature and sufficient water can be obtained.

- The paddy cultivation is the most suitable agriculture for the low-lying wet alluvial plain.

- It has a special water management with irrigation/drainage technologies different from dry crop cultivations in stable region.

Differences in WM between Paddy and Dry Field Farming

- **Paddy field farming: Collective and communal, forming the water-centered society – "Water Use Community"**

It is inevitable for the paddy field farming to develop the irrigation/drainage infrastructure, not for each field, but for an aerial extent of paddy fields. This leads to establish an unique local society as "Water Use Community". The greatest importance is placed on a collaborative water management in the community.

- **Dry field farming: Individualized and competitive**

Except for large-scale irrigated dry field areas in the arid region which had been developed since the middle of 20th century, dry field farming in the Western countries is formed under given conditions of stable rainfall and expansive terrain. It is originally on a rain-fed basis, and the use of river water is generally on a first-come-first-served basis. There is no need for a communal approach to water in such dry field farming zone.

These may reflect a big difference in the way of thinking of water management between humid Asia and other dry field farming zones.

Urban areas located in the alluvial plain

- The alluvial plain is the most **densely populated area** in tectonic zones ; big cities, town and villages are located in the alluvial plain.

- Alluvial plains, formed up by flooding of rivers, have a nature **vulnerable to be flooded**. Therefore, **flood control and flood disaster mitigation measures** are much more important in tectonic zones than in stable regions.

Jakarta, INDONESIA

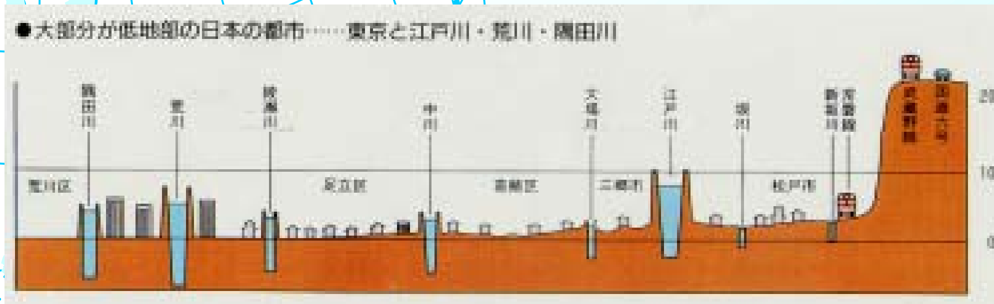
Flooding in Jakarta city

Water Issues to be Considered in IRBM in Monsoon Asia

Flood plain management

- The awareness of flood plains seems to be considerably different between warm-humid tectonic zones and stable regions.
- Generally in stable regions, almost of river reaches are erosive and in those reaches the bottom of valley is flood plain , which is relatively only limited areas. Most of population lives on undulating terrains above the valley.
- In tectonic zones, we have large alluvial flood plains along the middle and down reaches of river, where a lot of people live and human activities are most active.
- Therefore the idea of flood-plain management is basically different between two regions.

The Thames River and London City Area : Flooding areas are so limited



Cross Section of Down Town Tokyo Metropolitan Area: Flooding areas are so large

<u>In stable regions, they apply mainly non-structural measures such as land use restriction without the construction of flood control facilities like large-scale embankment, while we cannot help applying structural measures in tectonic zones.</u>

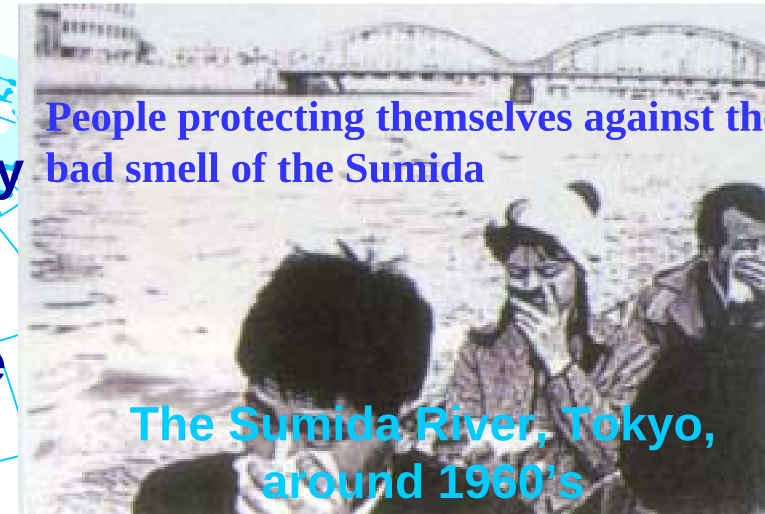
Water Issues to be Considered in IRBM in Monsoon Asia

"Too little water" problems

- Although there is much precipitation in humid Asia, serious water shortage is taking place in most of Asian countries due to the imbalance between water supply and increasing water demand. Also, serious water pollution and sanitation problems are taking place at the same time.

- Such "too little water" problems in humid Asia are considerably different in countermeasures to be applied from arid or semi-arid region, where the groundwater is a major source of available water.

In humid Asia, we have to solve "too little" and "too much" water problems at the same time.


People protecting themselves against the bad smell of the Sumida

The Sumida River, Tokyo, around 1960's


Surabaya River, Indonesia

Summary

- The Asian monsoon climate has often been quoted to explain regional characteristics of water issues in humid Asia.
  But this term alone is not sufficient for the explanation.
  Another important factor is land conditions formed by the plate tectonic motion as follows; fragile hilly and mountain slopes formed by seismic/volcanic activities and alluvial plains formed by the flooding of sediments transported by floods from the fragile upper reaches of river basins.
- These land conditions associated with Asian monsoon climate make unique relationships between water and human activities in humid Asia, such as land use, water utilization, flood disaster mitigation measures, water environment conservation, etc..

Summary (contd.)

- In this presentation, I proposed one way to represent regional characteristics of hydrology and water resources in humid Asia. But, it provides only a general framework for recognizing the regional characteristics from a macroscopic point of view.
- Actual water issues appear more specifically in local areas in each region or country, depending on their natural conditions, historical and cultural backgrounds, socioeconomic conditions, etc..
- Based on the accumulation of examining and formulating the technological and institutional water issues identified on both regional and local levels in monsoon Asia, we need to make an effort to establish “Asian standards” for various fields of hydrological and water resources management practices.

Introduction of "Asia Pacific Association of Hydrology and Water Resources (APHW)"

- In order to encourage and promote the exchange of knowledge/experience in water resources management and cooperative research activities in the Asia Pacific region, "Asia Pacific Association of Hydrology and Water Resources (APHW)" launched 1st Sept. 2002.
- The First International Conference was held with a great success of around 280 participant in March 2003 (just before the 3rd World Water Forum) Kyoto, Japan, and the Second Conference was also successfully held in June 2004 in Singapore. The Third Conference will be held in October 2006 at Bangkok in Thailand.
  <http://www.wrrc.dpri.kyoto-u.ac.jp/~aphw/APHW.html>
- The membership is open for individuals and institutes of every country in the world. We expect that the Association will be further advanced by the active participation of many researchers and practitioners in Asia Pacific region

Thank you for your attention !

ASSESSMENT OF WATER QUALITY STATUS FOR THE BRANTAS AND CITARUM RIVERS APPROACHING BY THE WATER QUALITY INDEX EVALUATION SYSTEM

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Water quality monitoring

Wastewater sampling point, industrial effluent

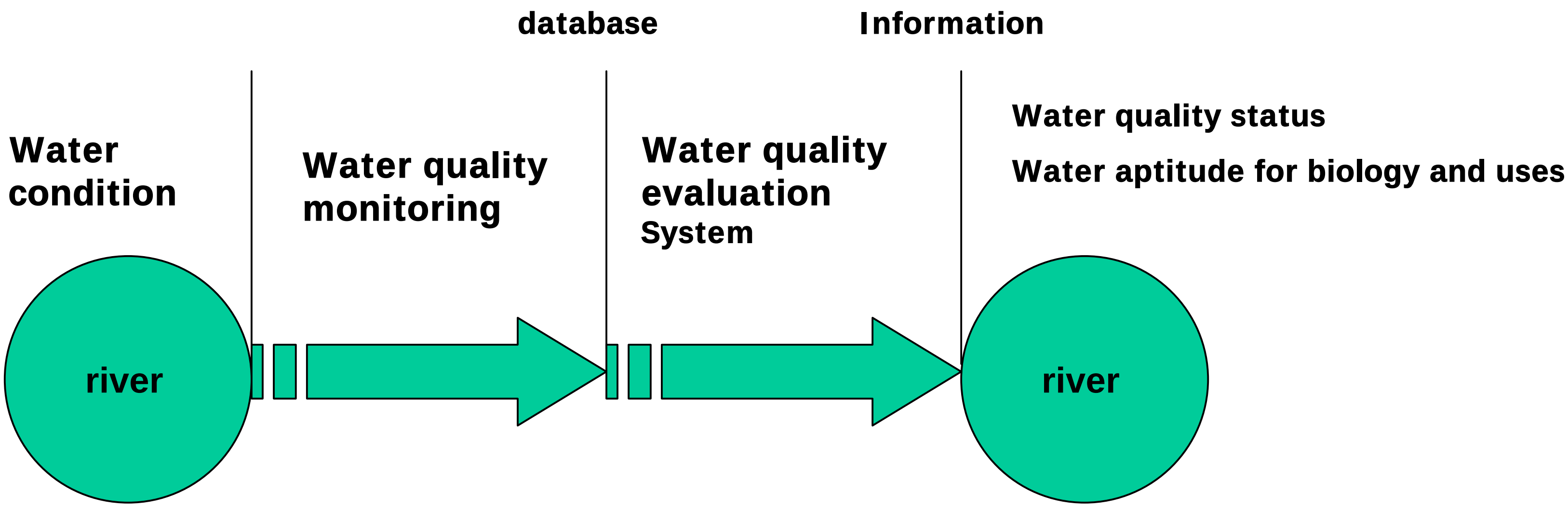
Sampling and field analysis

River water sampling point, bridge location

Laboratory analysis

Input : river water, effluent;
Output : data

How to change the data becoming the information ?



2 types of information

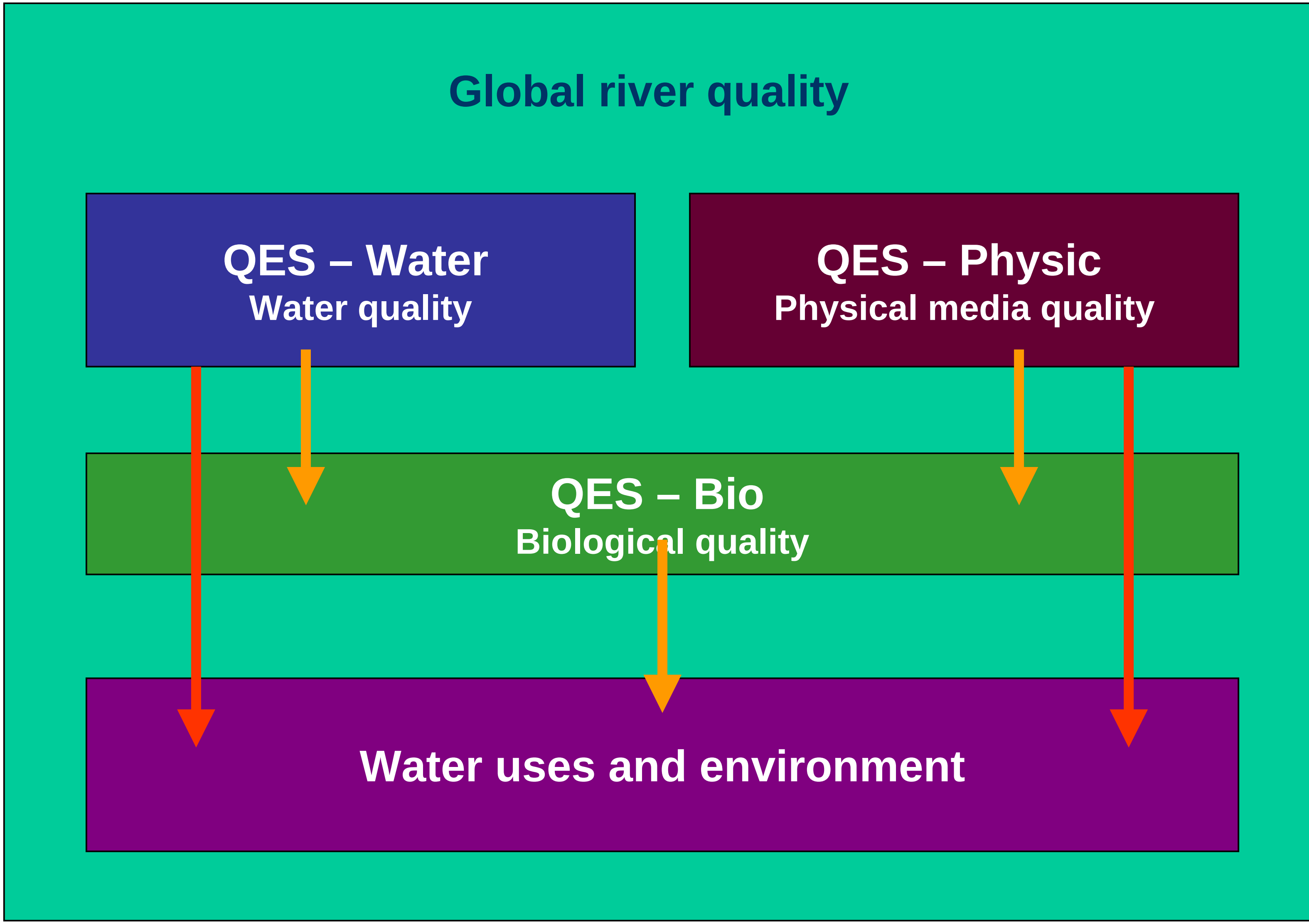
Water quality index :

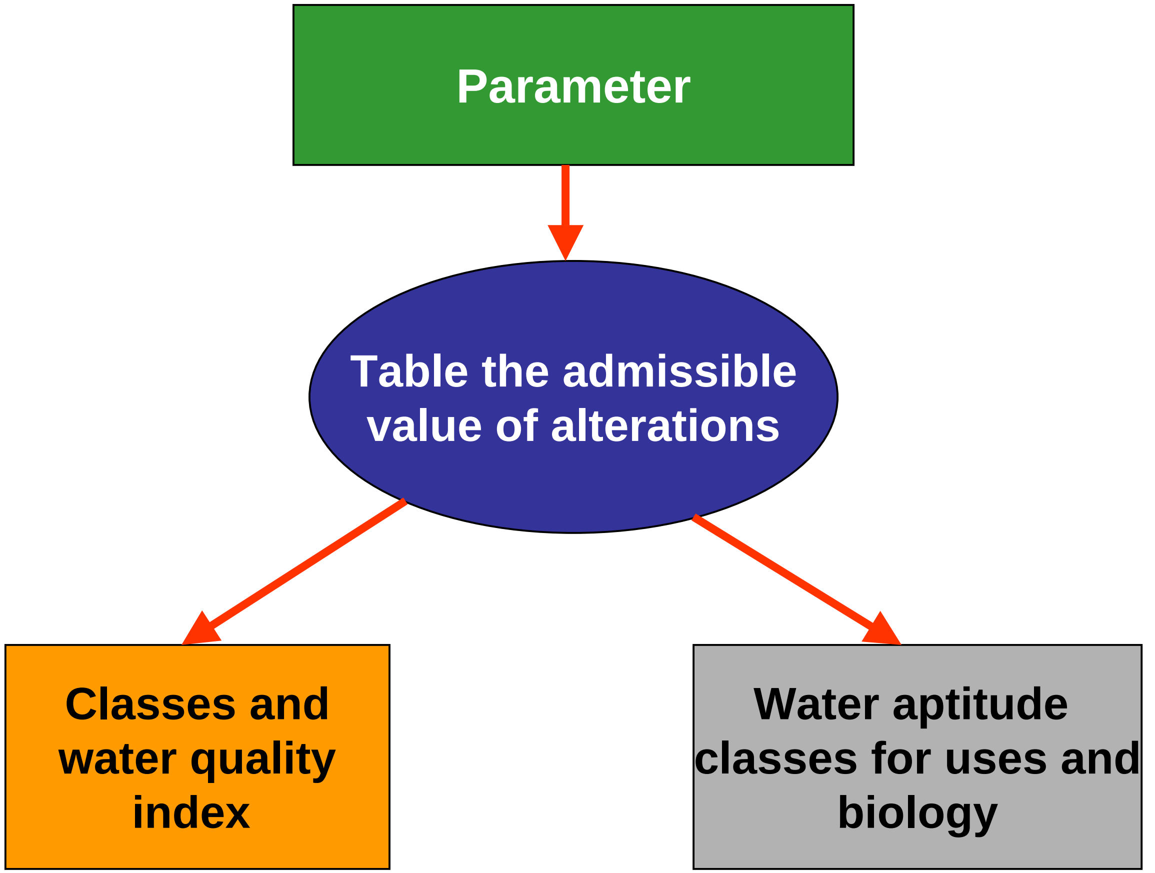
- excellent
- good
- moderate
- bad
- very bad

Water aptitude for biology and uses :

- biology
- drinking water
- recreation and sport
- irrigation
- fishery
- livestock

Water quality evaluation system




Parameter
Table the admissible value of alterations
Classes and water quality index
Water aptitude classes for uses and biology

Classification the quality of water according to the index and representing by the color

index (range)		class	quality
1	(> 80 - 100)	blue	very good
2	(> 60 - 80)	green	good
3	(> 40 - 60)	yellow	moderate
4	(> 20 - 40)	orange	bad
5	(0 - 20)	red	very bad

Water aptitude for biology and uses

blue	aptitude very good
green	aptitude good
yellow	aptitude moderate
orange	aptitude bad
red	no aptitude

Alteration and parameter

Alteration	Parameter
Oxidized organic matters	O_2; %O_2; COD; PV; BOD; DOC; NTK; NH_4^+ (1)
Nitrogen matters	NH_4^+; NTK; NO_2^- (1)
Nitrate	NO_3^-
Phosphorous matters	P_{total}; PO_4^{3-}
Suspended particles	SS; turbidity; transparence
Color	Color
Temperature	Temperature
Mineralization	Conductivity; salinity; Cl^-; SO_4^{2-}; Ca^{2+}; Mg^{2+}; K^+; Na^+; TAC; Saturation
Acidification	pH; Dissolved Al
Micro-organisms	Coliform thermo-tolerant; coliform fecal; streptococcus fecal or enterococcus
Phytoplankton	ΔO_2; ΔpH; % O_2 & pH; chlorophyl-a + feopigment; algae
Inorganic micro-pollutant for raw water	As; Hg; Cd; Cr_{total}; Pb; Zn; Cu; Ni; Se; Ba; CN
Inorganic micro-pollutant for bryophyte	As; Hg; Cd; Cr_{total}; Pb; Zn; Cu; Ni
Pesticides for raw water	List of pesticides
Non-pesticides organic micro-pollutant for raw water	List of non-pesticides organic micro-pollutant

(1) Parameter NTK and NH_4^+ have 2 different effects : oxygen consummation (oxidized organic matters and nutrition for algae and plants (nitrogen matters)

Classes and water quality index

Example, the oxidized organic matter parameters of water quality index classification

Alteration	Parameter	Unity	Limit value of parameter for index classification				
			Index-1	Index-2	Index-3	Index-4	Index- 5
Oxidized organic matters	Dissolved oxygen	mg/l O_2	8	6	4	3	< 3
	Oxygen saturation	% O_2	90	70	50	30	< 30
	COD	mg/l O_2	20	30	40	80	> 80
	BOD	mg/l O_2	3	6	10	25	> 25
	DOC	mg/l C	5	7	10	12	> 12
	NH_4^+	mg/l NH_4	0.5	1.5	2.8	4	> 4
	NTK	mg/l N	1	2	4	6	> 6

Note: COD as chemical oxygen demands; BOD as biochemical oxygen demands; DOC as dissolved organic carbons, NH_4^+ as ammonium, and NTK as nitrogen total Kjeldahl.

Example, evaluation of water quality index for the oxidized organic matters

Water quality parameter of oxidized organic matters	Unity	Value	Class of parameter index	Water quality index
Dissolved oxygen	mg/l O_2	0	5	5
COD	mg/l O_2	75	4	
BOD	mg/l O_2	30	5	
NH_4^+	mg/l O_2	0.955	2	

Remarks : location Nanjung – Citarum river; date of monitoring August 21, 2003

Water aptitude classes for biology and uses

Example, Class aptitude for drinking water production

blue	water with acceptable quality, needs disinfections treatment
green	water needs simple treatment
yellow	water needs classic treatment
orange	water needs complex treatment
red	water not acceptable for drinking water production

blue	green	yellow	orange	red
CMAd	A1	A2	CMAb A3	

CMAd : cons max admissible for drinking water; CMAb : cons max admissible for raw water;

A1 : simple physical treatment and disinfections; A2 : physical normal and chemical treatment and disinfections

A3 : physical, stressing chemical and affinage treatments and disinfections

Example, suspended particles admissible for drinking water production use

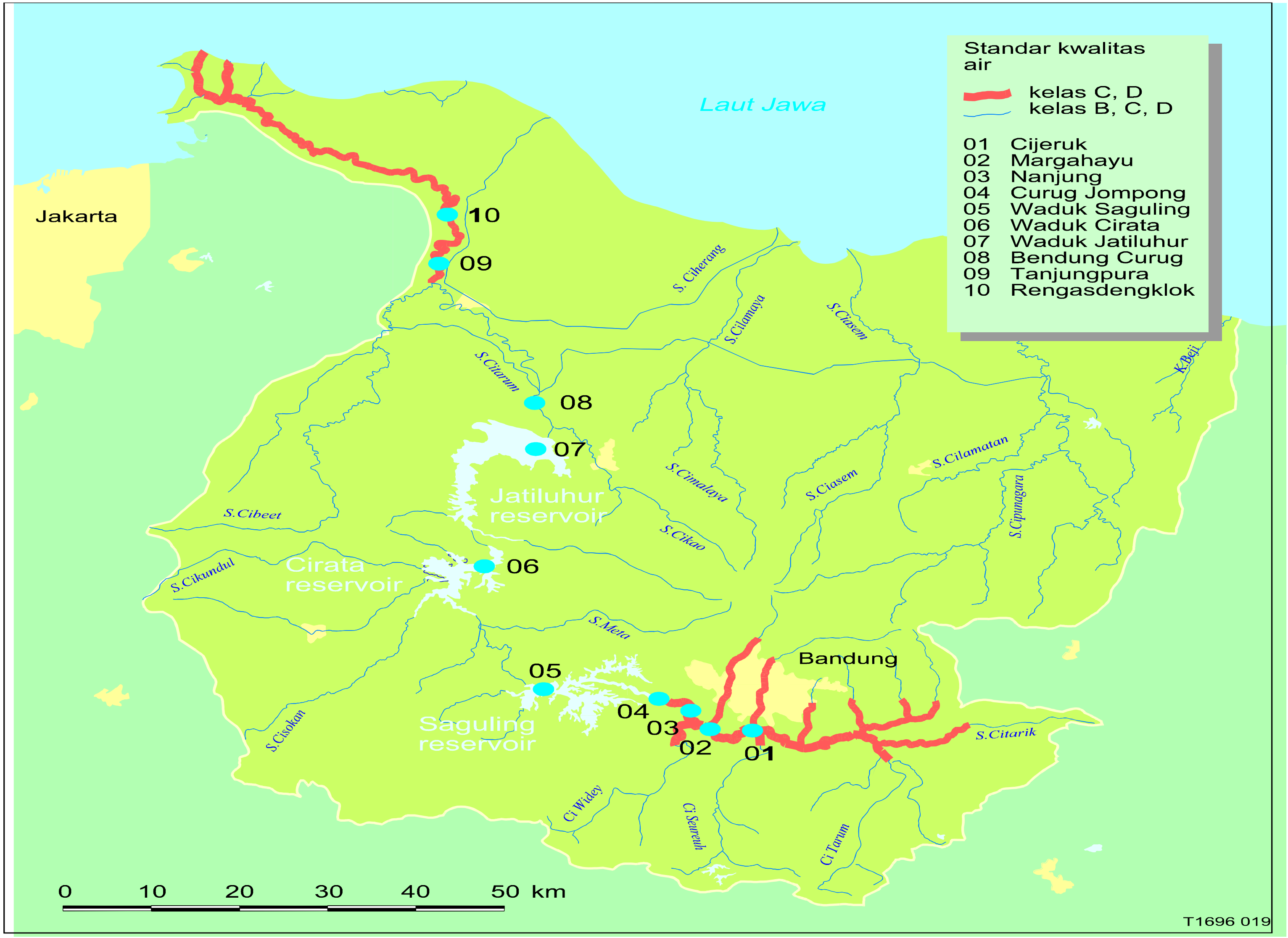
	blue	green	yellow	orange	red
SS (mg/l)	5	50	2000	5000	
Turbidity (NTU)	2	35	1500	3750	
Transparence (m)	2	1	0,1	0,05	

water quality parameters of suspended particles	unity	value	class aptitude of parameter	class aptitude of water
SS	mg/l	60	yellow	yellow
Turbidity	NTU	35	green	
Transparence	m	-	-	

Remarks : **sampling location at Nanjung, Citarum river**

Water needs physical normal and chemical treatments to remove suspended particles for drinking water production

Water quality sampling station in the Citarum river

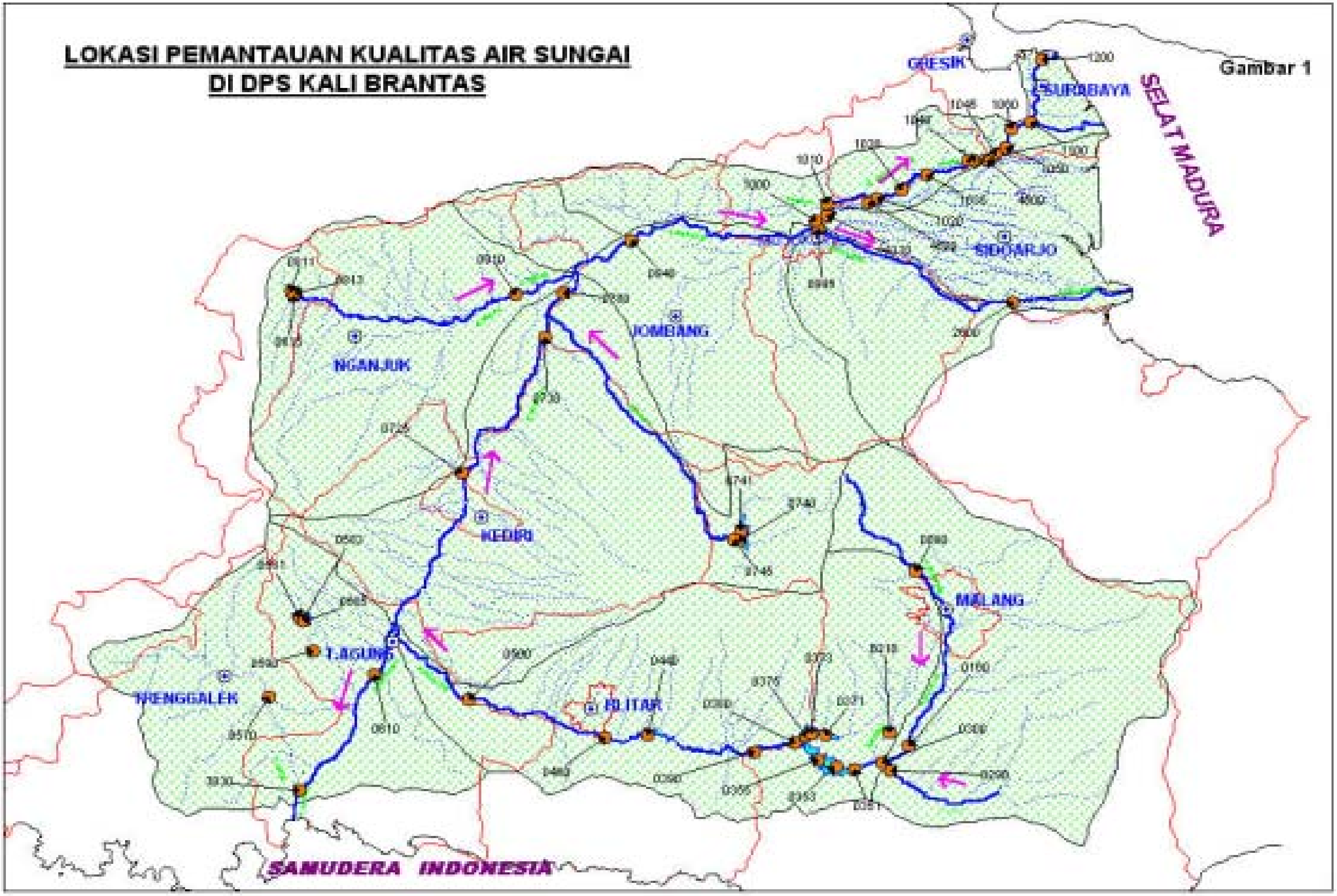


Result of water quality index evaluation for the Citarum River

Types of alteration	Index of alteration									
	01a	01b	01c	01	03a	03b	03	08	09a	09
Temperature	1	1	1	1	1	1	1	1	1	1
Color	2	2	4	3	3	3	4	2	3	2
Suspended particles	5	4	5	5	3	4	5	2	2	3
Oxidized organic matters	2	5	5	5	4	5	5	2	2	2
Nitrogen matters	3	1	3	3	3	3	3	3	1	3
Nitrate	1	1	1	1	1	1	1	1	1	1
Phosphorous matters	5	5	5	5	5	5	5	2	2	3
Mineralization	3	1	3	2	1	1	2	1	1	2
Asidification	1	1	4	1	1	1	3	1	1	1
Inorganic micro-pollutant for raw water	3	3	4	3	4	4	5	1	1	1
Inorganic micro-pollutant for bryophytes	1	1	1	1	1	2	3	1	1	1
Pesticides for raw water										
Organic micro-pollutant non-pesticides for raw water										
Micro-organisms	3	5	5	5	5	5	5	3	3	5
Phytoplankton	1	1	4	1	1	1	3	1	1	1
Water quality index	5	5	5	5	5	5	5	3	3	5
Number of parameter analysis	33	33	33	33	33	33	33	33	33	33

Remarks: 01a Wangisagara, 01b Majalaya, 01c Sapan, 01 Cijeruk, 03a Dayeuhkolot, 03b Brujul, 03 Nanjung, 08 Bendung Curug, 09a Bendung Walahar, 09 Tanjungpura.

Water quality sampling station in the Brantas river

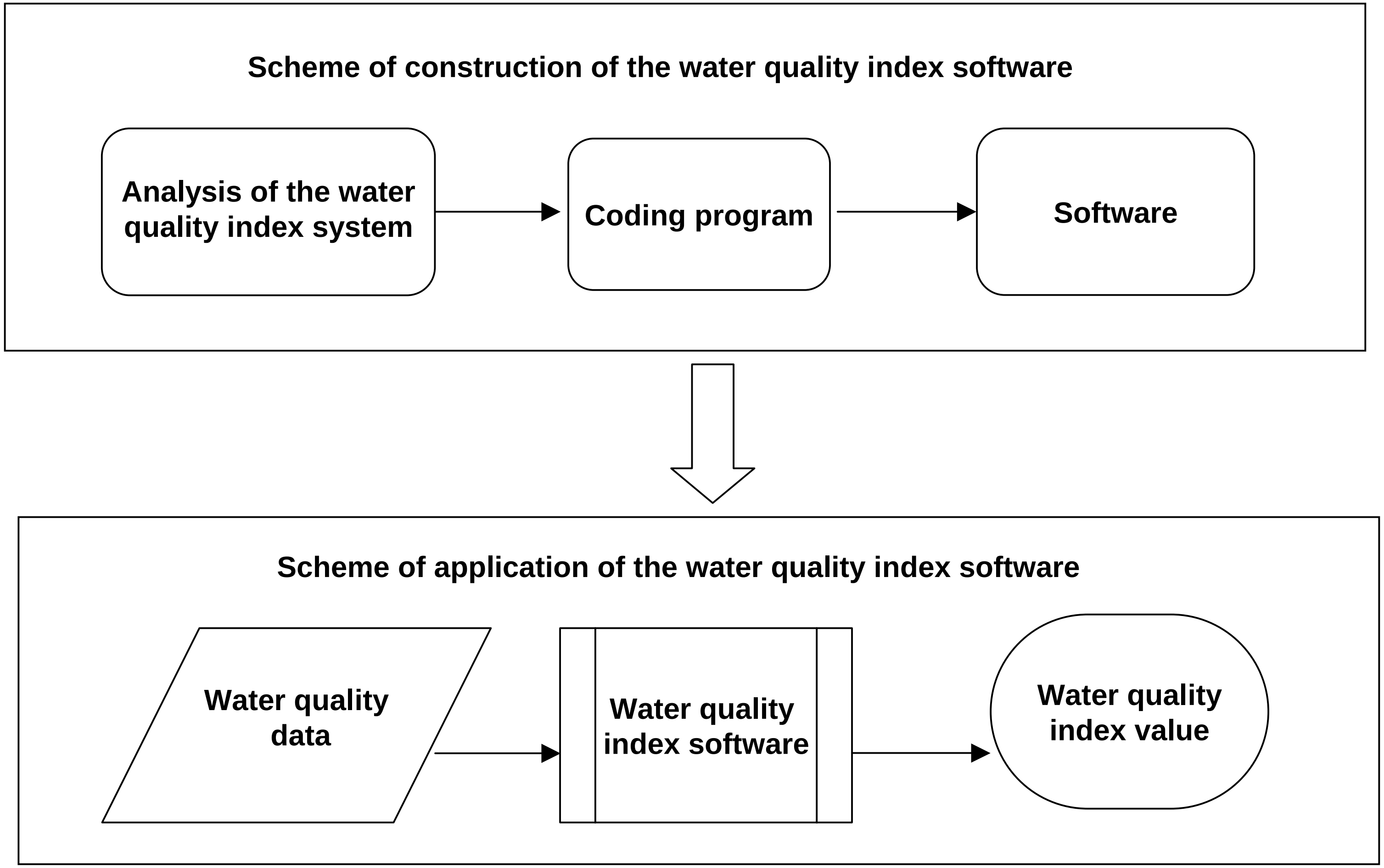


Result of water quality index evaluation for the Brantas river

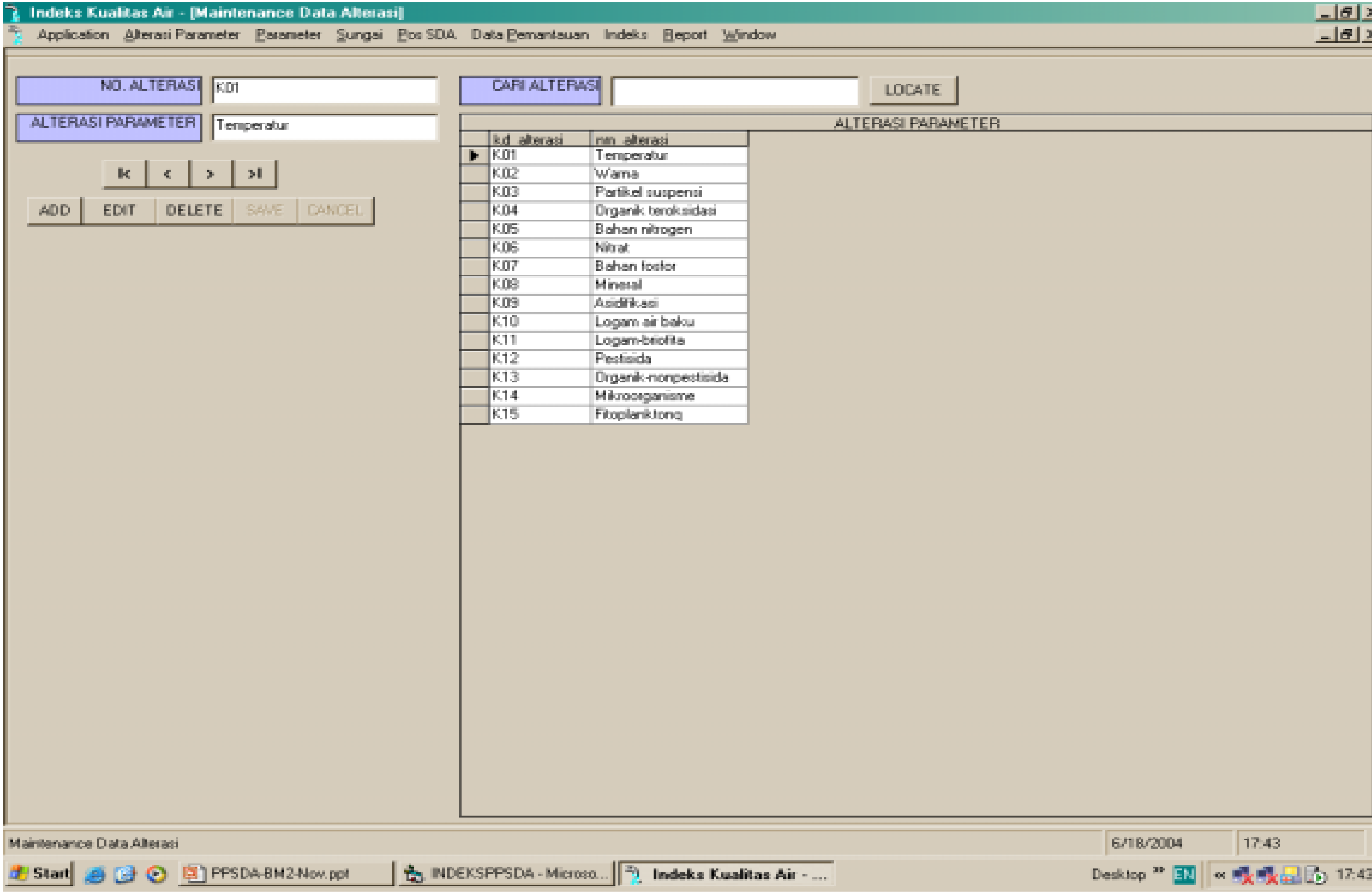
Types of alteration	Number of applicable result and index of alteration									
	0160		0940		1020		1100		2600	
	i	indx	N	indx	N	indx	N	indx	N	indx
Temperature	9	1	8	1	9	1	10	1	9	1
Color										
Suspended particles	9	5	3	5	9	5	10	5	9	5
Oxidized organic matters	9	4	8	4	9	4	10	5	9	5
Nitrogen matters	9	3	8	3	9	5	10	3	9	3
Nitrate	9	3	7	2	9	2	10	2	8	2
Phosphorous matters	9	4	8	5	9	4	10	5	9	5
Mineralization	9	1	8	1	9	1	10	1	9	2
Asidification	9	1	8	1	9	1	10	1	9	1
Inorganic micro-pollutant for raw water	9	5	1	5	7	5	8	5	7	5
Inorganic micro-pollutant for bryophytes	9	4	5	1	7	3	10	1	7	3
Pesticides for raw water										
Organic micro-pollutant non-pesticides for raw water										
Micro-organisms										
Phytoplankton	9	2	8	3	9	3	10	2	9	4
Water quality index	**5**		**5**		**5**		**5**		**5**	
Number of parameter analysis	28		22		25		26		25	

Location remarks: 0160 Kedung Pedaringan; 0940 Jembatan Ploso; 1020 Jembatan Perning; 1100 Ngagel; 2600 Jembatan Porong

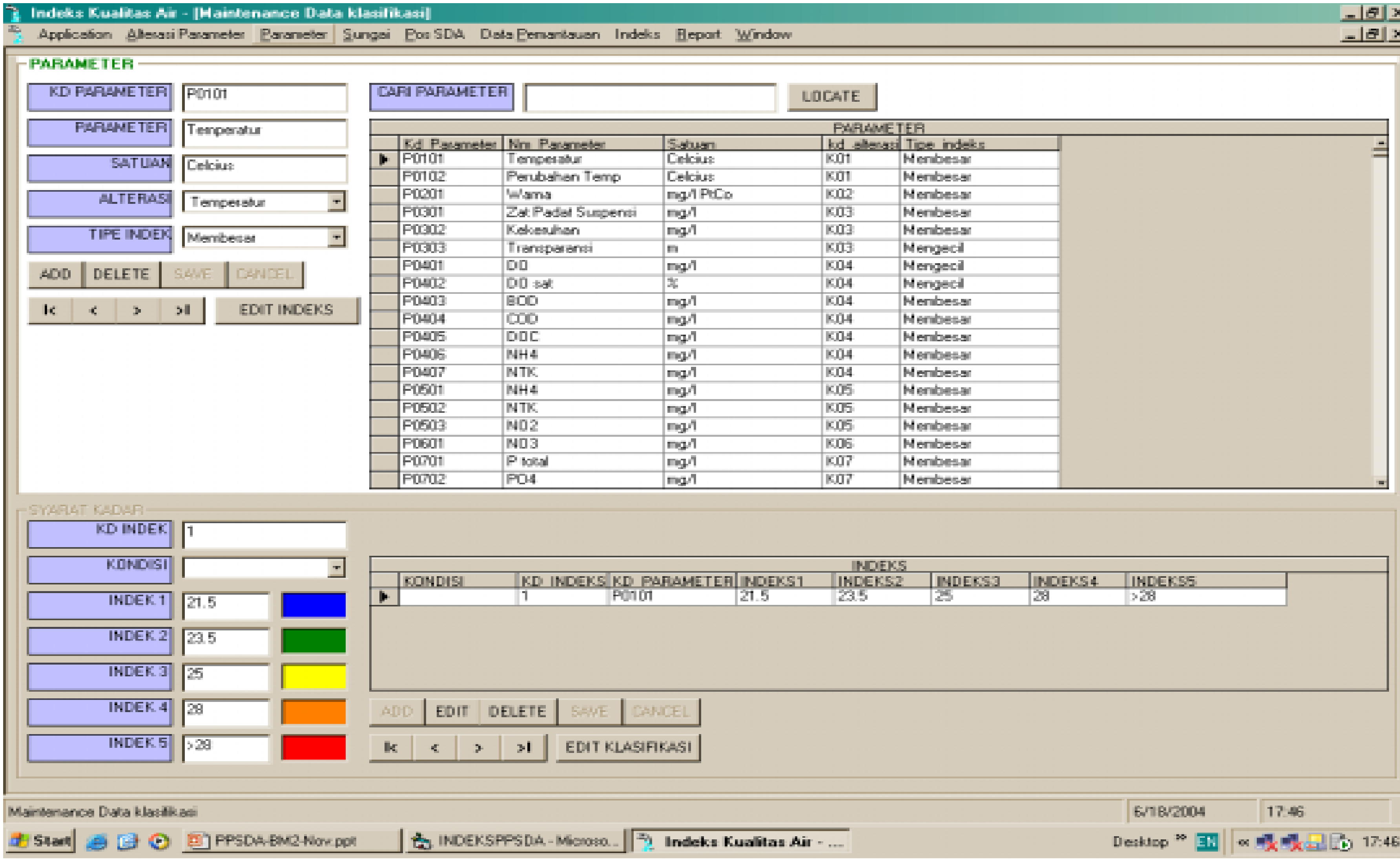
Scheme of software construction and application



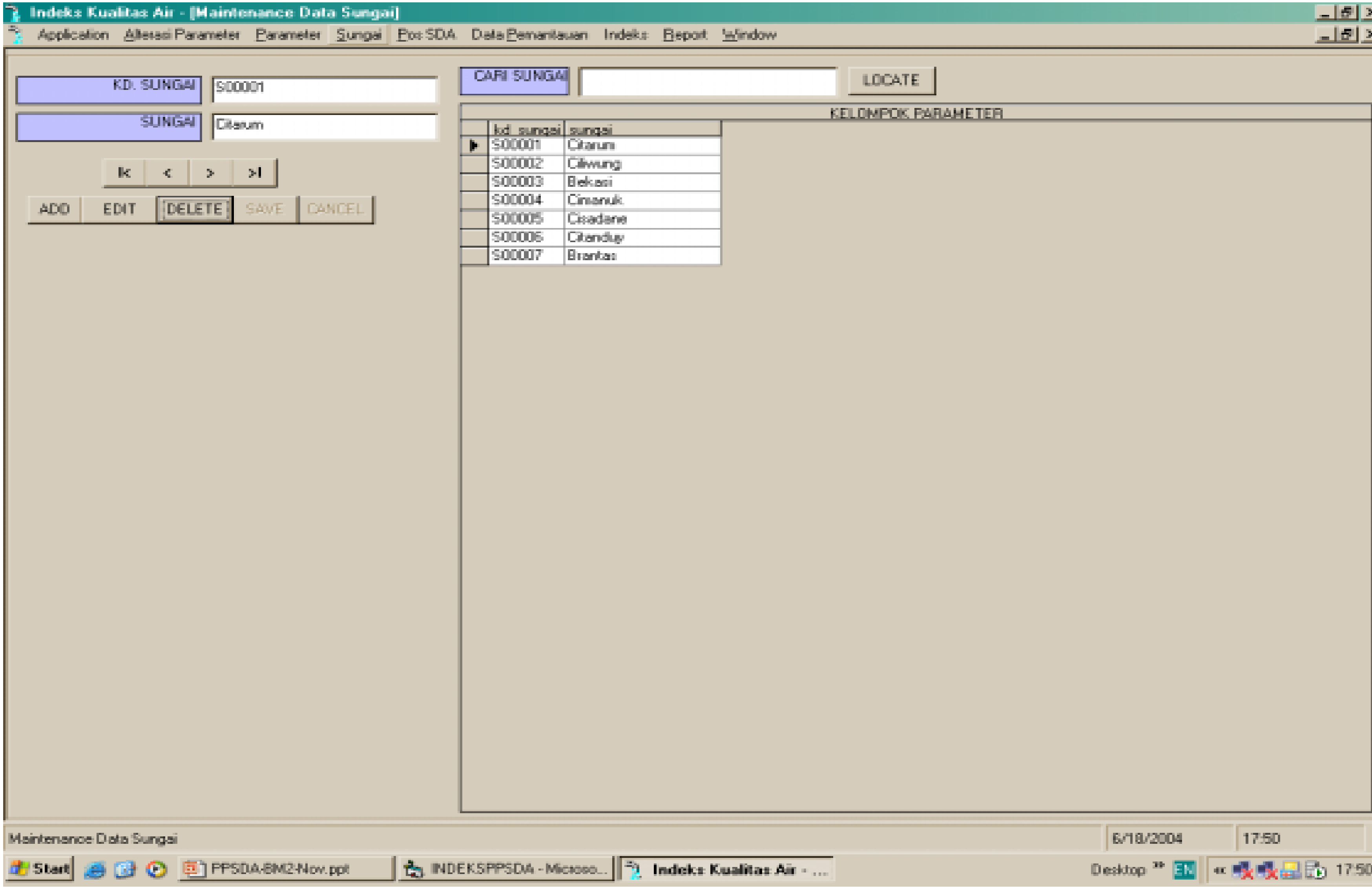
Classification of 150 parameters into 15 alterations



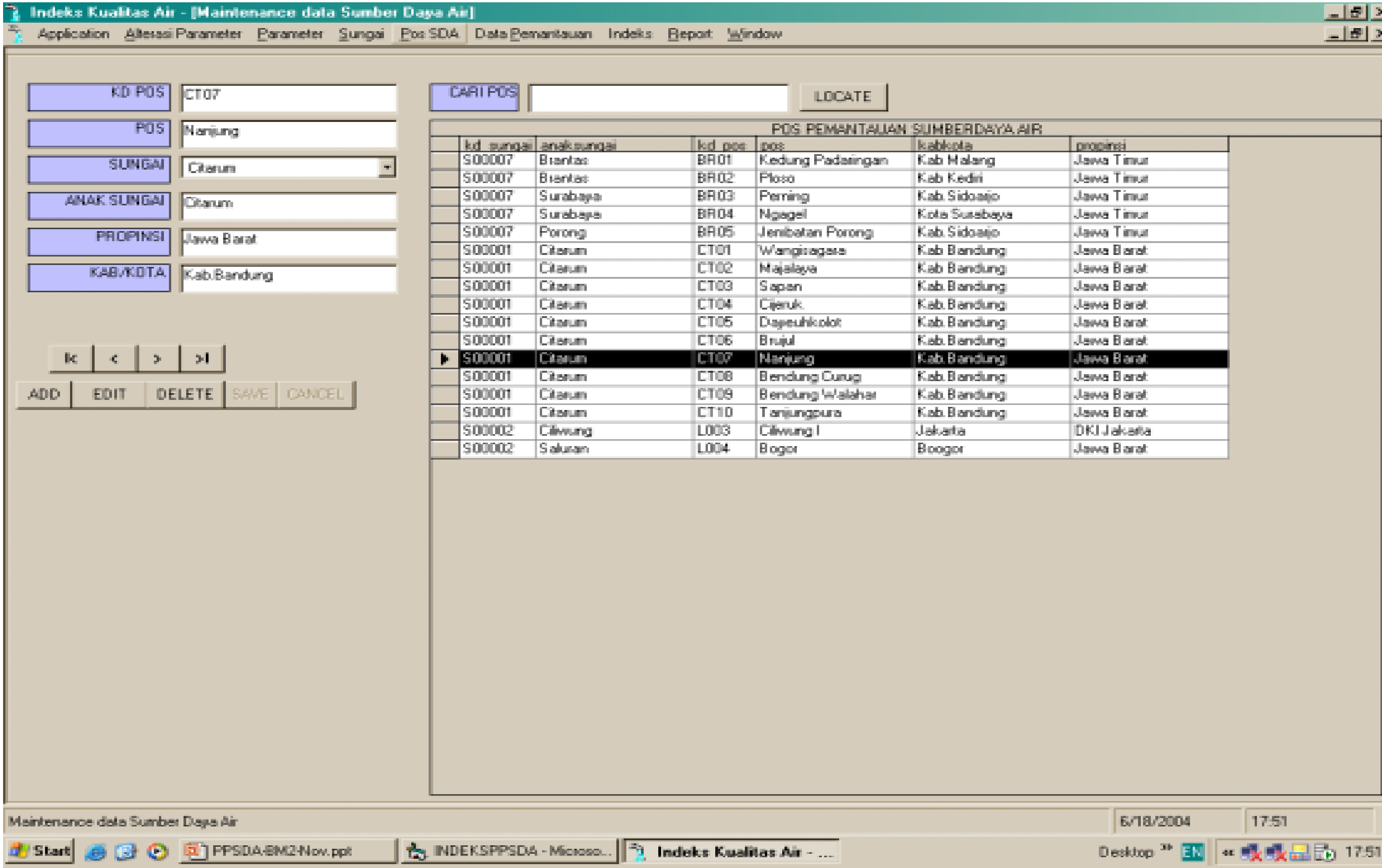
Parameter, alteration and index



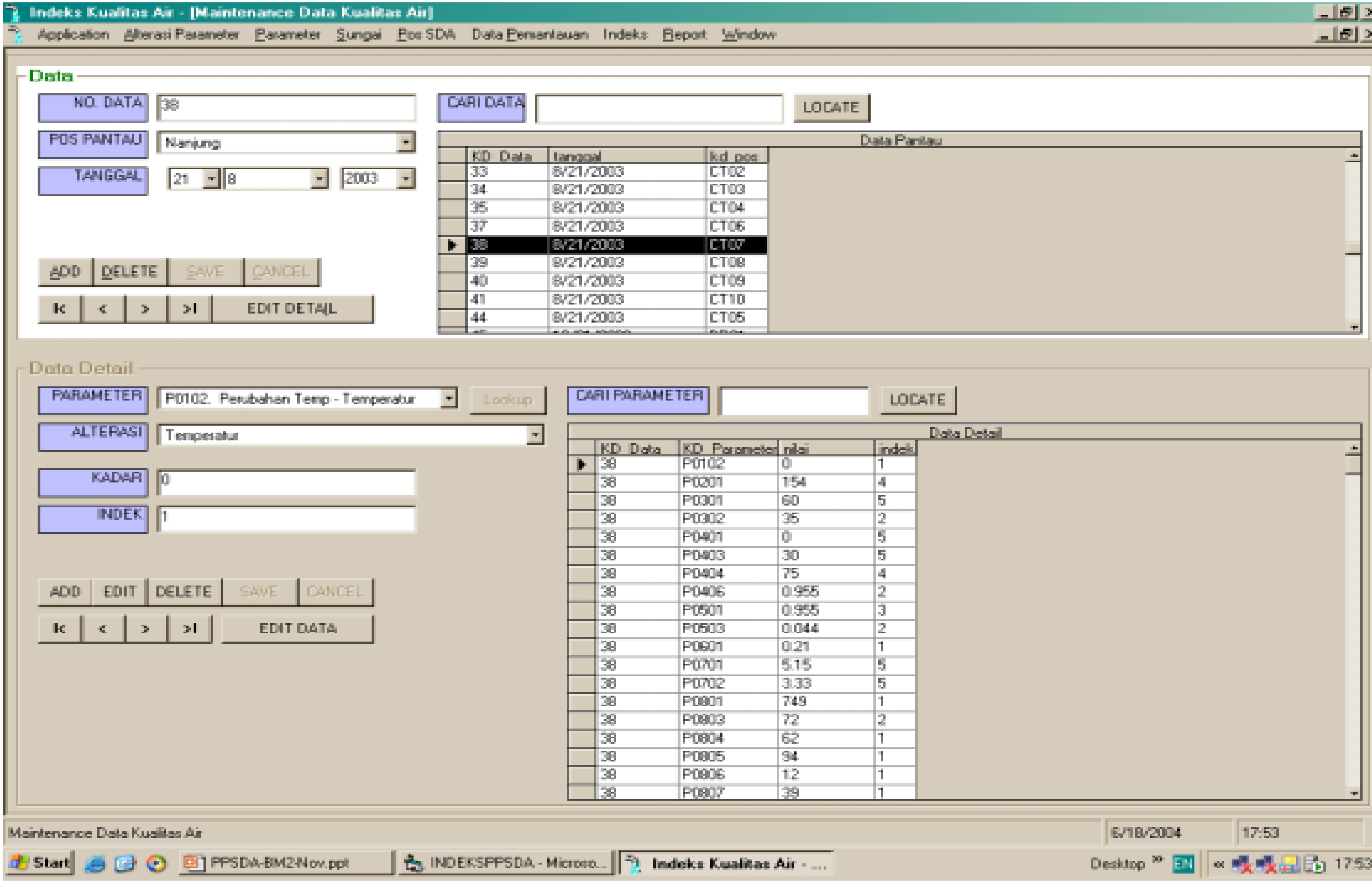
River and river code



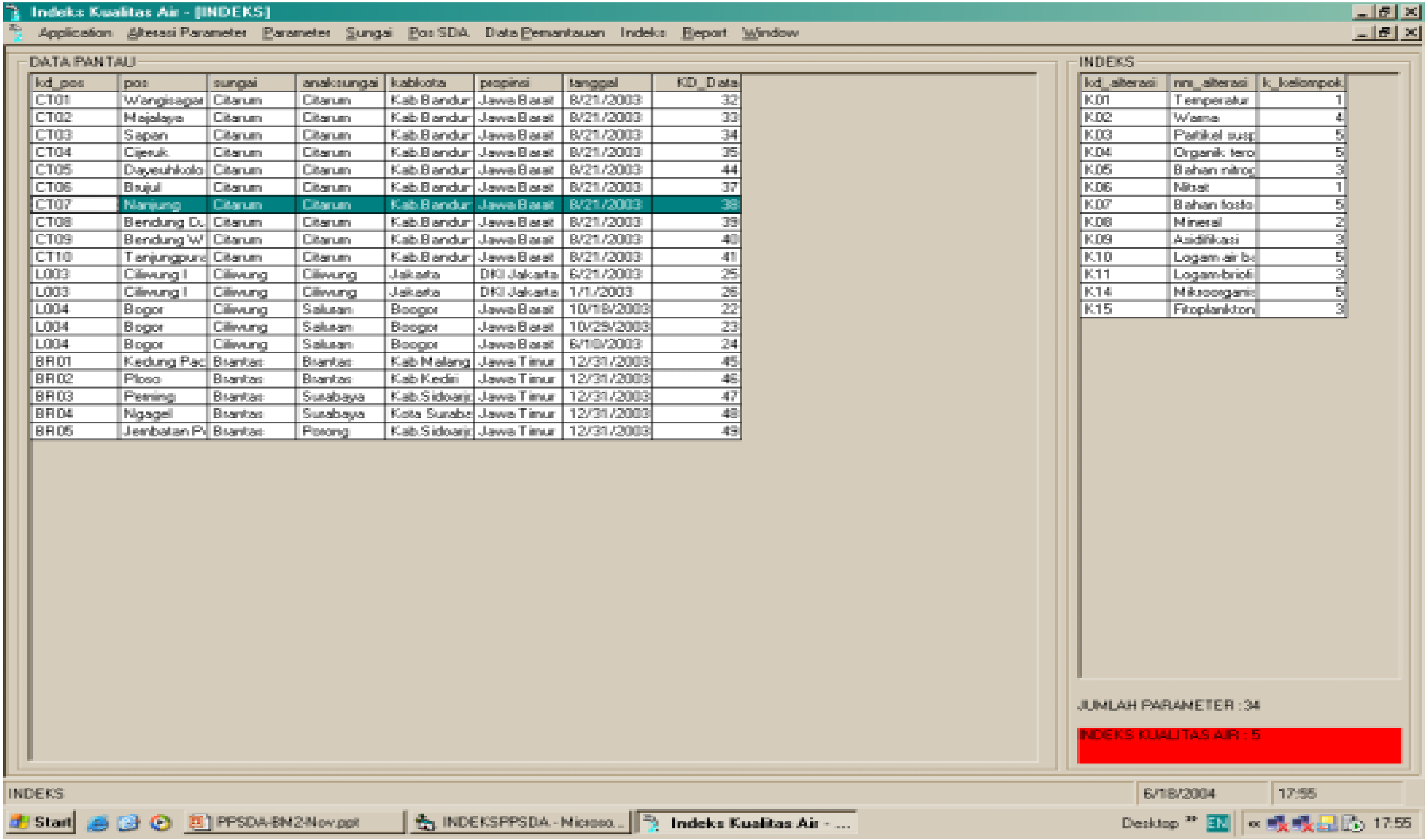
River and sampling point location



Date and monitored value of parameter



Location, index of alteration and water quality index



DATA PANTAU

kd_pos	pos	sungai	anaksungai	kabkota	propinsi	tanggal	KD_Data
CT01	Wangisagar	Citarum	Citarum	Kab Bandur	Jawa Barat	8/21/2003	32
CT02	Majalaya	Citarum	Citarum	Kab Bandur	Jawa Barat	8/21/2003	33
CT03	Sapan	Citarum	Citarum	Kab.Bandur	Jawa Barat	8/21/2003	34
CT04	Cijeruk	Citarum	Citarum	Kab.Bandur	Jawa Barat	8/21/2003	35
CT05	Dayeuhkolo	Citarum	Citarum	Kab.Bandur	Jawa Barat	8/21/2003	44
CT06	Brujul	Citarum	Citarum	Kab.Bandur	Jawa Barat	8/21/2003	37
CT07	Nanjung	Citarum	Citarum	Kab.Bandur	Jawa Barat	8/21/2003	38
CT08	Bendung D.	Citarum	Citarum	Kab.Bandur	Jawa Barat	8/21/2003	39
CT09	Bendung W	Citarum	Citarum	Kab.Bandur	Jawa Barat	8/21/2003	40
CT10	Tanjungpura	Citarum	Citarum	Kab.Bandur	Jawa Barat	8/21/2003	41
L003	Ciliwung I	Ciliwung	Ciliwung	Jakarta	DKI Jakarta	6/21/2003	25
L003	Ciliwung I	Ciliwung	Ciliwung	Jakarta	DKI Jakarta	1/1/2003	26
L004	Bogor	Ciliwung	Saluran	Boogor	Jawa Barat	10/18/2003	22
L004	Bogor	Ciliwung	Saluran	Boogor	Jawa Barat	10/29/2003	23
L004	Bogor	Ciliwung	Saluran	Boogor	Jawa Barat	6/10/2003	24
BR01	Kedung Pac	Brantas	Brantas	Kab Malang	Jawa Timur	12/31/2003	45
BR02	Ploso	Brantas	Brantas	Kab Kediri	Jawa Timur	12/31/2003	46
BR03	Pening	Brantas	Surabaya	Kab.Sidoarjo	Jawa Timur	12/31/2003	47
BR04	Ngagel	Brantas	Surabaya	Kota Surabaya	Jawa Timur	12/31/2003	48
BR05	Jembatan P	Brantas	Porong	Kab.Sidoarjo	Jawa Timur	12/31/2003	49

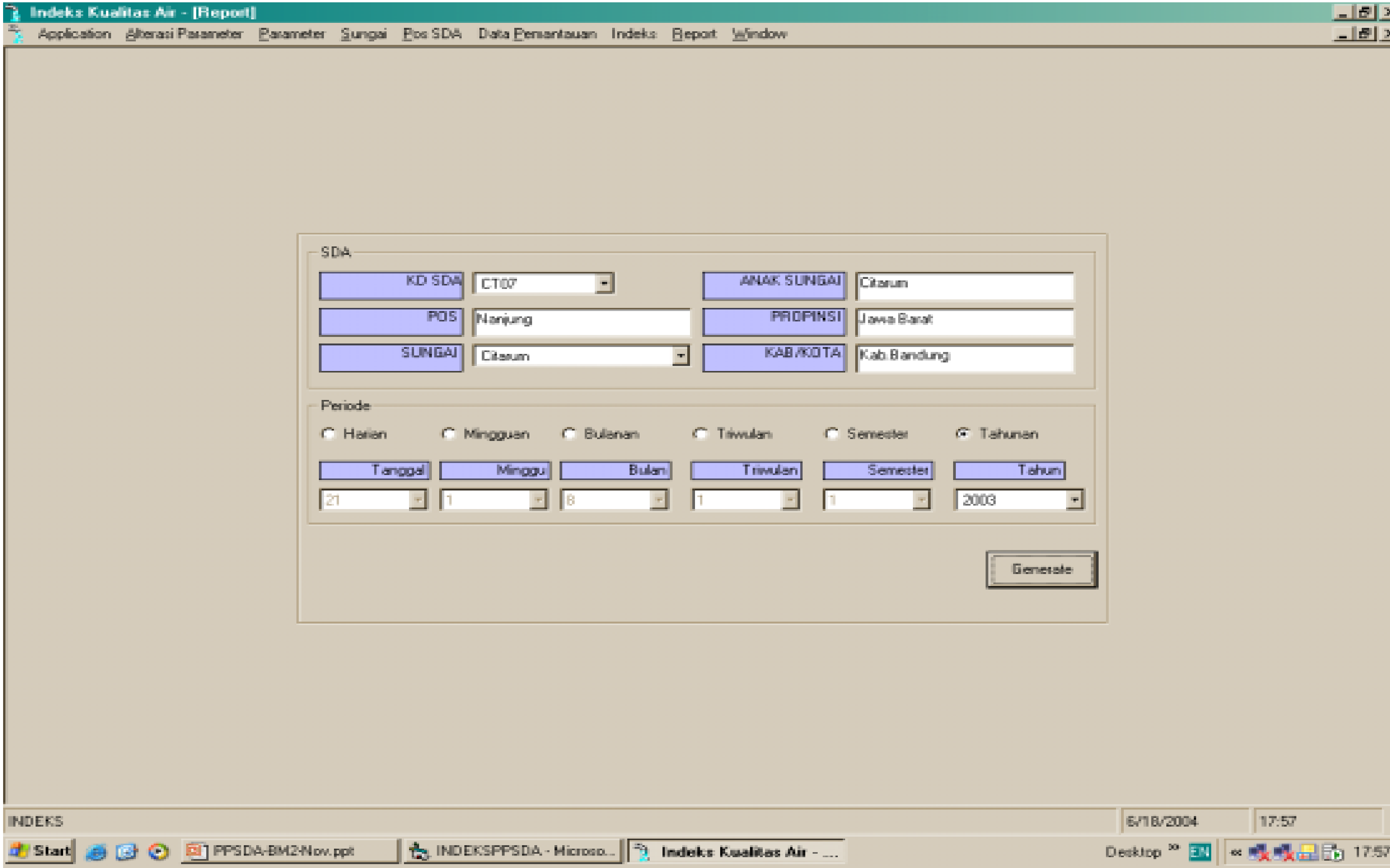
INDEKS

kd_alterasi	nm_alterasi	k_kelompok
K01	Temperatur	1
K02	Warna	4
K03	Partikel susp	5
K04	Organik tero	5
K05	Bahan nitrog	3
K06	Nitrat	1
K07	Bahan fosfo	5
K08	Mineral	2
K09	Asidifikasi	3
K10	Logam air be	5
K11	Logam-briofi	3
K14	Mikroorganis	5
K15	Fitoplankton	3

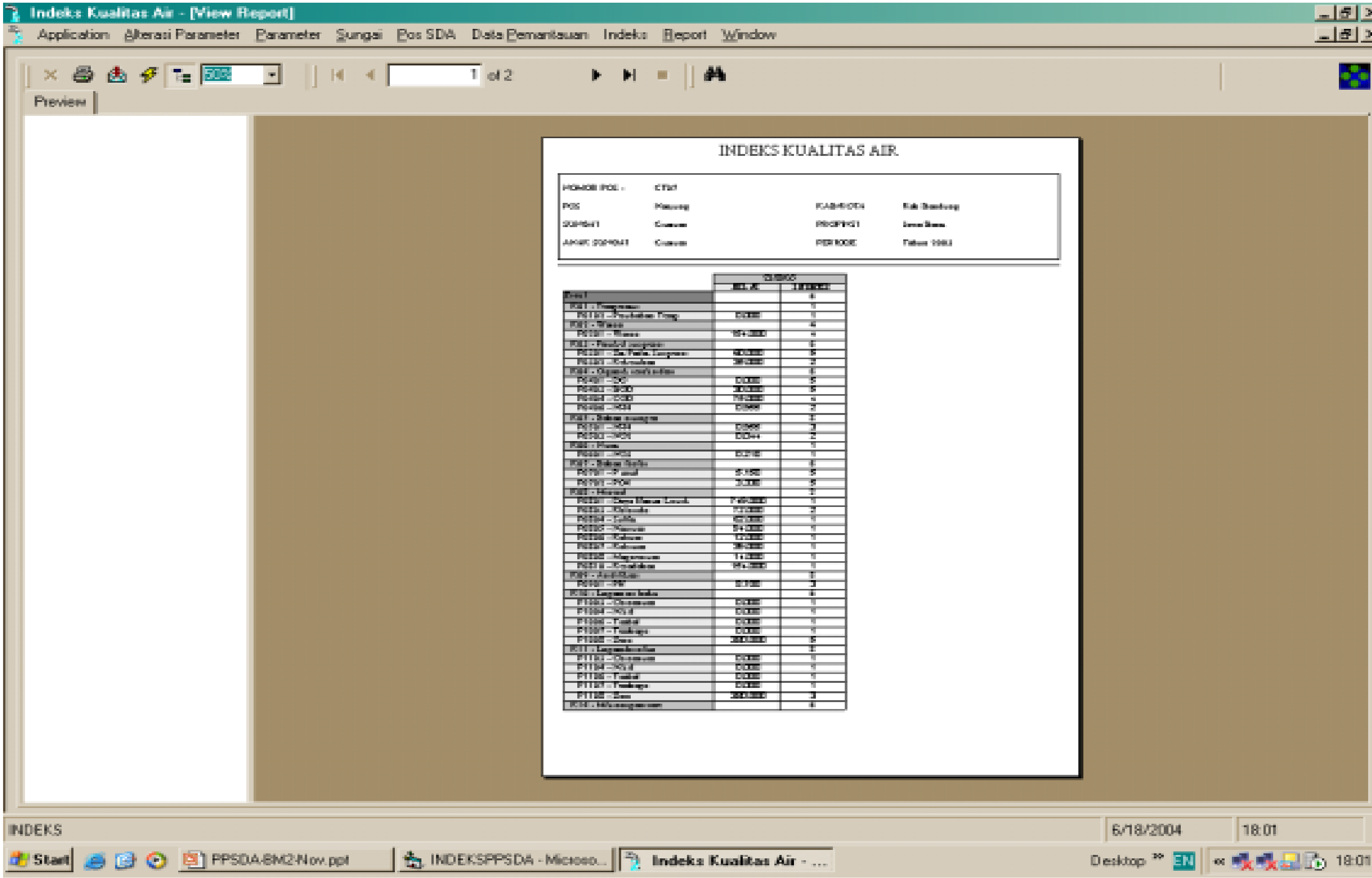
JUMLAH PARAMETER : 34

INDEKS KUALITAS AIR : 5

Location and time series data



Water quality index and publication form



Comprehensive Sediment Control in JAPAN

Ryosuke TSUNAKI

Director

Research Center for Disaster Risk Management

National Institute for Land and Infrastructure Management

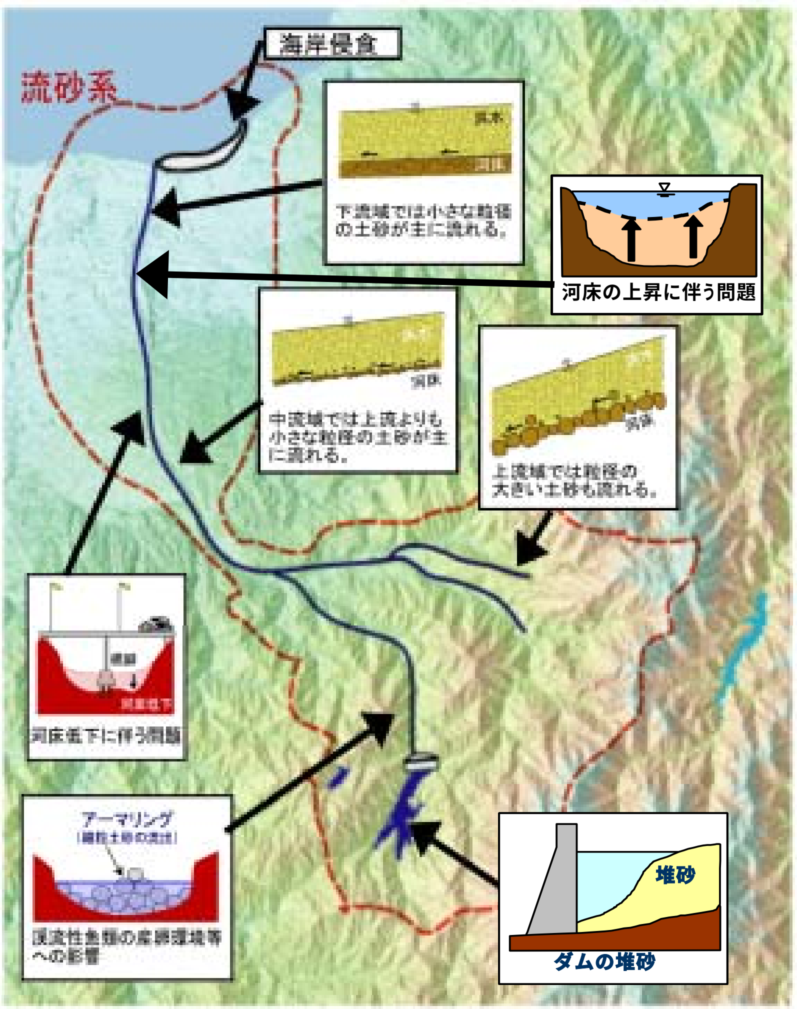
Ministry of Land, Infrastructure and Transport

Today's Topics

- Introduction
  Sediment Drainage System
  Problems related to sediment transportation
- Comprehensive sediment control
  Concept
  Flow chart for establishing plan
  Examples of measures to control sediment transportation
- Techniques for monitoring sediment transportation
- Topographical Change Estimation Model
  Techniques for monitoring sediment transportation
- Activities in Sabo section

Introduction

- Sediment Drainage System -



- Sediment moves down from mountainous area through the phenomena of landslide and erosion, and enters a river.
- Sediment in river is transported downstream with the current and pours into sea.
- In order to dissolve big problems related to sediment transportation, it is necessary to take the sediment transportation in river system and coast into consideration.

Introduction

- Managements Of Sediment Drainage System In Japan -

- Sediment drainage system is divided into four sections;
  Sabo section,
  Reservoir (Dam) section,
  River section,
  Coast section.
- Plans related to each section are established in each sections.

Introduction

- Problems Related to Sediment Transportation -

- During transporting, sediment movement changes geomorphology, which is causing problems.

Introduction

- Classification of Problems Due To Sediment Transportation -

Problems due to sediment transportation

Cases for short term

Debris flow
Landslide
Slope failure
Large amount of sediment discharge

→

- Flood & Flash flood
- Loss of reservoir storage

Cases for long term

Ordinal sediment transport
Drift sand

→

- Unbalanced structure foundation
- Loss of reservoir storage
- Overflow of tidal wave

Introduction

- Examples of Short Term Cases - Mountainous Area - -

Introduction

- Examples of Short Term Cases - Mountainous Area - -

Large amount of sediment discharge in July 1995

4 million m^3 of sediment was deposited on River Hime.
River bed was raised at maximum 13.7m.

After

Before

Introduction

- Examples of Long Term Cases - Reservoir - -

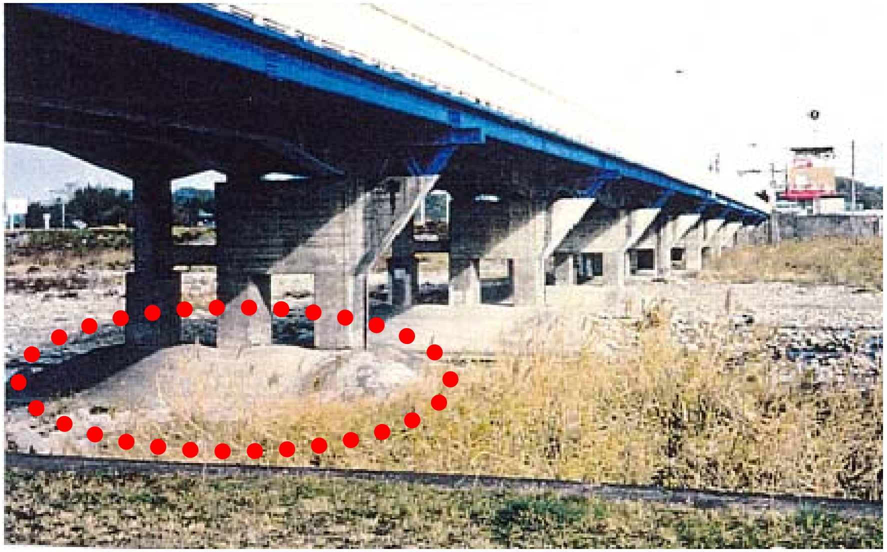
- Averaged ratio of sedimentation to storage capacity of dams in Japan is about 7%.

Asahi Shinbun on November 18, 2002

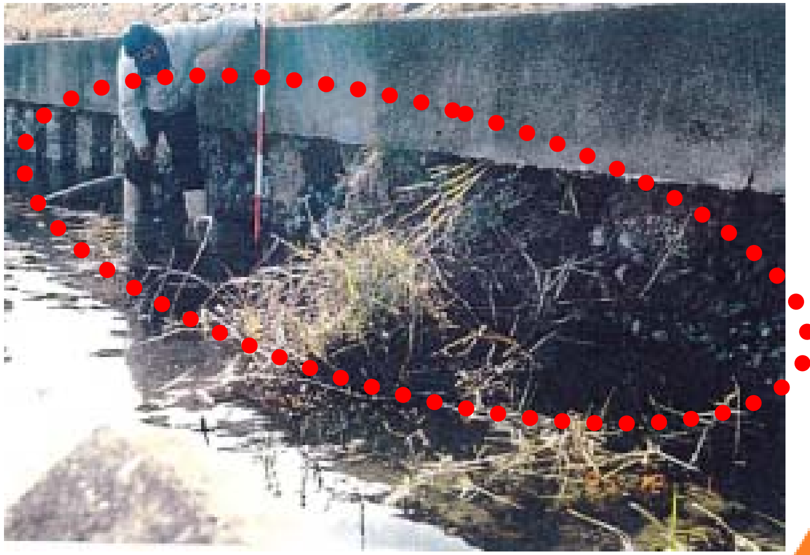
Introduction

- Examples of Long Term Cases - Degradation - -

- If river bed is degraded, structure foundation loses its stability.



Pier foundation

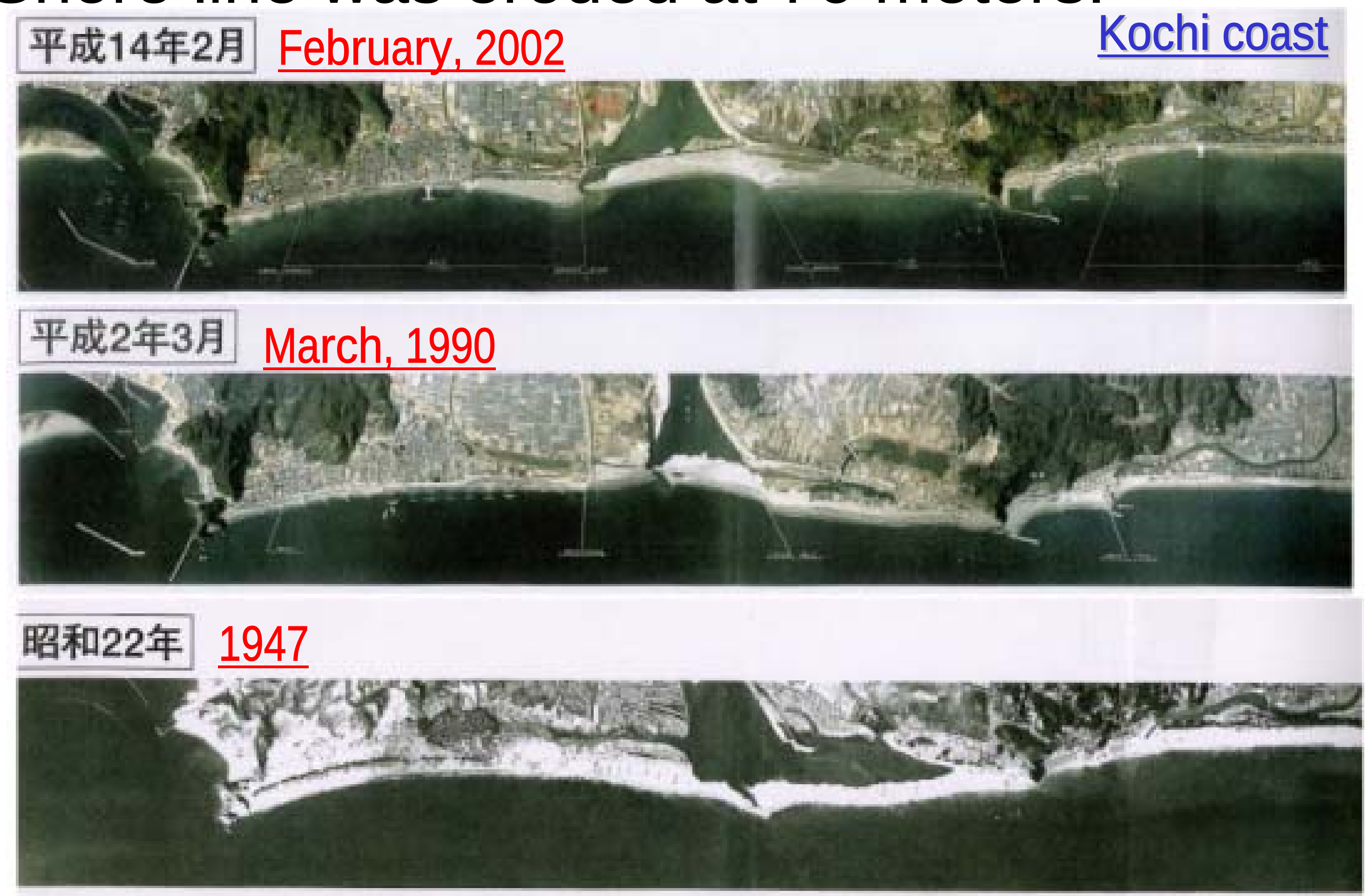


Revetment foundation

Introduction

- Examples of Long Term Cases - Coastal Erosion - -

- Shore line was eroded at 76 meters.



Introduction

- Coastal Erosion in JAPAN -

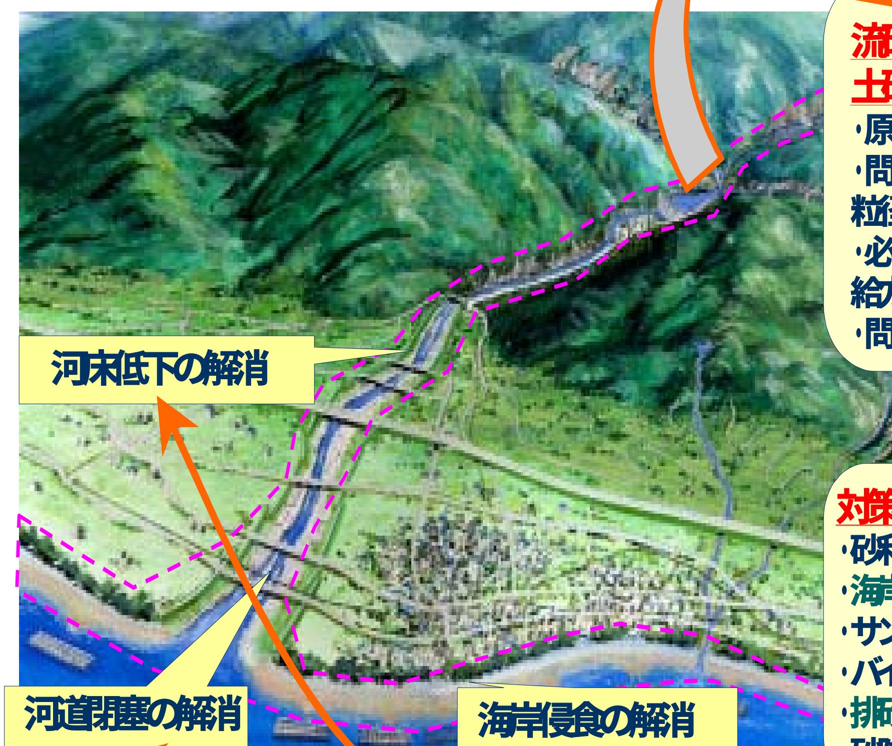
- Rate of erosion in coast was 72ha a year up to 1978, and 160ha a year after 1978.

海岸名	侵食機構					
	沿岸漂砂の連続性の阻止	遮蔽域の形成	深海への土砂損失	供給土砂量の減少	浚渫・砂利採取	地盤沈下
標津海岸	○			○	○	
日高海岸	○				○	
胆振海岸	○				○	
青森海岸	○					
下北・八戸海岸	○			○		
大曲海岸	○	○			○	
仙台湾海岸	○			○		
常盤海岸		○			○	
大洗海岸		○			○	
鹿島灘沿岸	○	○			○	
飯岡・下永井海岸	○			○		
九十九里海岸	○				○	
湘南海岸				○	○	
西湘海岸	○		○	○		
富士海岸	○		○	○		
蒲原海岸	○		○	○		
清水海岸	○		○	○		
静岡海岸				○		
駿河海岸	○		○	○		
遠州海岸	○	○		○		
赤羽根海岸	○					
伊勢湾沿岸	○			○		
御座海岸		○				
新宮川河口左岸	○			○		
西浜沿岸	○			○		
高知海岸	○			○	○	
黒島海岸		○				
宮崎海岸		○				
江津海岸	○				○	
皆生海岸	○			○		
鳥取海岸		○			○	
石川海岸				○		
下新川海岸	○		○	○		
市振海岸	○					
親不知海岸	○				○	
糸魚川海岸		○		○		
直江津海岸		○				
大潟海岸		○			○	
松ヶ崎海岸		○				
新潟海岸	○			○		○
神林海岸	○	○			○	

:直轄が関わる海岸

Comprehensive Sediment Control

- Concept -



流砂系一貫とした
土砂管理手法の構築

・原因の推定
・問題解決のために必要な粒径別の土砂量の決定。
・必要な粒径階の土砂の供給方法の決定
・問題解決の手法の提示

Establishment of Sediment Control Plan in River and Coastal Area

- Suspect the cause of problems
- Establish of plan

対策の提案

・砂利採取の禁止
・海岸の養浜
・サンドリサイクル
・バイパストンネル
・排砂ゲートの設置
・砂防えん堤のオープン化 等

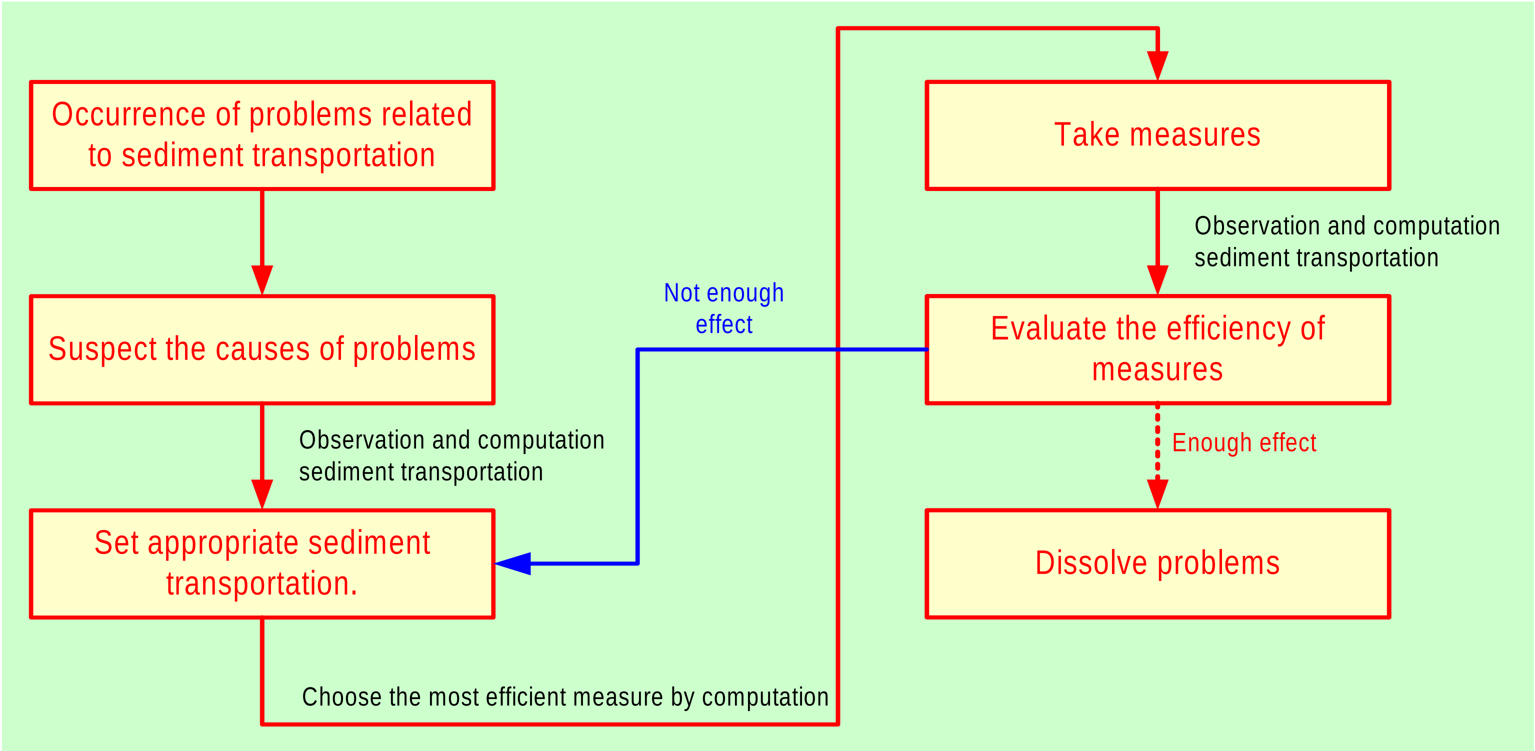
Measures to Dissolve Problems

- Restriction of sand mining
- Supplication of sediment to coast
- Install gate for discharging sedimentation
- Open type dam

Comprehensive Sediment Control

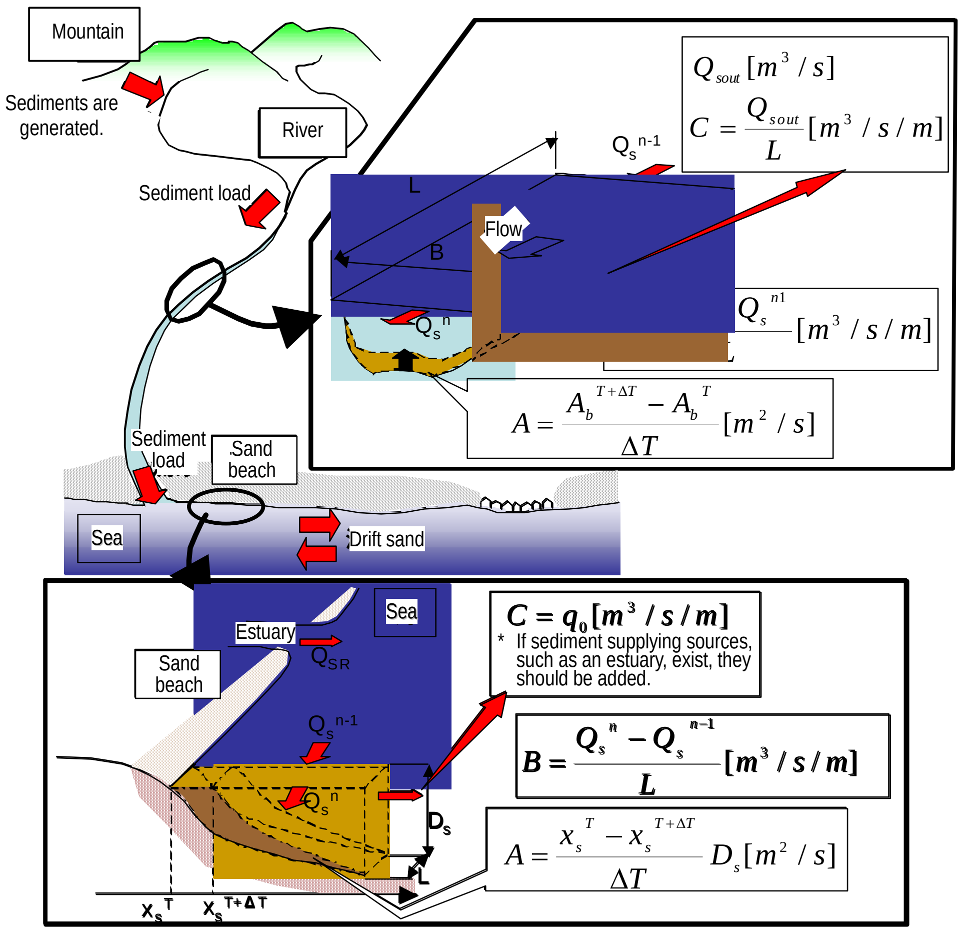
- Flow Chart of Establishing Plan -

- "Comprehensive sediment control" should be taken by Sabo, dam, river and coastal sections.
- In order to establish a plan for comprehensive sediment control, it is necessary to clarify sediment transportation in sediment drainage system.



Comprehensive Sediment Control

- How Do Problems Occur? -



Relationship Between Sediment Transport and Topographical Change

$$A + B = C$$

A: Topographical changes with time

B: Spatial changes in the movement of sediments at a certain point in time

C: Temporary changes in sediments entering into or moving out of the river or sea

If B is unbalanced, A - topography such as elevation of river bed - will be changed. And the change causes some problems.

Comprehensive Sediment Control

- How to Set Appropriate Sediment Transportation -

- "Appropriate Sediment Transportation" is the pattern of sediment movement that will NOT cause serious problems.
- Appropriate sediment transportation may be identified by developing a few patterns for correction of the topography to evaluate the sediment volume or artificial structures, predicting the future vision for each pattern and improving the pattern of sediment transportation.

Comprehensive Sediment Control

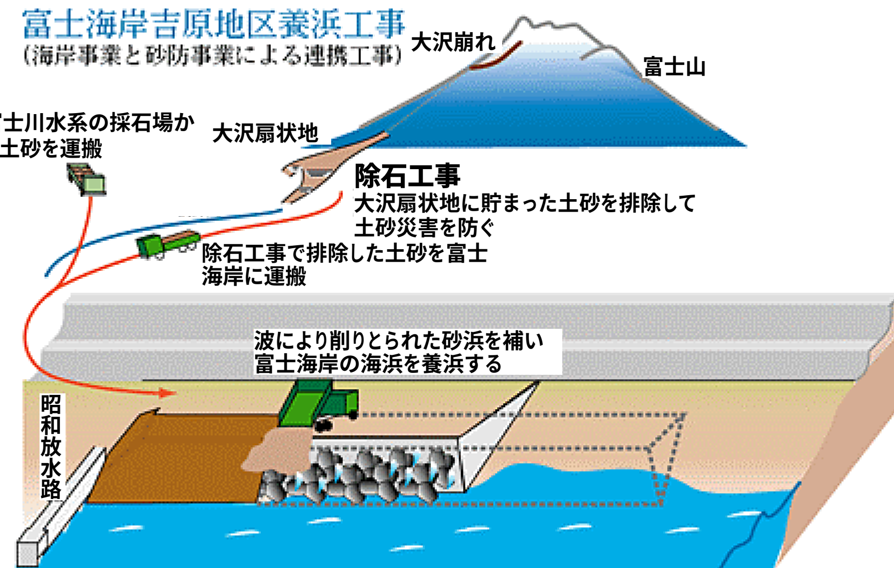
- Examples of Measures in Sabo Section -

←Open type dam

In order to capture harmful sediment and not to capture not harmful sediment, open type dams are installed.

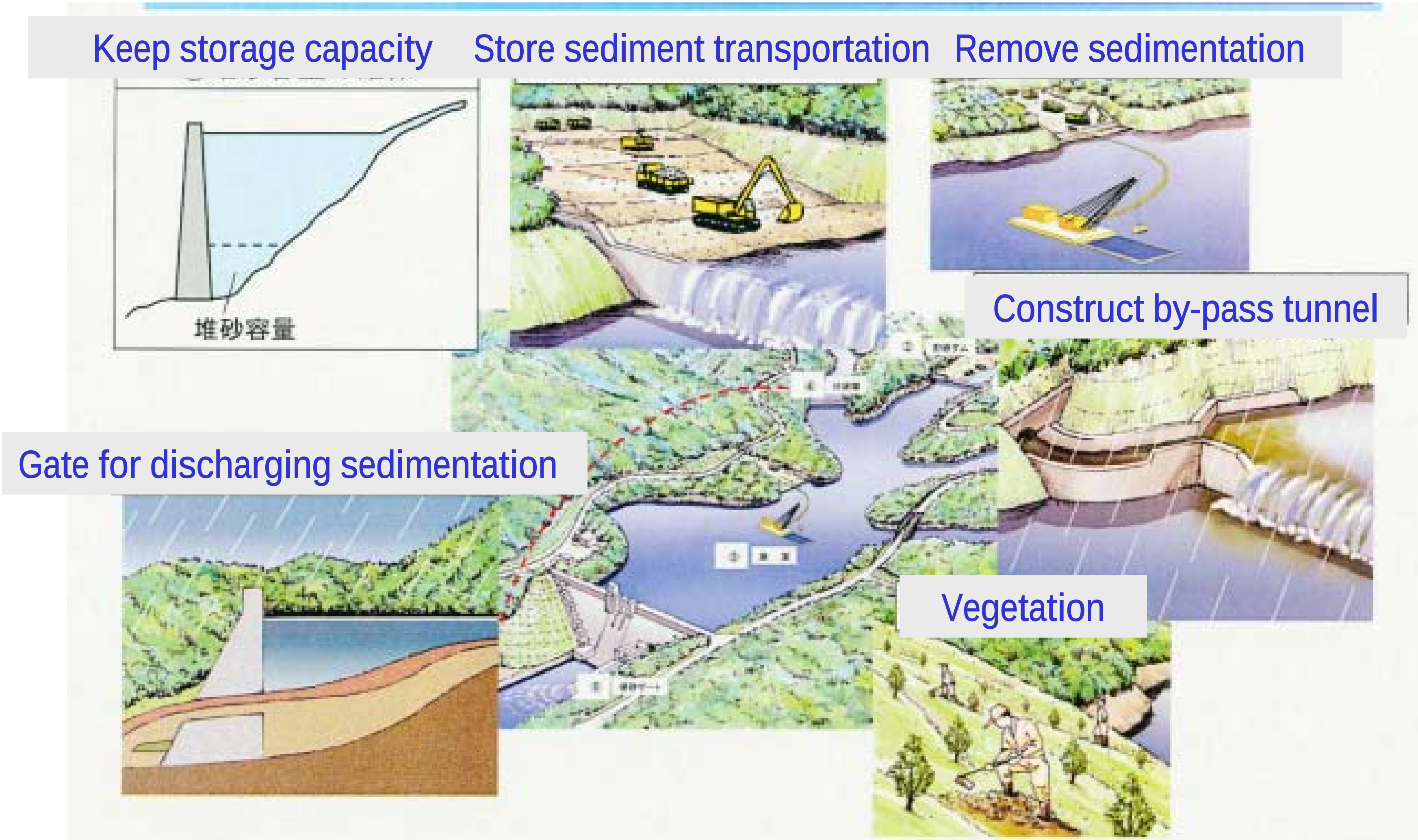
Re-use sediment deposited in SABO facilities→

Sediment deposited in Sabo facilities is supplied to coastal area where severe erosion occurrs.



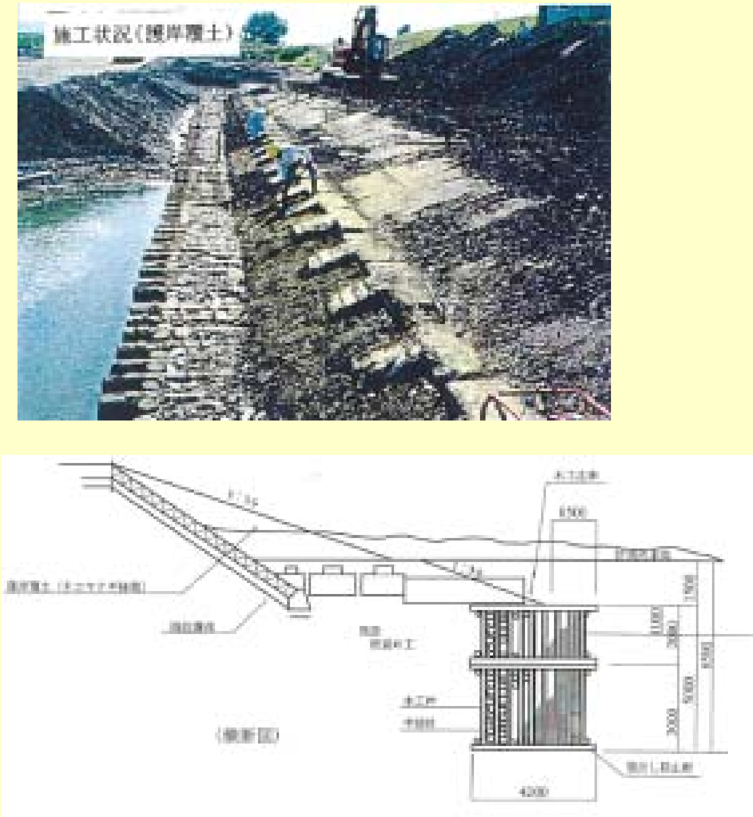
Comprehensive Sediment Control

- Examples of Measures in Reservoir Section -



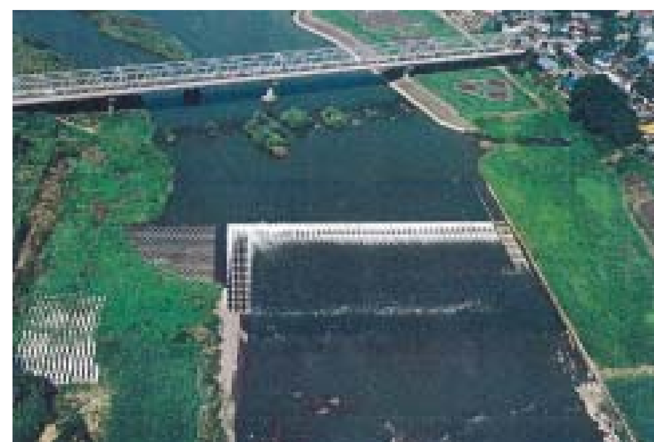
Comprehensive Sediment Control

- Examples of Measures in River Section -



Protection works

Dredge



Construction of structures

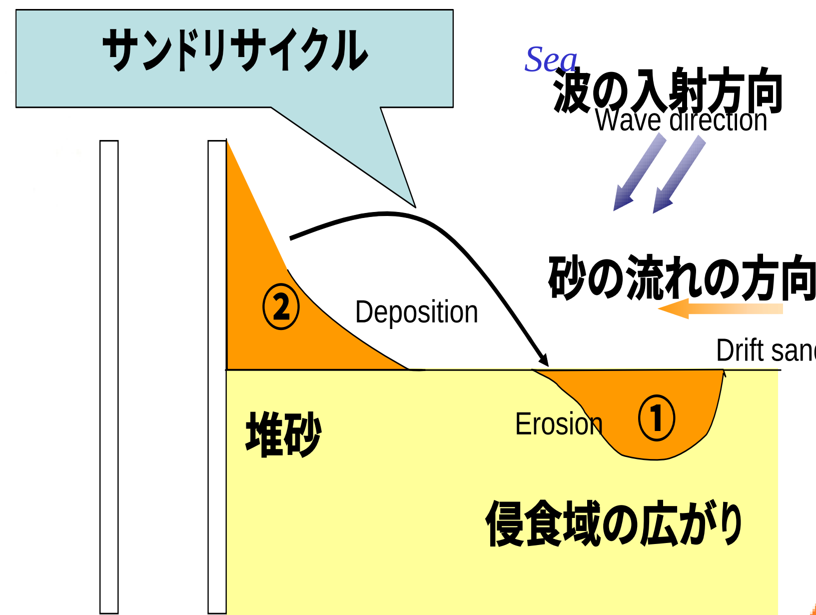
Comprehensive Sediment Control

- Examples of Measure in Coastal Section -

←Sand bypass

Sand recycle→

Sediment deposited behind embankment is artificially transported to erosion area.



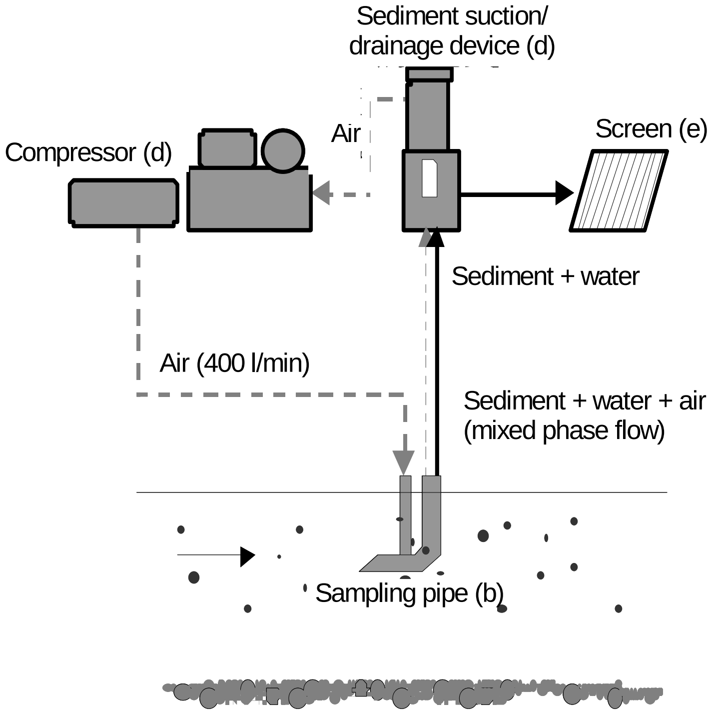
Techniques for Monitoring Sediment Transportation

- Development and Improvement (1) -

Observation of suspended load using the self-sucking pump

Techniques for Monitoring Sediment Transportation

- Development and Improvement (2) -



Hinuma flood observation facility (River Laboratory, National Institute of Land and Infrastructure Management)

Techniques for Monitoring Sediment Transportation

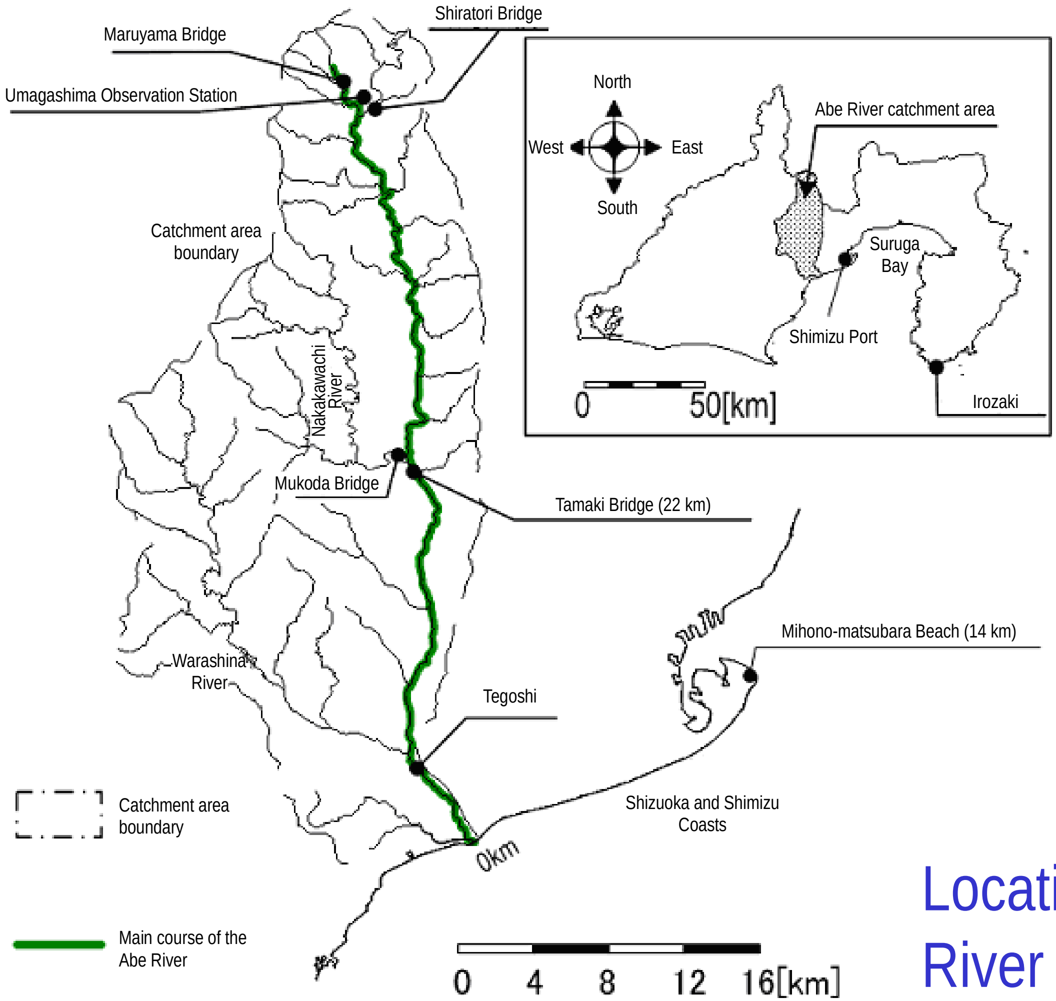
- Development and Improvement (3) -

Peeled sample

Geoslicer (Coast Laboratory, National Institute of Land and Infrastructure Management)

Techniques for Monitoring Sediment Transportation

- An Example of Observation in Abe River (1) -

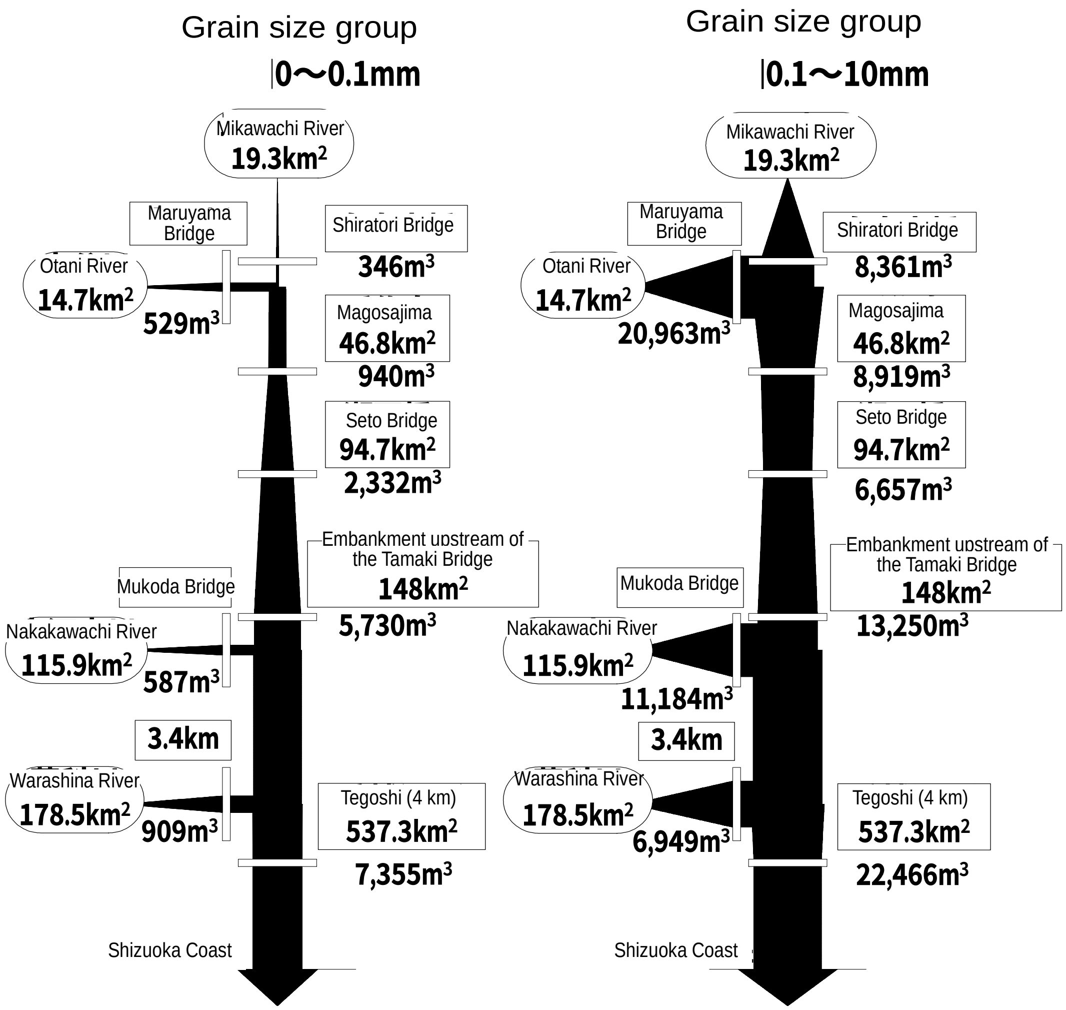


- Sediment drainage system in Abe River and Shizuoka-Shimizu coast has a severe problem due to coastal erosion.
- Investigation of the bottom sediments around the estuary of the Abe River revealed that the dominant grain size is in the range of 0.1 mm to 10 mm.

Location map of the Abe River catchment area

Techniques for Monitoring Sediment Transportation

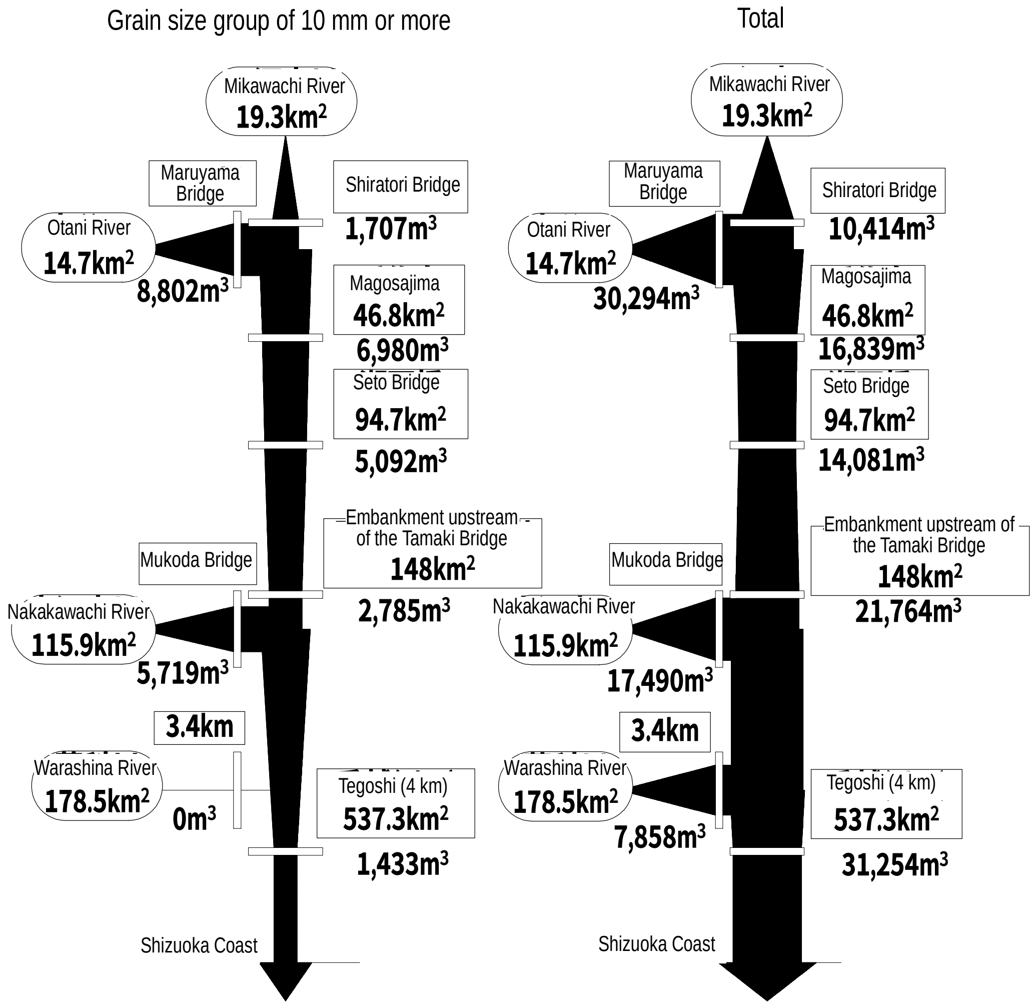
- An Example of Observation in Abe River (2) -



An example of sediment transportation map by the grain size (October 1 to 3, 2002)

Techniques for Monitoring Sediment Transportation

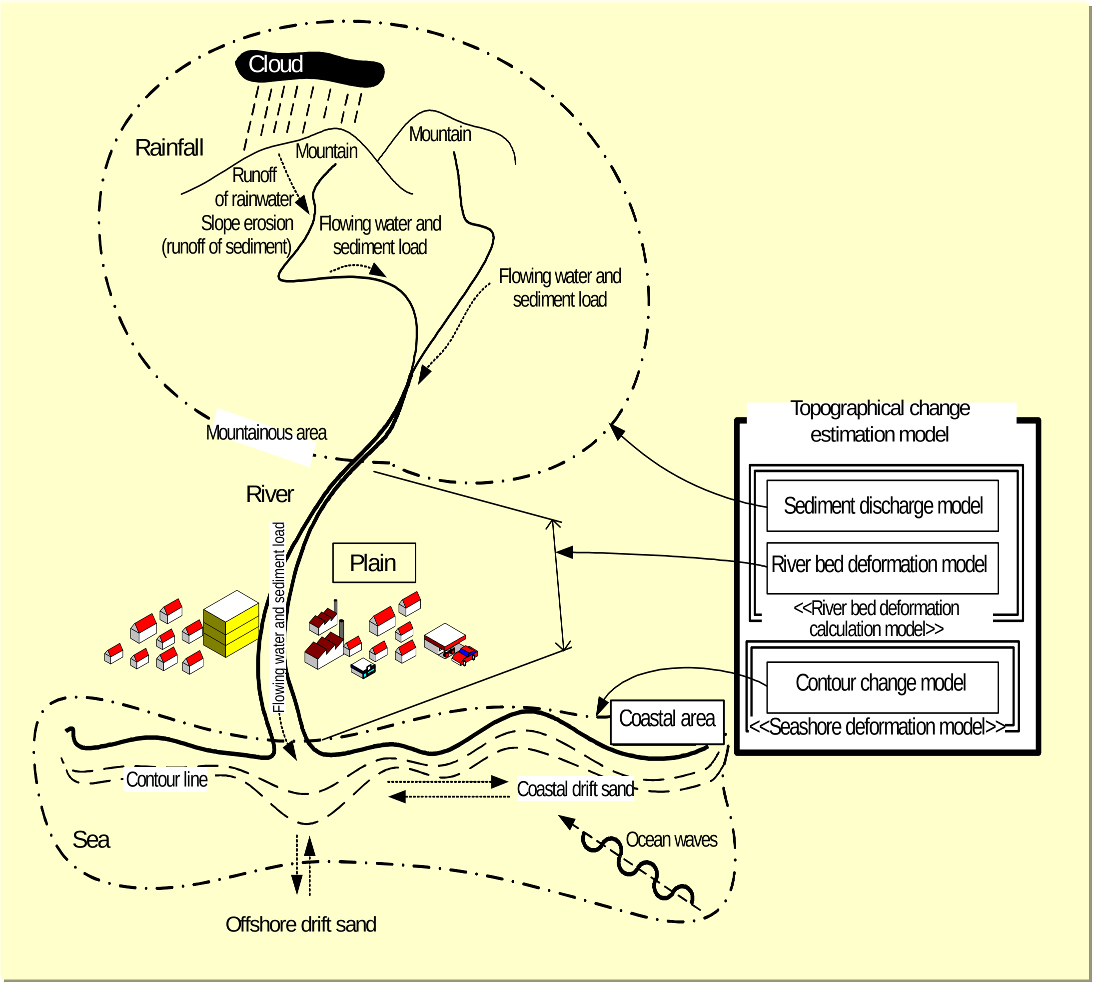
- An Example of Observation in Abe River (3) -



- Sediment transportation of grain size from 0.1 mm to 10 mm, which is main size of material in Shizuoka-Shimizu coast, occupies about 72% of the total of the sediment load at the Tegoshi Observatory (about 31,000 m^3).

Topographical Change Estimation Model

- Structure -



Structure of a topographical change estimation model

- The model consists of two parts; riverbed deformation calculation model and seashore deformation model.
- Riverbed deformation model consists of two parts; sediment discharge model and riverbed deformation model.

Topographical Change Estimation Model

- *Riverbed Deformation Model (1)* -

- Sediment discharge model is applied to mountainous area - Sabo section etc.

Slope parts

Surface flow

Equation of continuity $\frac{\partial h}{\partial t}+\frac{\partial q}{\partial x}=(r-f_1)\cos\theta_S$

Equation of motion $q=\alpha\cdot h^m$

Sub-surface flow

Equation of continuity $\lambda_{Bm}\frac{\partial h_{Bm}}{\partial t}+\frac{\partial q_{Bm}}{\partial x}=(f_m-f_{m+1})\cos\theta_S$

Equation of motion $q_{Bm}=k_m h_{Bm} S_m$

Stream parts

Equation of continuity

Water $\frac{\partial h}{\partial t}+\frac{1}{B}\frac{\partial(uh)}{\partial x}=\frac{q}{B}+r\cos\theta_R$

Sediment $\frac{\partial(C_*\cdot z_B+C\cdot h)}{\partial t}+\frac{\partial(Cu_S h)}{\partial x}=0$

Equation of motion $u=\frac{1}{n}\cdot(\tan\theta_R)^{1/2}\cdot h^{2/3}$

Bed load, suspended load and wash load are taken into consideration.

Topographical Change Estimation Model

- Riverbed Deformation Model (2) -

- Riverbed deformation model is applied in the downstream of sediment discharge model.

River parts

Equation of continuity

Water $$\frac{\partial(Buh)}{\partial x}=0$$

Sediment $$\frac{\partial(C_* \cdot z_B + C \cdot h)}{\partial t}+\frac{\partial(Cu_S h)}{\partial x}=0$$

Equation of motion $$\frac{\partial}{\partial x}\left(\frac{u^2}{2g}+h\cos\theta+z\right)+\frac{u_*^{\,2}}{gR}=0$$

Bed load, suspended load and wash load are taken into consideration.

Topographical Change Estimation Model

- Seashore Deformation Model -

- Seashore deformation model is applied to coast.

Coast parts

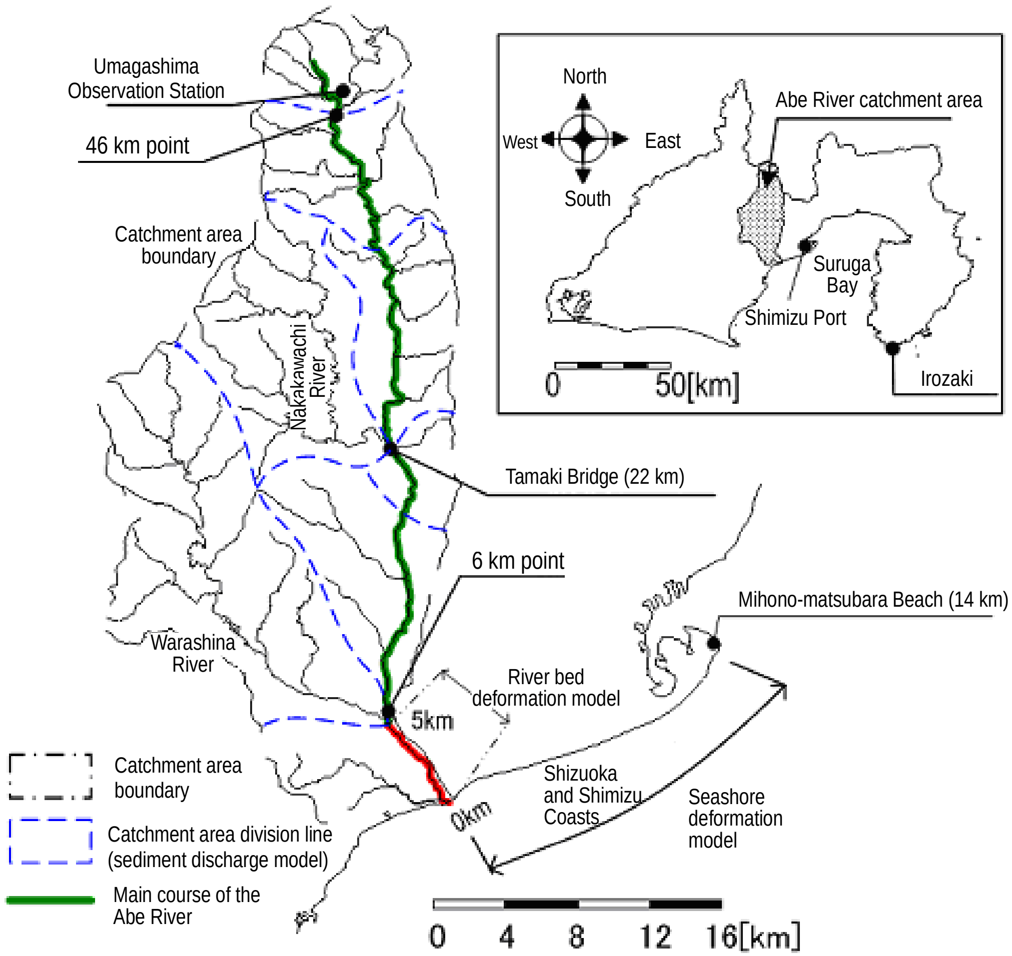
Equation of continuity

Sediment $$\frac{\partial x_k}{\partial t}+\frac{1}{D_k}\left(\frac{\partial Q_{Ck}}{\partial y}-q_{ok}\right)=0 \quad (k=1,2,\cdots,n)$$

Equation of coastal drift

$$Q_{Ck}=\frac{1}{\gamma_S}\left(EC_g\right)_b\cdot\left(K_1\cdot\sin\alpha_{bs}\cdot\cos\alpha_{bs}-\frac{K_2}{\tan\beta}\cdot\cos\alpha_{bs}\cdot\frac{\partial H_b}{\partial y}\right)$$

Verification of Topographical Change Estimation Model - *Application Scope* -



Application scope of topographical change estimation model
- Abe River sediment drainage basin-

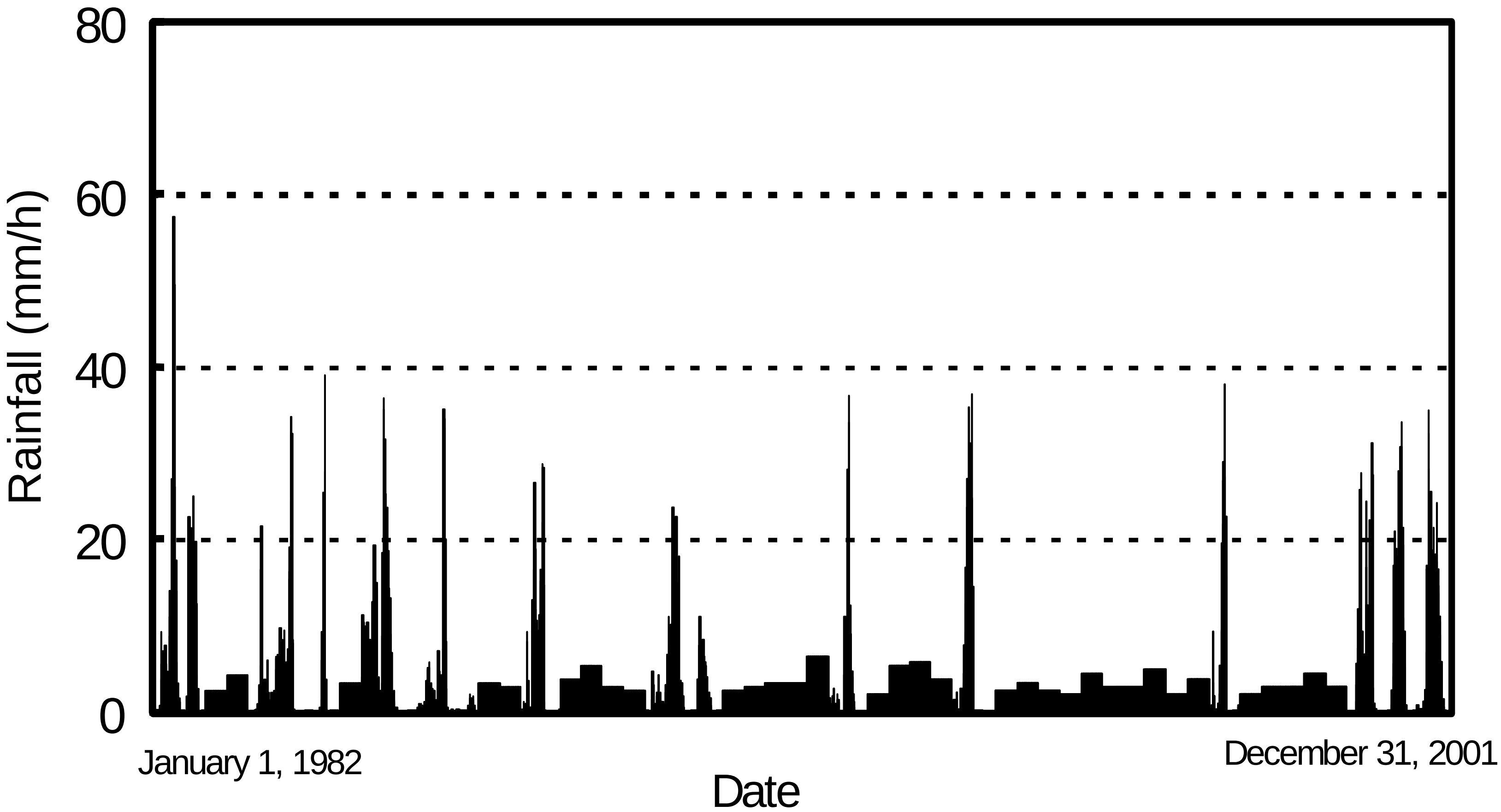
- The model is applied to Abe River.
- Sediment discharge model is applied in the upstream basin from Tamahata bridge, which is the reference point of Sabo plan, and in the Warashina river basin.
- Riverbed deformation model is applied from 0km to 22km, downstream of Tamahata Bridge.
- Seashore deformation model is applied to Shizuoka-Shimizu coast.

Verification of Topographical Change Estimation Model - *Calculation Conditions (1)* -

Calculation period				January 1, 1982 - December 31, 2001
River bed deformation calculation model	Sediment discharge model	Slope part	Initial infiltration capacity	$f_1 = 1.39\times10^{-4}[\mathrm{m/s}]$, $f_2 = 1.39\times10^{-6}[\mathrm{m/s}]$, $f_3 = 1.39\times10^{-7}[\mathrm{m/s}]$ (Except for Warashina River catchment area, for which : $f_1 = 2.78\times10^{-5}[\mathrm{m/s}]$, $f_2 = 2.78\times10^{-7}[\mathrm{m/s}]$, $f_3 = 2.78\times10^{-8}[\mathrm{m/s}]$)
			Final infiltration capacity	$f_1 = 6.94\times10^{-5}[\mathrm{m/s}]$, $f_2 = 6.94\times10^{-7}[\mathrm{m/s}]$, $f_3 = 6.94\times10^{-8}[\mathrm{m/s}]$ (Except for Warashina River catchment area, for which $f_1 = 1.39\times10^{-5}[\mathrm{m/s}]$, $f_2 = 1.39\times10^{-7}[\mathrm{m/s}]$, $f_3 = 1.39\times10^{-8}[\mathrm{m/s}]$)
			Infiltration capacity reduction factor	$2.78\times10^{-9}[1/\mathrm{s}]$
			Equivalent roughness factor	Mountains: $N = 2.00[\mathrm{s/m^{1/3}}]$ Barren land: $N = 1.00[\mathrm{s/m^{1/3}}]$
			Layer thickness	First layer: 0.08 [m] Second layer: 1.00 [m]
			Coefficient of permeation	$k_1 = 3.00\times10^{-3}[\mathrm{m/s}], k_2 = 3.00\times10^{-4}[\mathrm{m/s}]$ (Except for Warashina River catchment area, for which $k_1 = 1.00\times10^{-3}[\mathrm{m/s}], k_2 = 1.00\times10^{-4}[\mathrm{m/s}]$)
	River bed deformation model	Stream part	Roughness factor	Main course of the Abe River: $n = 3.50\times10^{-2}[\mathrm{s/m^{1/3}}]$(0k □ 22k), $5.00\times10^{-2}[\mathrm{s/m^{1/3}}]$(22k □ 51k) River courses other than the main course of the Abe River: $n = 1.00\times10^{-1}[\mathrm{s/m^{1/3}}]$
			Porosity of sediment deposited in the river course	$\lambda = 0.40$
			Sand density	$\sigma = 2.65\times10^{3}[\mathrm{kg/m^3}]$
			Water density	$\rho = 1.00\times10^{3}[\mathrm{kg/m^3}]$
			Dynamic viscosity coefficient	$\nu = 1.31\times10^{-6}[\mathrm{m^2/s}]$
Seashore deformation model	Contour line change model	Coefficient of amount of drift sand		$K_1 = 0.05, K_2 = 0.00$
		Boundary conditions of surface wave calculation	Water level (tide level)	**T.P.+0.26[m]** (Average tide level at Shimizu Port)
			Wave height	**1.47[m]** (Average at Irozaki Observation Station)
			Cycle	**6.90[s]** (Average at Irozaki Observation Station)

Calculation conditions

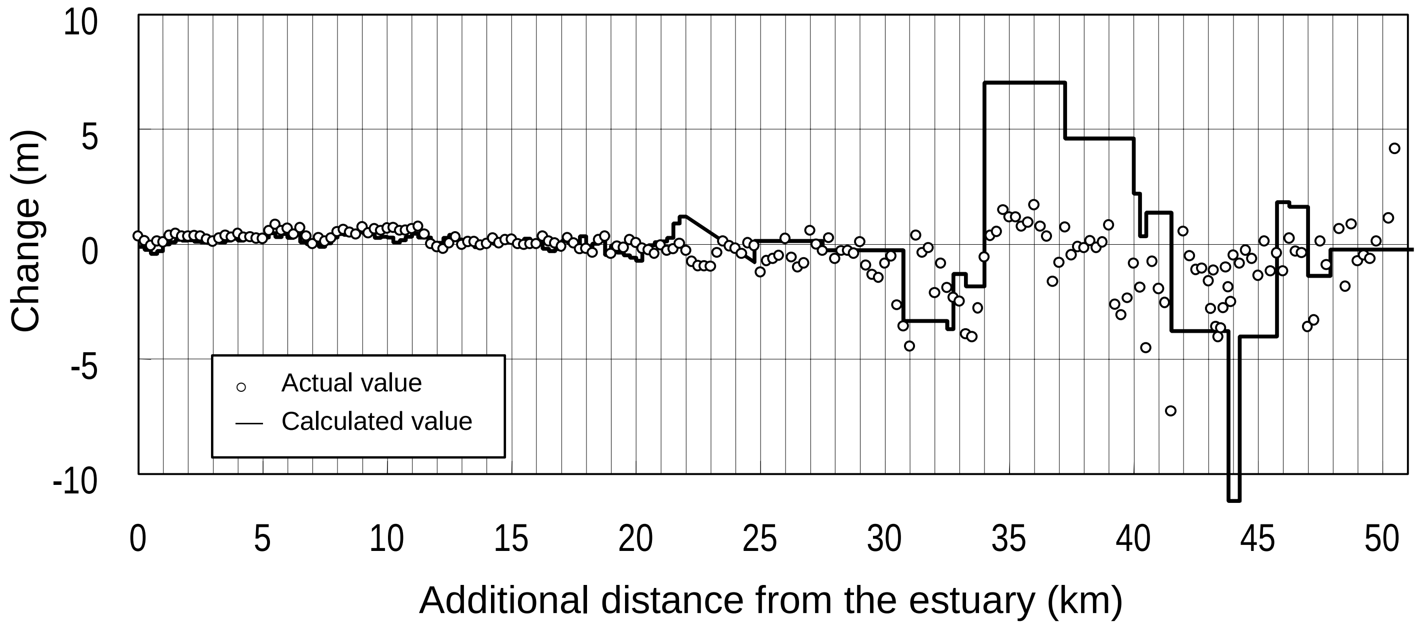
Verification of Topographical Change Estimation Model - *Calculation Conditions (2)* -



Hyetograph (Umegashima Observation Station)

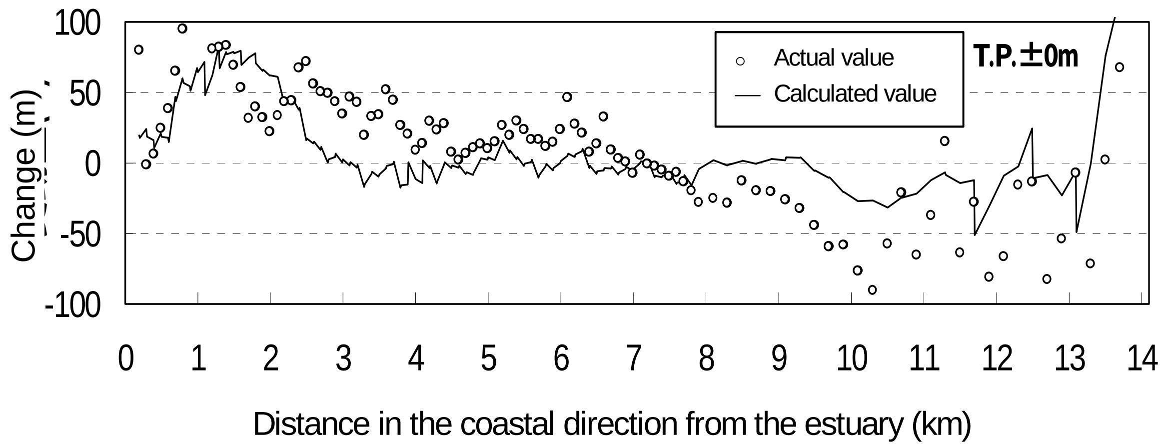
Verification of Topographical Change Estimation Model - *Calculation Results (1)* -

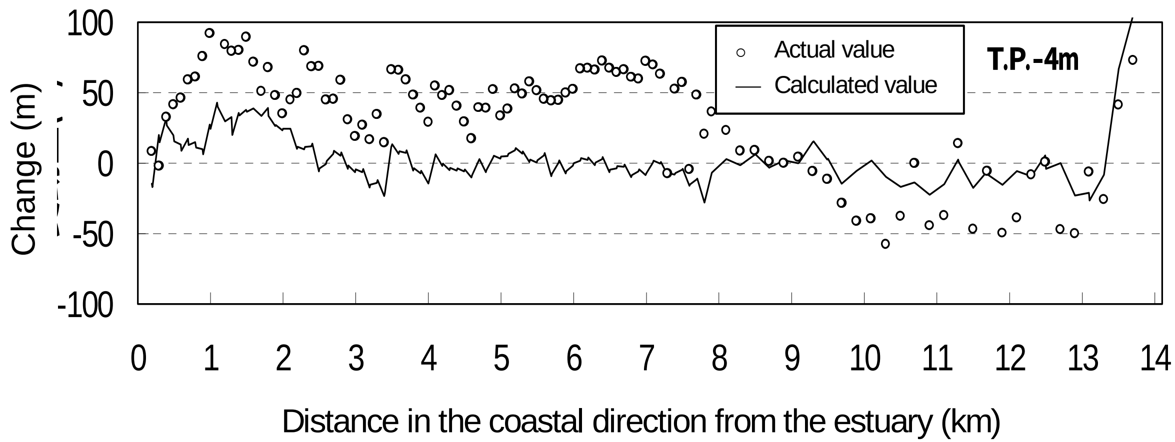
- Calculation values turned out 2 to 4 m lower for the section from 41.5 km to 44.3 km and 4 to 6 m higher for the section from 34.0 to 41.5 km than the measured values.
- There were many differences between them for the section particularly from 30 km to 47 km.



Comparison of the changes in the river bed level

Verification of Topographical Change Estimation Model - *Calculation Results (3)* -

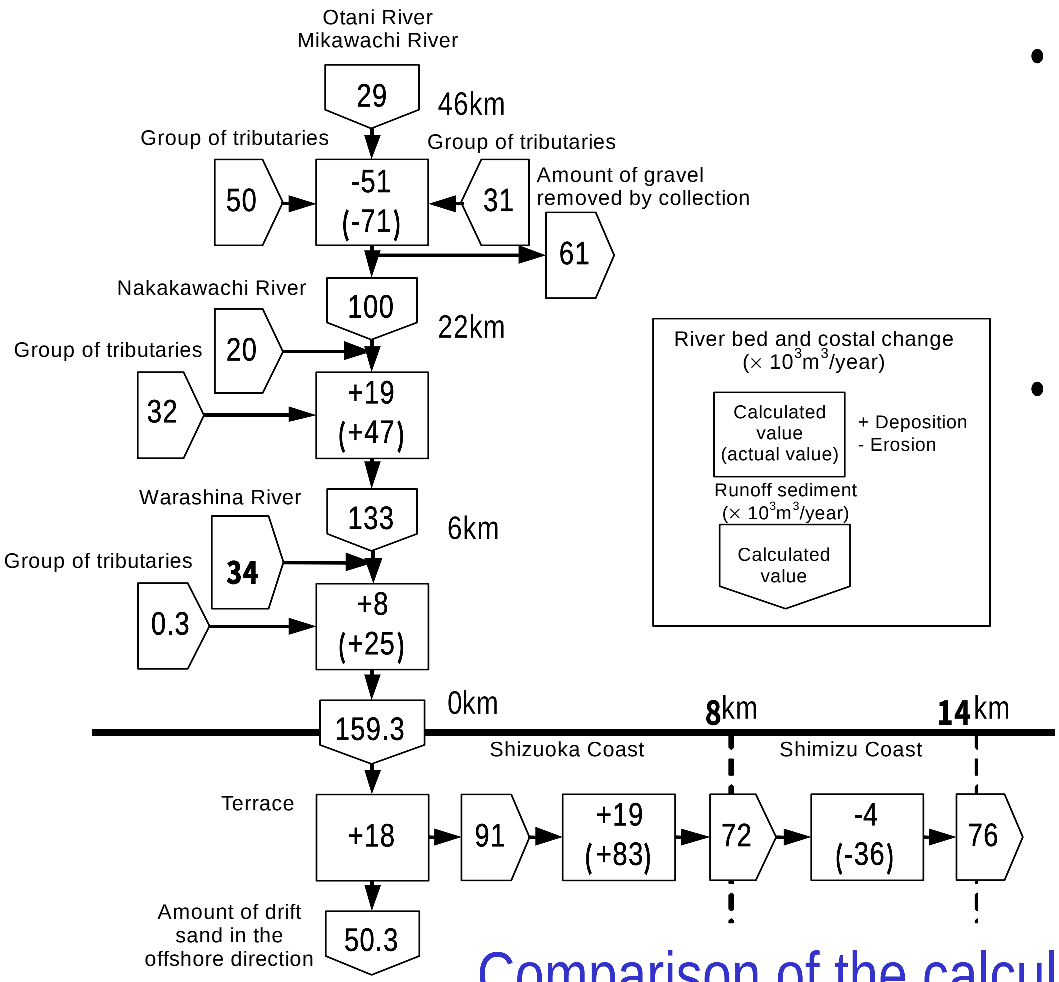




- Calculated values and observed values match well each other for ±0 to -2 m at T.P.
- As the depth becomes greater than that, the calculations are up to about 70 m smaller than the measurements in the section of 0 to 9 km, but larger in the section of 9 to 14 km.

Changes in contour line (T.P. sample of ± 0 m and 4 m)

Verification of Topographical Change Estimation Model - *Calculation Results (4)* -



- Deposit is about 45✕10^3 m^3/year smaller in the section of 0 to 22 km, and erosion is about 21✕10^3 m^3/year smaller in the section upstream of 22 km point.
- For the Shizuoka Coast and the Shimizu Coast, the calculated erosion is about 64✕10^3 m^3/year smaller and 32 64✕10^3 m^3/year smaller, respectively, than the measurements.

Comparison of the calculations and the measurements for the sediment balance

Activities in Sabo Section

- Development of Observation Equipment (1) -

- For suspended load, a catching system using a self-suction pump capable of measuring at a velocity of less than 5 m/s was developed.
- For bed load, a wire net sediment catcher was developed as movable observation equipment

Suspended load being measured by the self-suction pump

Observation of the amount of sediment discharge with the wire net sediment load catcher

Activities in Sabo Section

- Development of Observation Equipment (2) -

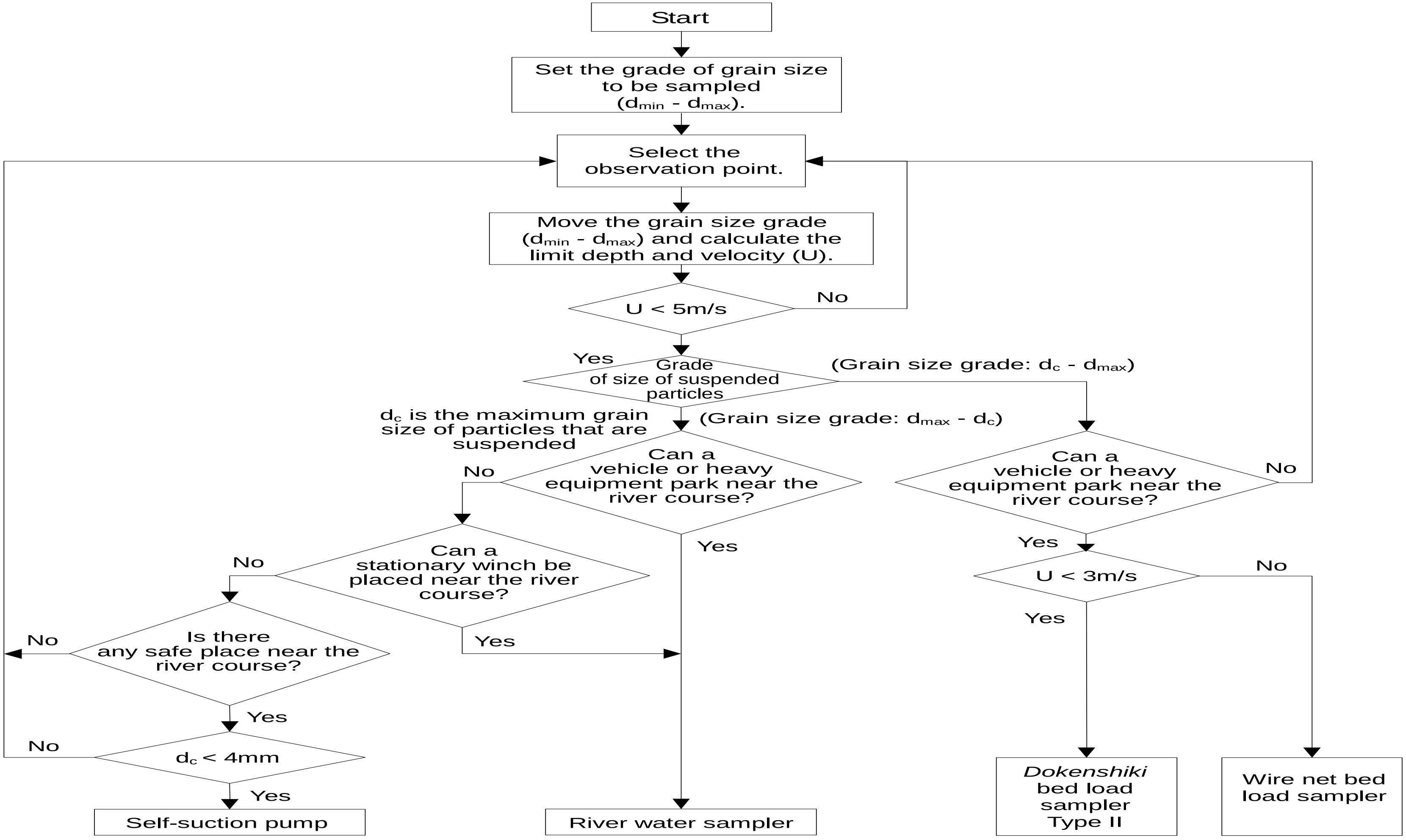
- Many types of observation equipments are being developed.
- It is necessary to select appropriate equipments among them from hydraulic and topographical conditions.

Type	Name	Points to note about observation equipment
Suspended load observation equipment	River water sampler	Usable if the environment or situation allows use of a wire during observation (to be specific, if a vehicle or heavy equipment can be parked or a stationary winch can be placed at the observation point)
	Self-suction pump	Inexpensive, but since it requires constant synchronization of the pump suction velocity and the flow velocity, the number of observation points where this equipment is applicable is limited. As use of this system requires manual labor, suitable observation points may be the embankment, where men can safely work near the water.
	Turbidity meter	It allows continuous observation of the amount of sediment discharge, but observation of the grain size is difficult.
Bed load observation equipment	*Dokenshiki* Type II bed load sampler	It can sample particles of a large range of grain size and at a high precision if the velocity is less than 3.0 m/s.
	Wire net bed load sampler	It can sample water even if the velocity is 3.0 m/s or more, but since sampling of sediments of grain size smaller than the net of the sampler is difficult, the target grain size is limited to the size of particles that can be sampled.

Points to remember for use of movable observation equipment

Activities in Sabo Section

- *Development of Observation Equipment (3)* -

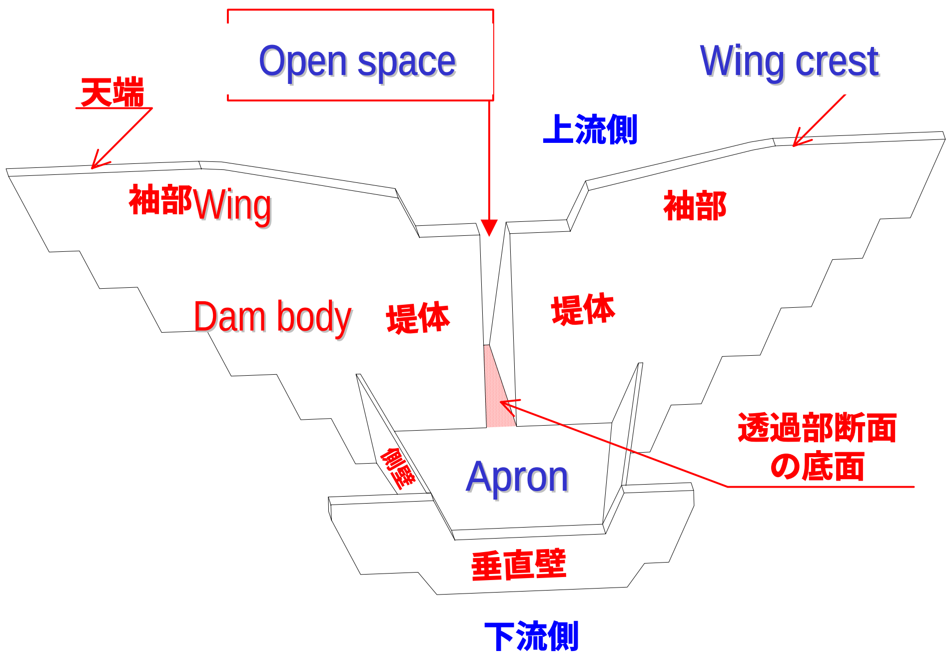


Flow chart for selection of movable observation equipment (draft)

Activities in Sabo Section

- Sediment Control by Check Dams (1) -

- Permeable dams are expected to catch debris flow or sediment load (bed loads or suspended load) during large flood.
- Permeable dams let the water pass downstream through the permeable section without catching sediment load during small flood or at ordinary situations.



Open type dam = Permeable type dam

(a)透過型砂防えん堤

Example of concrete slit dam

Activities in Sabo Section

- Sediment Control by Check Dams (2) -

- Permeable dams should be selected from its characteristics.

Expected effects

- Catches debris flow during a flood
- Catches no bed load in the normal condition

- Catches bed loads and suspended load during a flood
- Catches no bed load in the normal condition

Classification

Closed type
(Permeable sediment control dam to capture debris flow)

Water level raising type
(Permeable sediment control dam to adjust sediments)

Conditions satisfied by the permeable section to show the expected effects

(1) The permeable section should be closed by cobble contained in the debris flow during a flood.
(2) The permeable section should not be closed by sediment load in the normal condition.
(3) The permeable section should be wide enough not to raise the level of flowing water either during a flood or in the normal condition.

(1) The permeable section should be narrow enough to raise the level of flowing water during a flood.
(2) The permeable section should be wide enough not to raise the level of flowing water in the normal condition.
(3) The permeable section should not be closed by sediment load in the normal condition.

Type of permeable sediment control dam

*1

Concrete slit

Steel slit

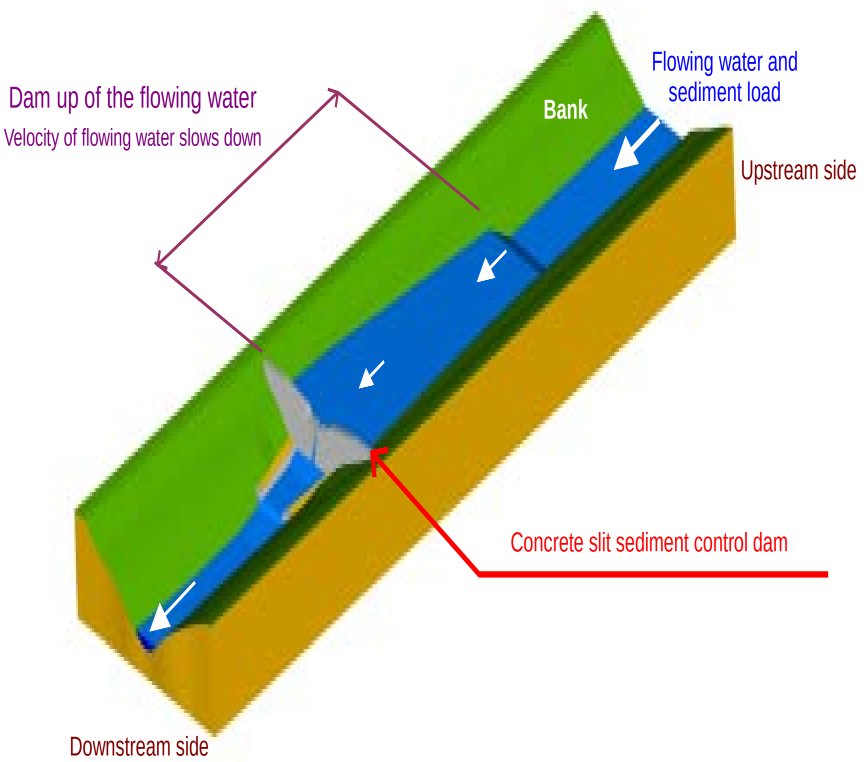
Large conduit

*1) Special installations are required, such as steel pipes laterally installed to ensure closure of the permeable section.

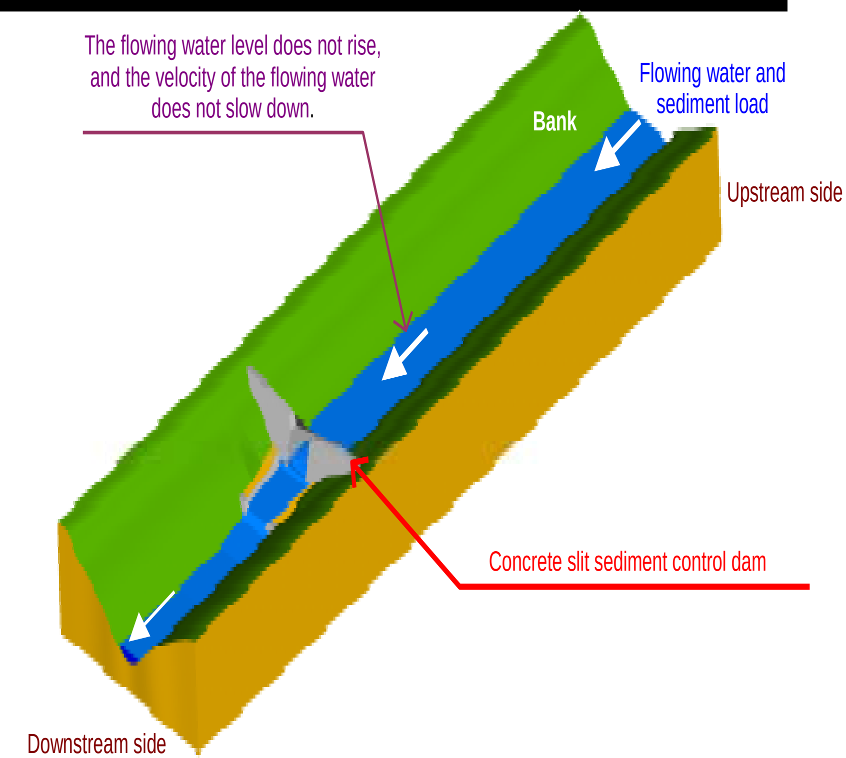
Activities in Sabo Section

- *Sediment Control by Check Dams (3)* -

- Permeable dam is able to control bed load and suspended load if it generates back water (a).
- If it does not generate, it is not able to [redacted]



(a) when the permeable section is narrow



(b) when the permeable section is wide

Conclusion

- Problems caused by sediment transportation in sediment drainage system are introduced.
- General concept and procedure for establishment of comprehensive sediment control are introduced.
- Some examples of measures and activities are also introduced.
- At this moment, there is not enough data to clarify sediment transportation in sediment drainage system.
- It is more important to improve the precision of the method to estimate the amount of sediment movement.

SEDIMENT RUNOFF IN THE BRANTAS RIVER BASIN AFTER THE ERUPTION 1990 OF MT. KELUD

Masaharu Fujita
Disaster Prevention Research Institute, Kyoto University
Yoshifumi Satofuka
Graduate School of Agriculture, Kyoto University
Shinji Egashira
Ritsumeikan University

Activities

- **1994-1999 Under IDNDR Project**

  Prof. Egashira, Prof.Takara, Dr.Fujita, Dr.Satofuka
- **2000-2002 Under Dr.Takara's Project**

  Prof.Takara, Prof.Egashira, Dr.Fujita, Dr. Satofuka
- **2003-2005 Under my own Project**

  Dr.Fujita, Prof.Takara, Prof.Nakagawa, Dr.Satofuka, Dr. Suwa, Dr.Djoko Legono

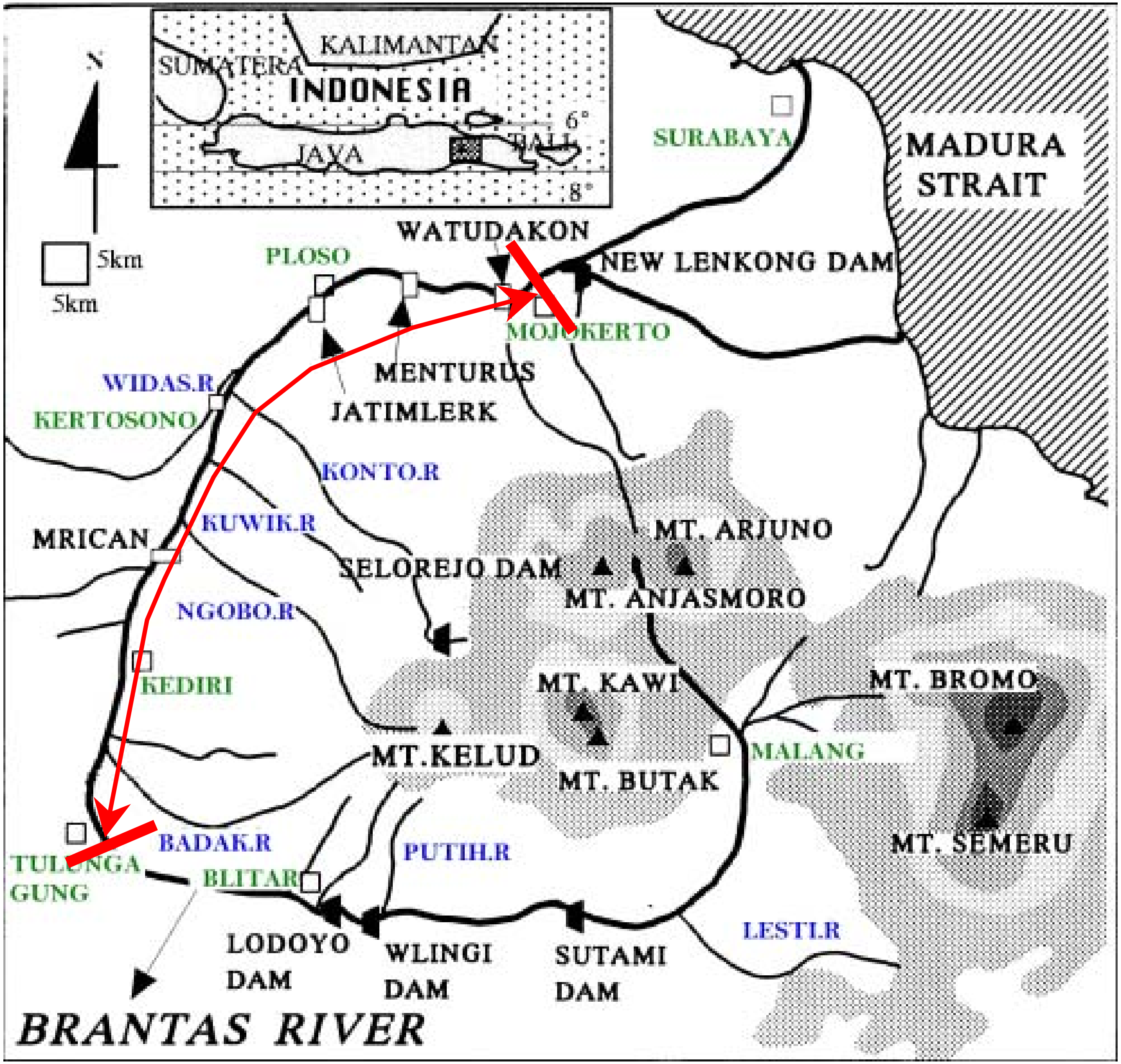
- **Bed variation**

  Brantas middle reach
- **Change of grain size distribution of bed material**

  Brantas middle reach, K.Batak, K.Putih,……..
- **Wash load observation**

  Brantas middle reach

The reach of our interest

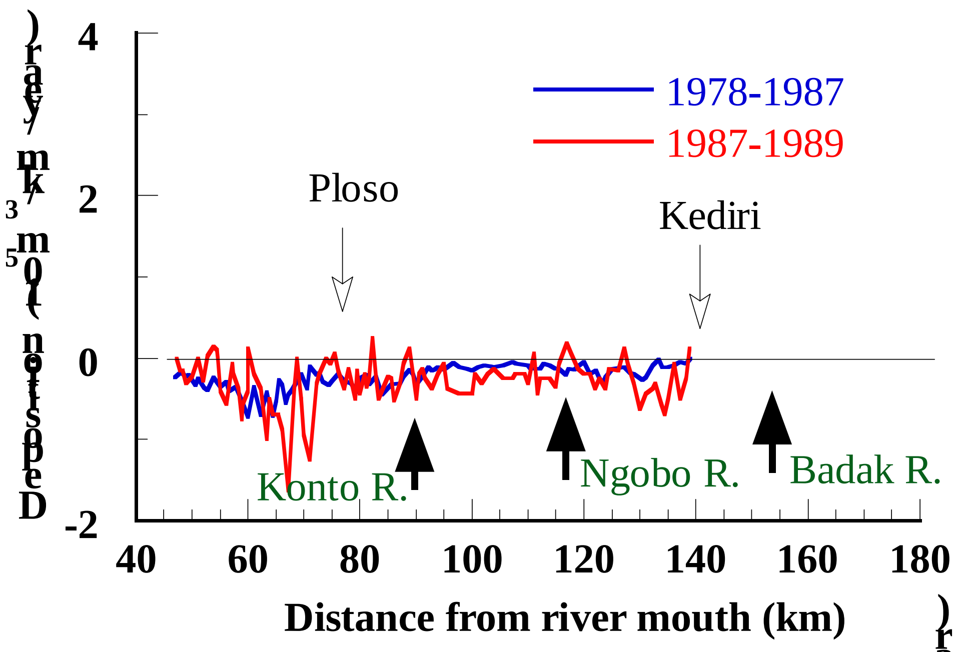


Contents

The bed variation and the change in sediment runoff after the eruption 1990 of Mt.Kelud

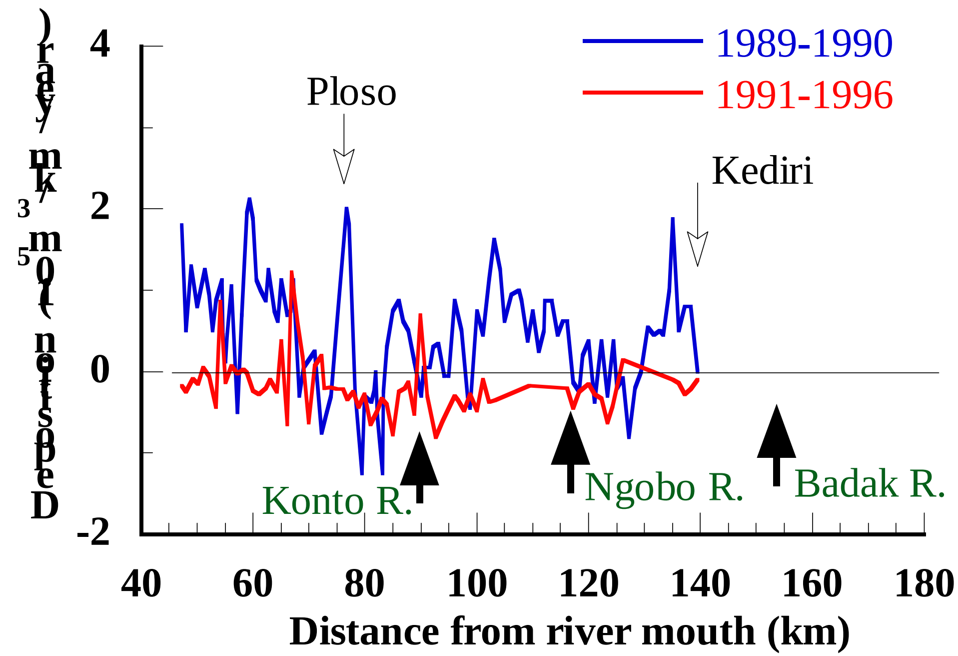
- Quantitative and qualitative change of riverbed
- Change in sediment supply condition from tributaries
- Change in activity of sediment erosion
- Impact on human activities like sand mining

Bed variation in Brantas middle reach



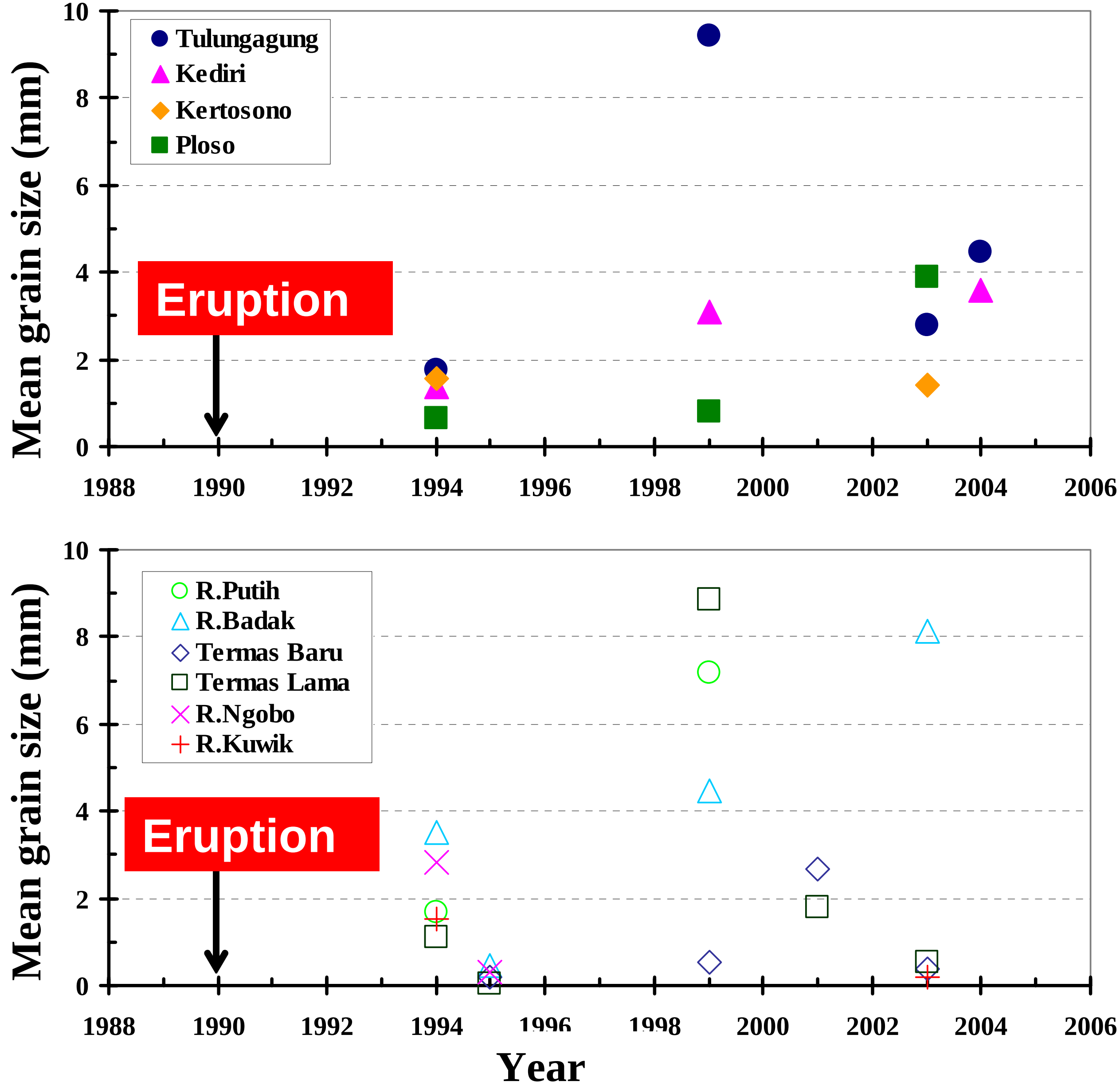
Before the eruption 1990

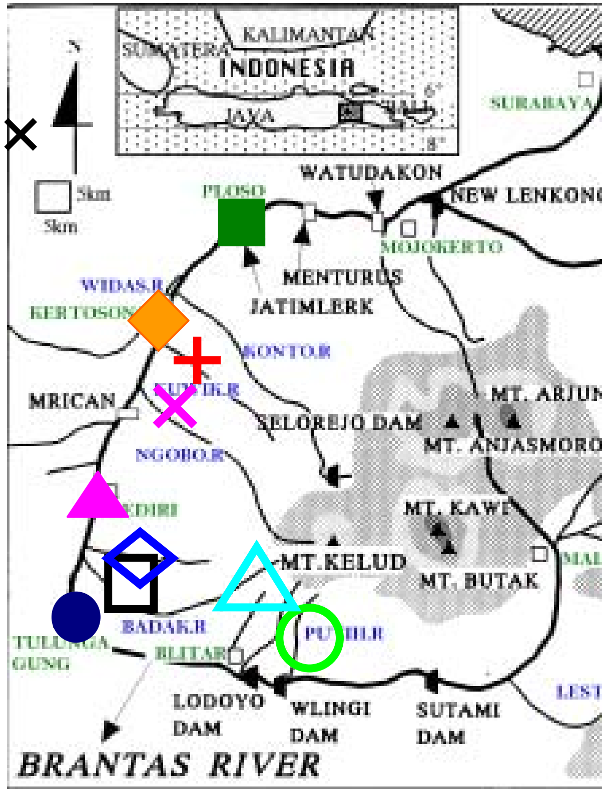
After the eruption 1990



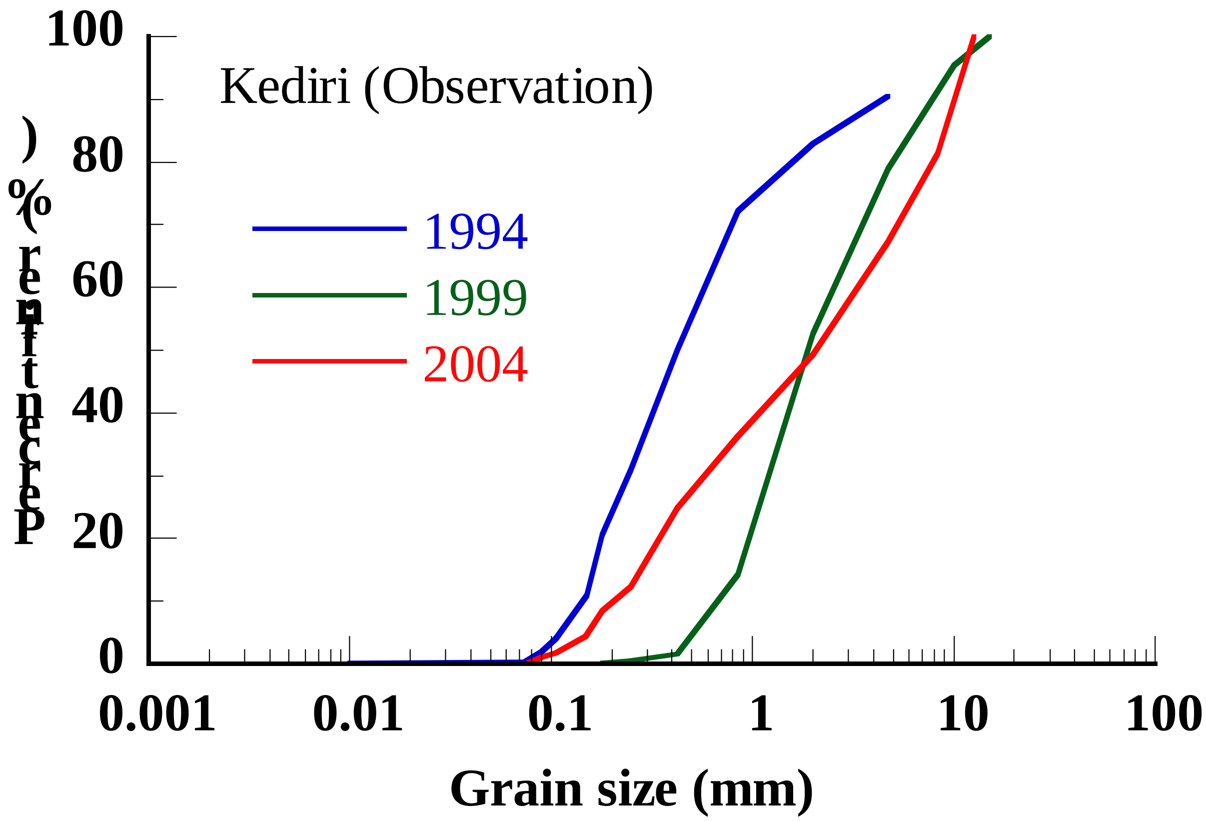
Kediri

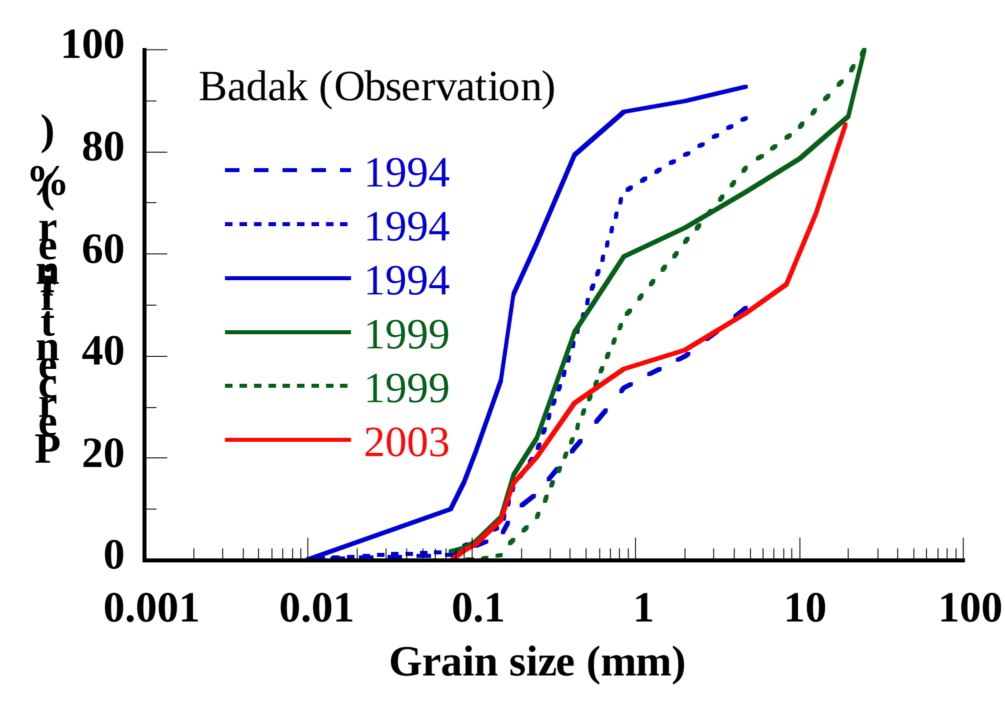
Change of mean grain size of bed material





Change of grain size distribution of bed material





Badak (Observation)
1994
1994
1994
1999
1999
2003
Percent (%)
100
80
60
40
20
0
0.001
0.01
0.1
1
10
100
Grain size (mm)

Situation of tributaries (Termas Lama)


1994.9

1998.1

2001.1

2004.7


1994.9


1998.1


2001.1


2003.12

Situation of tributaries (Ngobo)

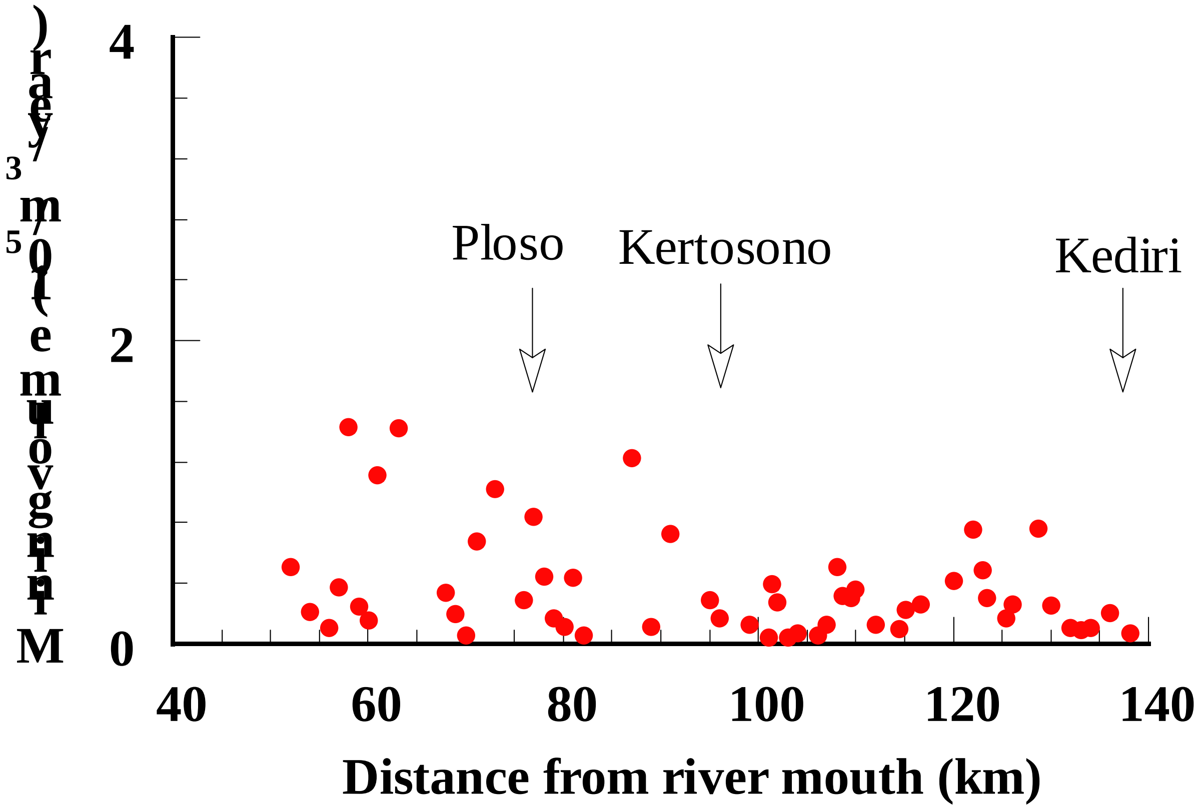
Situation of tributaries
(Sand pocket in K.Putih)


1994.9


1998.1


2001.1

Sand mining

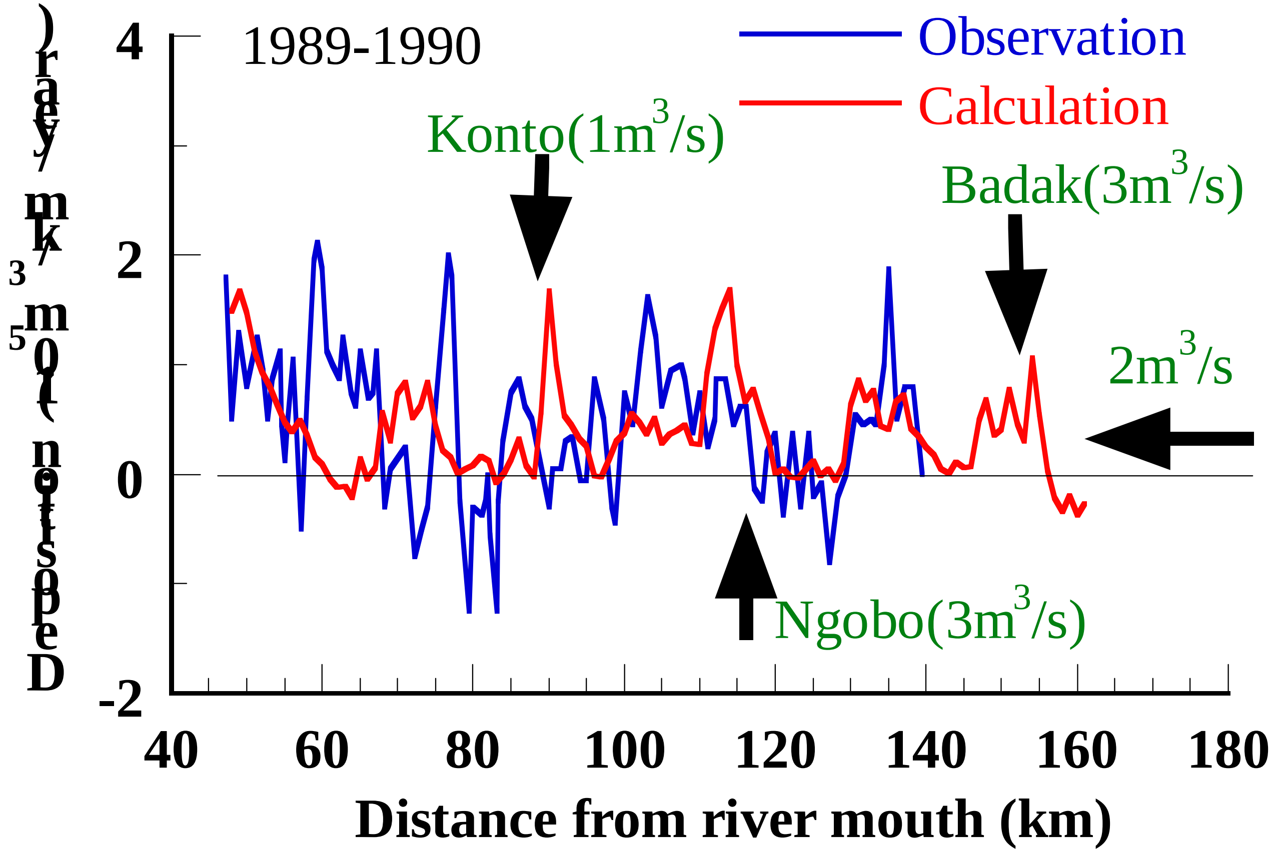


Mining volume (10^5 m^3/year)
4
2
0
Ploso
Kertosono
Kediri
40
60
80
100
120
140
Distance from river mouth (km)

Jasa Tirta

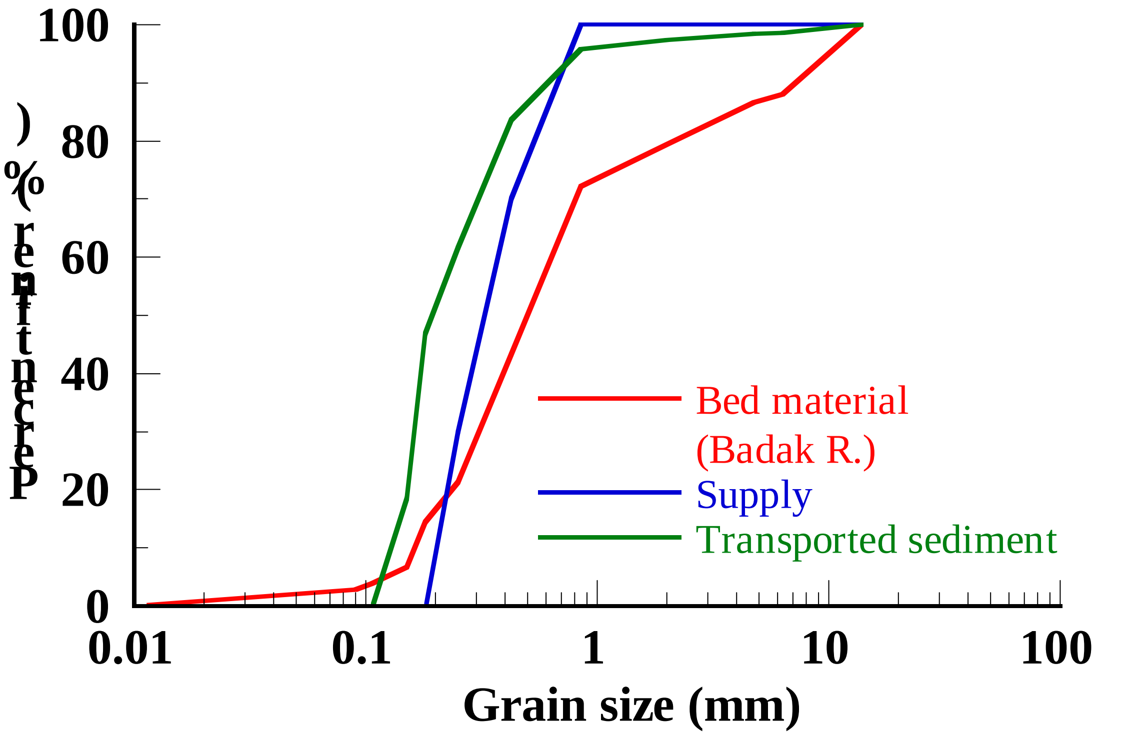
Sediment supply

Immediately after the eruption

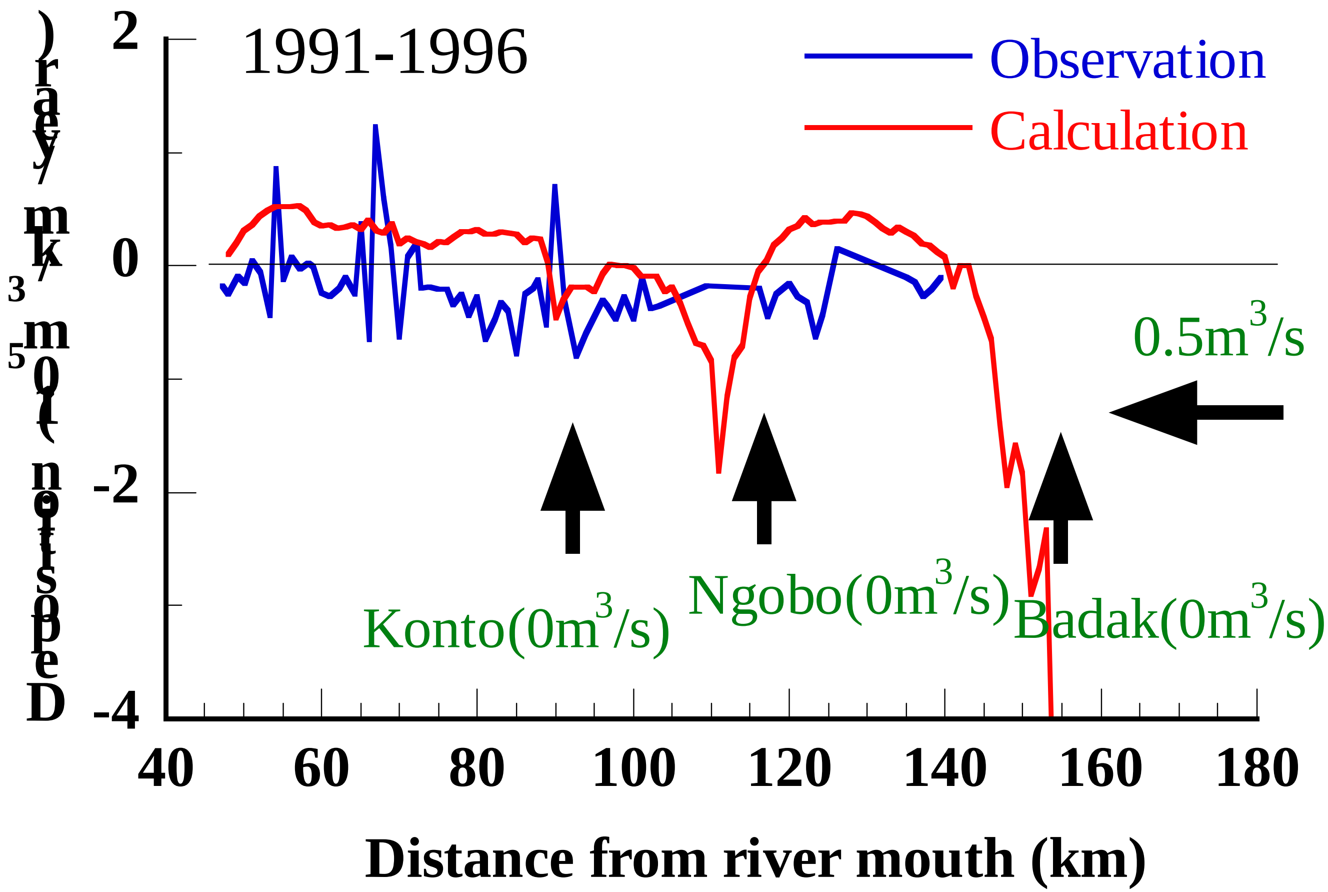


Condition

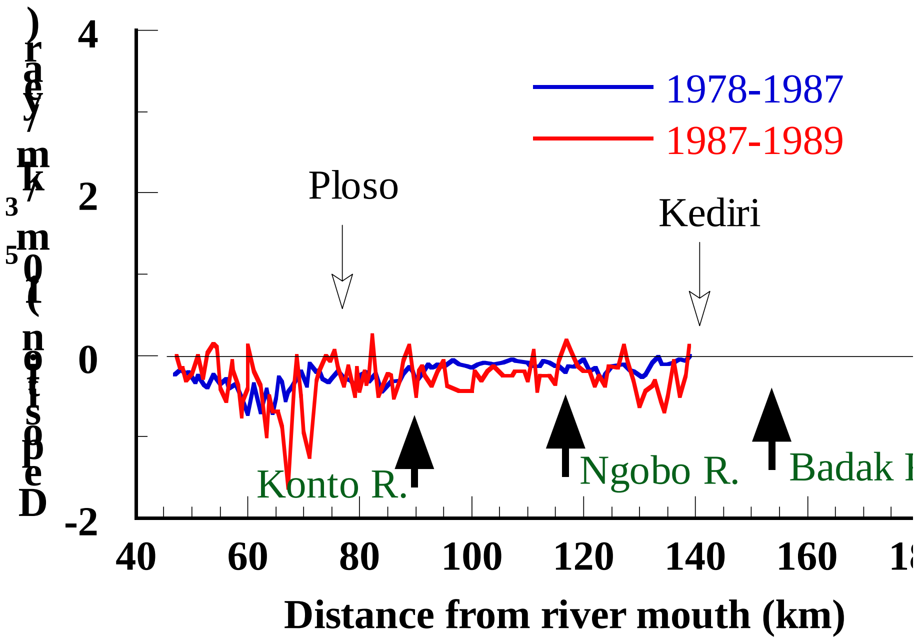
- Local hydraulic condition
- Grain size distribution of bed material

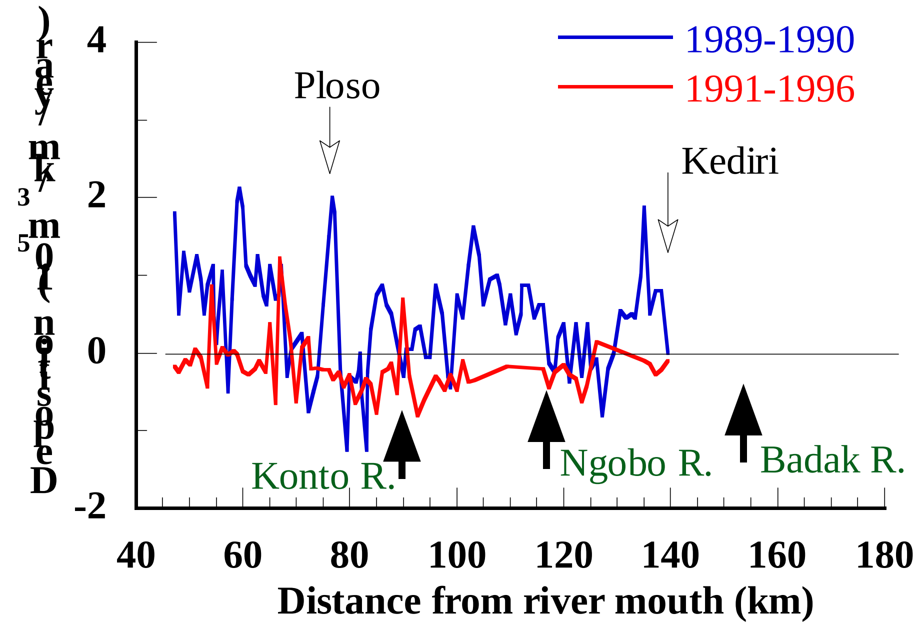


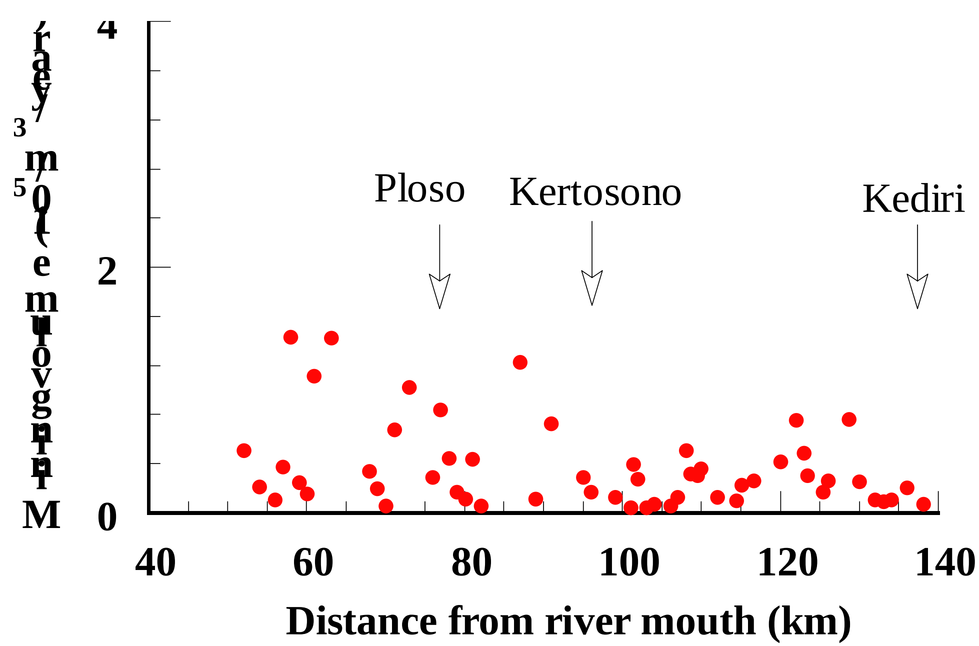
I991-1996


1991-1996
Observation
Calculation
0.5m3/s
Konto(0m3/s)
Ngobo(0m3/s)
Badak(0m3/s)
2
0
-2
-4
40
60
80
100
120
140
160
180
Distance from river mouth (km)
Deposition (105m3/km/year)

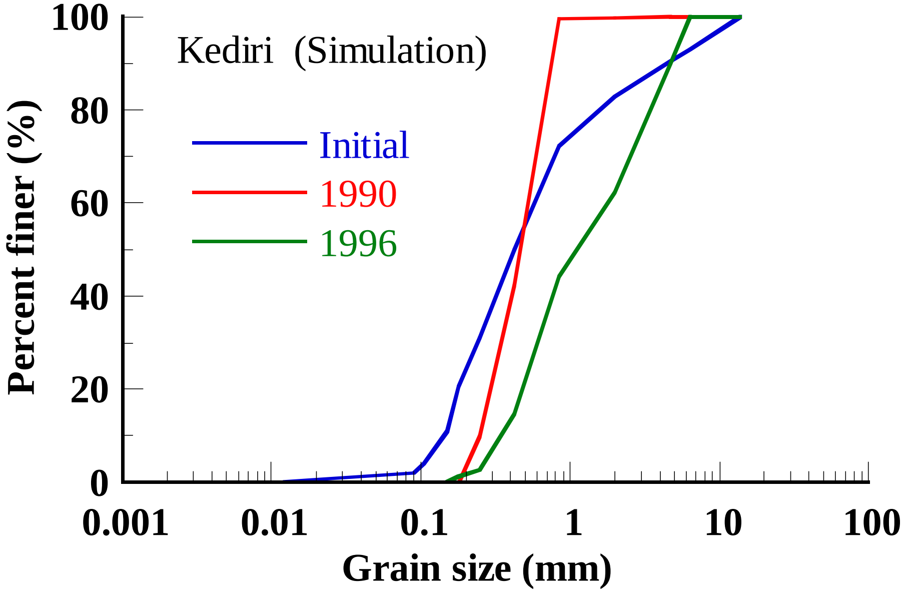
Influence of sand mining

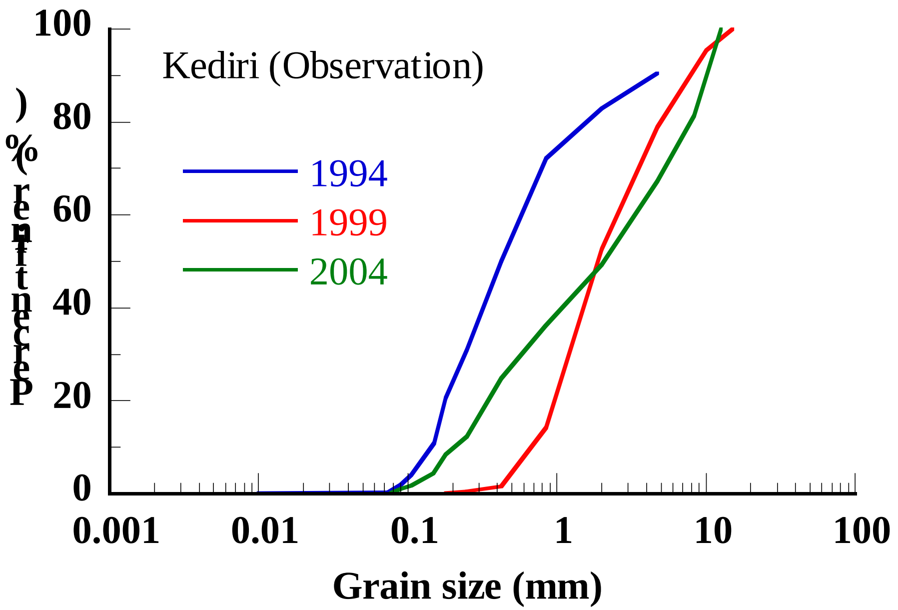






Simulation result on grain size distribution of bed material





Wash load

Wash load transport rate

$$Q_w = \alpha Q^{\beta}$$

Q : Water discharge

α: A coefficient reflecting the activeness of sediment erosion

β: a constant (according to a lot of observation, β =2)

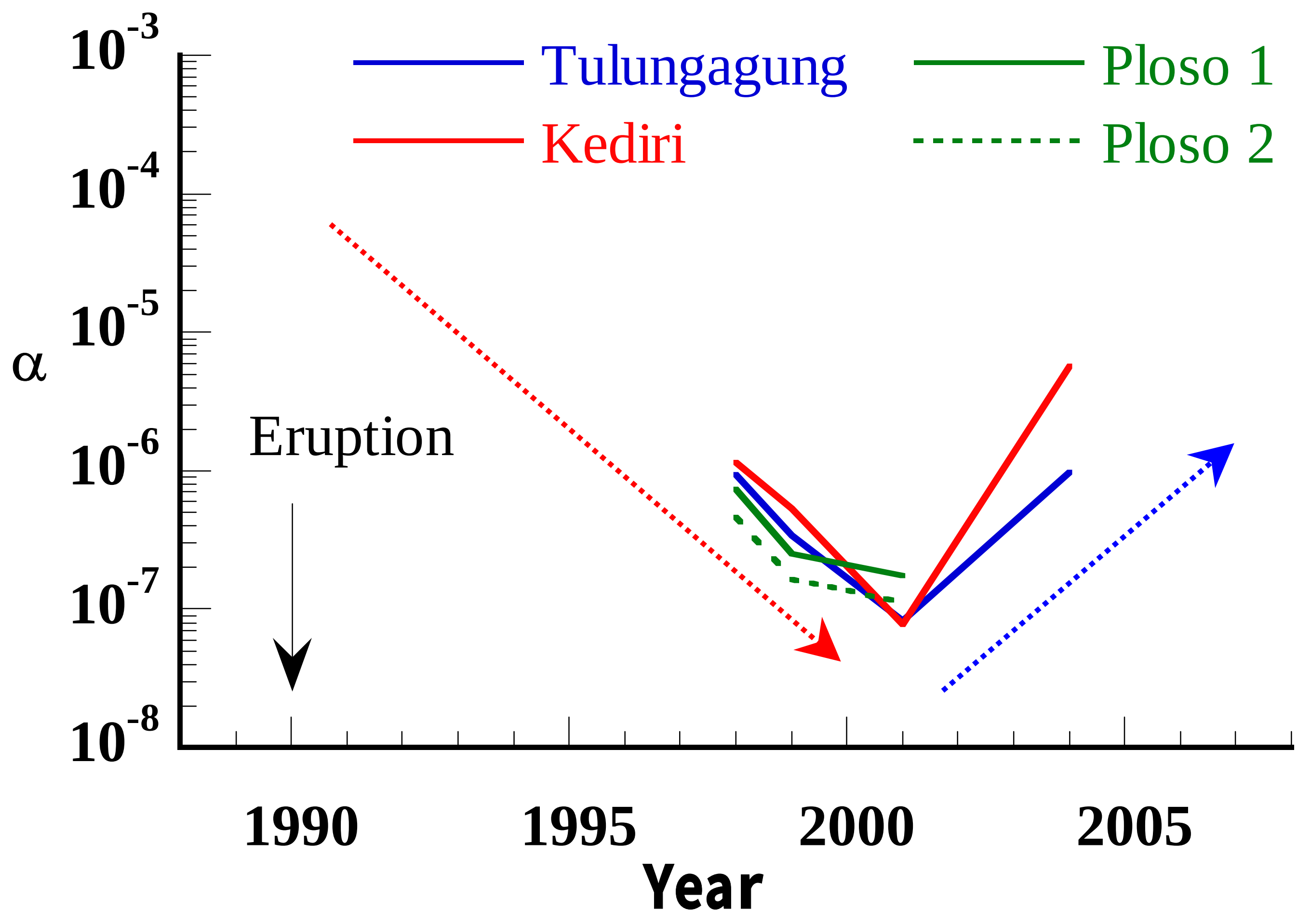
Sources

Deforestation

Change of α

Stabilization of sediment sources

More active sand mining ?
More active deforestation?



Conclusion

- Immediately after the eruption, sediment supply from the tributaries is roughly estimated with the grain size distribution of sediment deposit in the upper reach and the local hydraulic condition near the confluence.
- But after that sand mining is dominant factor of bed variation.
- The coefficient α decreased rapidly after the eruption, but these days it is increasing probably because of more active sand mining and deforestation.

FORESTRY DEPARTEMENT

DIRECTORATE GENERAL OF LAND REHABILITATION AND SOCIAL FORESTRY

HANDLING CRITICAL LAND of BRANTAS WATERSHED

BANDARA JUANDA Street SURABAYA POS CODE 61253A

PHONE CALL. (031) 8673303, FAX. (031) 8669936

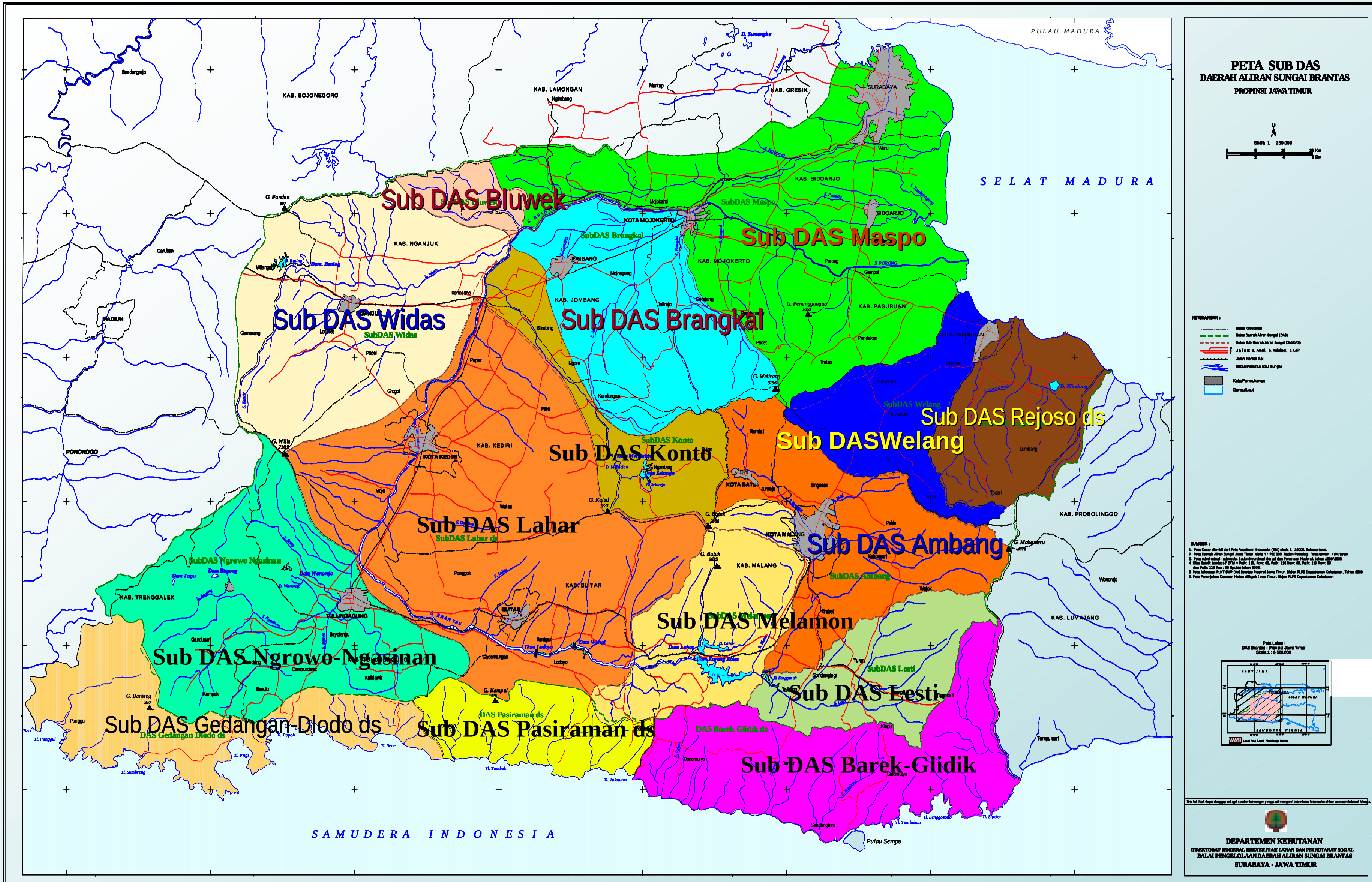
I. OVERVIEW

A. BACKGROUND

Watershed is region land that accept, to catch and saving rainfall in order flow to sea / lake by mainriver. Therefore watershed be devided around other watershed by nature abut (topography) formed up mountain and hill.

Brantas Watershed by astronomics located between 7 ° 4'00" - 8 ° 29'00" Lat.south and 111 ° 30'00" - 113 ° 00'00" Long East. Geographically side north east side abut on Strait of Madura, east and south east side abut on Sampean Watershed, westside and north side abut on Solo Watershed, and south side abut on Indonesian Ocean broadly entire 1.575.285 Ha.
Brantas Watershed region divided to become three part, there are :
(1) Brantas Watershed broadly 1.188.559 Ha (75,45%);
(2) Brantas Watershed South part for the width of 2.55.899 Ha (16,25%); and
(3) Brantas Watershed of East part for the width of 130.827 Ha (8,30%);

Brantas Watershed covering 10 Sub-Province and 7 town, there are : Malang District, Blitar, Trenggalek, Tulungagung, Kediri, Nganjuk, Jombang, Mojokerto, Pasuruan and also Sidoarjo, and Batu Town, Malang, Blitar, Kediri, Mojokerto, Pasuruan and also Surabaya.


PETA SUB DAS
DAERAH ALIRAN SUNGAI BRANTAS
PROPINSI JAWA TIMUR
PULAU MADURA
SELAT MADURA
SAMUDERA INDONESIA
Sub DAS Bluwek
Sub DAS Maspo
Sub DAS Widas
Sub DAS Brangkal
Sub DAS Rejoso ds
Sub DASWelang
Sub DAS Konto
Sub DAS Lahar
Sub DAS Ambang
Sub DAS Melamon
Sub DAS Ngrowo-Ngasinan
Sub DAS Lesti
Sub DAS Gedangan-Dlodo ds
Sub DAS Pasiraman ds
Sub DAS Barek-Glidik
SURABAYA
SIDOARJO
KOTA MOJOKERTO
JOMBANG
KOTA KEDIRI
KOTA BATU
KOTA MALANG
TULUNGAGUNG
BLITAR
KAB. BOJONEGORO
KAB. LAMONGAN
KAB. GRESIK
KAB. SIDOARJO
KAB. MOJOKERTO
KAB. NGANJUK
KAB. JOMBANG
KAB. PASURUAN
KAB. KEDIRI
KAB. MALANG
KAB. BLITAR
KAB. TRENGGALEK
KAB. PROBOLINGGO
KAB. LUMAJANG
PONOROGO
MADIUN
Pulau Sempu
DEPARTEMEN KEHUTANAN
DIREKTORAT JENDERAL REHABILITASI LAHAN DAN PERHUTANAN SOSIAL
BALAI PENGELOLAAN DAERAH ALIRAN SUNGAI BRANTAS
SURABAYA - JAWA TIMUR

WHY DO NEED MANAGE …???

- To arrange interelationship between people and natural resources especially land and water
- Decreating of sediment yield
- Increasing of rainfall absorpsion, enlarge saving ground water


LAHAN KRITIS DAS BRANTAS
Brantas Watershed Critical Land


BENCANA ALAM DAS BRANTAS
Brantas Watershed Natural Damages

HOW TO MANAGE …???

- One “ WATERSHED “ One “ MANAGEMENT “
- Integrated management watershed
- Plan integrated up stream and down stream and participation all STAKEHOLDERS

Table 1. Region Brantas Watershed Management

No	D A S / Sub D A S	Luas (Ha)
I.	**DAS Brantas Hulu**	**238.148**
1.	Sub DAS Melamon	78.089
2.	Sub DAS Ambang	101.675
3.	Sub DAS Lesti	58.384
II.	**DAS Brantas Tengah**	**606.290**
4.	Sub DAS Ngrowo-Ngasinan	145.198
5.	Sub DAS Widas	151.532
6.	Sub DAS Lahar	258.796
7.	Sub DAS Konto	50.764
III.	**DAS Brantas Hilir**	**344.121**
8.	Sub DAS Bluwek	21.482
9.	Sub DAS Brangkal	96.097
10.	Sub DAS Maspo	226.542
	J u m l a h	**1.188.559**
IV.	**Wilayah DAS Bagian Selatan**	**255.899**
1.	Sub DAS Barek Glidik DS	117.870
2.	Sub DAS Pasiraman DS	50.889
3.	Sub DAS Gedangan Dlodo DS	87.140
V.	**DAS Brantas Tengah**	**130.827**
3.	Sub DAS Ngrowo-Ngasinan	63.369
4.	Sub DAS Widas	67.458
	J u m l a h	**386.762**
	T O T A L L U A S	**1.575.285**

Table 2. Region of District and Town Otonom

No	Kabupaten / K o t a	Luas (Ha)
I.	**WILAYAH KABUPATEN**	**1.524.344**
1.	Malang	364.524
2.	Blitar	177.079
3.	Tulungagung	115.722
4.	Trenggalek	126.267
5.	Kediri	154.373
6.	Nganjuk	130.914
7.	Jombang	111.348
8.	Mojokerto	95.467
9.	Sidoarjo	65.877
10.	Pasuruan	146.812
II.	**WILAYAH KOTA**	**50.941**
1.	Malang	7.144
2.	B a t u	9.445
3.	B l i t a r	1.874
4.	Kediri	7.585
5.	Mojokerto	1.188
6.	Surabaya	21.643
7.	Pasuruan	2.062
	J u m l a h	**1.575.285**

B. GOALS

1. To minimise erosion hazard and sedimentation
2. To improve the farmer income
3. To regulate the quantity, quality and continuity of water yield

C. PROBLEM

- There are critical land : 161.165 Ha (Outside Forest Area), 71.140,77 (State Forest Land) resulting the to have decreasing of rainfall absorpsion as saving of ground water and enlarge surface run off
- High sedimentation in accumulating of Karangkates Lake (of old age remain 30 year) and Sengguruh Lake (of old age remain 2,8 year)
- Wrong crop cultivation on slope area
- Awareness of society / farmer to environment still lower also in participatory
- No guarantee for farmer product market system
- No good relationship between upper and lower watershed

CRITICAL LAND

Critical Land condition early year 2005 in each district / town wich enter in Brantas Watershed management as follows :
Malang, Blitar, Tulungagung, Trenggalek, Kediri, Nganjuk, Jombang, Mojokerto, Pasuruan and Sidoarjo district and also Batu, Malang, Blitar, Kediri, Mojokerto, Pasuruan, and Surabaya town.

Result from compilation of the plan medicate that critical land still very high reach 280,258 Ha, compose from : *Very critical* 26,267 Ha, *Critical* 93,459 Ha, *Rather critical* 120,953 and *Potential critical* 39,569 Ha ad for that existing forest and out side

Table 3. Critical Land of Brantas Watershed

No.	Kawasan	Luas Lahan Kritis (Ha)				Total
		Sangat Kritis	Kritis	Agak Kritis	Potensial Kritis	
1.	Hutan Lindung	4.706	700	-	-	5.406
2.	Hutan Konservasi	-	7.067	3.930	-	10.997
3.	Hutan Produksi	16.761	26.339	4.238	-	47.338
4.	Lindung diluar Kawasan Hutan	456	4.300	9.046	674	14.476
5.	Budidaya Pertanian	3.231	47.216	70.707	37.794	158.948
6.	Kanan Kiri Sungai	-	3.284	18.530	93	21.907
7.	Ruang Terbuka Hijau Kawasan Pemukiman	-	1.014	1.815	-	2.829
8.	Perkotaan Sekitar Pantai	1.113	3.549	12.529	1.008	18.119
9.	Kawasan Banjir	-	-	158	-	158
	Jumlah	26.267	93.469	120.953	39.569	280.258

Region of watershed there are some barrages as prop at amount of water required in this part of East Java Province Areas, to house hold, irigation, power electric and drinking water.

Table 4. Barrages in Brantas Watershed

No	N A M A	Sungai Utama	Luas Bangunan (Ha)	Vol. Daya Tampung (m^3)	Vol. kantong Lumpur (m^3)
1.	Sengguruh	Brantas, Lesti	3,80	2.500.000	19.000.000
2.	Sutami	Brantas, Lesti	15,00	253.000.000	90.000.000
3.	Lahor	Lahor	2,63	29.400.000	6.600.000
4.	Wlingi	Brantas	3,30	5.200.000	19.800.000
5.	Lodoyo	Brantas, Lesti	0,94	5.000.000	200.000
6.	Wonorejo	Bodeng, Song	3.36	106.000.000	16.000.000
7.	Bening	Widas	5,70	28.400.000	4.500.000
8.	Selorejo	Konto	3,50	54.600.000	7.700.000

II. CRONOLOGY

A. SUB BRLKT Brantas : 1983 - 1999

Sub Central Rehabilitation and Soil Conservation under BRLKT Region VI Directorate General Reboisation and Land Rehabilitation (now Directorate General Rehabilitation and Social Forest)

Some kind of function :

- Building technical plan middle Land Rehabilitation and Soil Conservation
- Technical coaching implementation Land Rehabilitation and Soil Conservation
- Evaluation of Water Management and implementation Land Rehabilitation and Soil Conservation
- Implementation Administration

B. BRLKT Brantas : 1999 - 2002

Brantas Central Land Rehabilitation and Soil Conservation is a technical unit of Directorate General Land Rehabilitation and Social Forest.

Some kind of function

- Build longterm plan (pola RLKT = 25 years) and middterm plan (RTL = 5 years)
- Emplementation Monitoring and Evaluation Watershed Management
- Emplementation Monitoring and Evaluation Succesfull Land Rehabilitation and Soil Conservation
- Evaluation Technical Plan Land Rehabilitation and Soil Conservation

C. CENTRAL of BRANTAS WATERSHED MANAGEMENT

Central of Brantas Watershed Management under control and responsibility to Directorate General Land Rehabilitation and Social Forest of Forestry Departement

SK. 665 / Kpts-II / 2002, about : Organisation and Administration Central of Brantas Watershed Management with Vision is Becoming Service Center and Information of Forest and Land for Watershed Management and Mission are :

1. **Providing Plan of Watershed Management for the Stakeholders**
2. **Developing Watershed Management Model**
3. **Developing System and Institution Model and also System and Partnership of Watershed Management Model**
4. **Monitoring and Evaluating Watershed Management**
5. **Providing Information of Watershed Management Sufficient**
6. **Providing Efficient and Effective Supporting System**

MAIN PRODUCT of CENTER for BRANTAS WATERSHED MANAGEMENT

BRANTAS WATERSHED PLANNING

Brantas Watershed Forum

- Management of natural resources watershed have to be formulated by holistic.
- Watershed Forum is one alternative solution for management watershed study.
- In principle Watershed Forum formed on the basis of aware and requirement all the stakeholders.
- Brantas Watershed Forum have been formed by a Chief of Brantas Watershed with decision letter number SK.36/Kpts/V/BPDAS.Bts-3/2004 on 24’th May 2004 at the same time await stipulating of governor of East Java, so that the forum can immediately execute duty and function properly.
- The role of Watershed Forum is to support watershed management teamwork on institution.

Farmer Group Enpowering

- Enpowering Society (Farmer Group) Program supported training inherent and systimatic, including in compilation of activities planning.

- The Principal Enpowering effort is how to help themselves increasing income which able to reach capital, technology and marketing system.

Trainings

- In order to increase the technical and managerial skill, Center Brantas Watershed had been training for the farmers. The training had held in since 1989, are :
  1. Training of Micro Model Watershed
  2. Social Forestry Model Training for the farmers
  3. Comparing Study
  4. Training of Mangrove Model

- To increase human resource, Center Brantas Watershed have held trained staff itself also send to other Institution

BRANTAS WATERSHED EVALUATION SECTION

A. SOCIAL – ECONOMIC

1. Evaluation of Income for Farming
2. Evaluation of Capital Income Region
3. Evaluation of Development Village People
4. Evaluation of Education Village People
5. Evaluation of Institution Village People

B. SOIL CONSERVATION and LAND REHABILITATION

1. Evaluation Planting / Vegetative Activity
2. Evaluation of Civil Technic

C. LAND USE CHANGE

1. Evaluation of Land Use
2. Evaluation of Land Cover
3. Evaluation of Land Conservation
4. Evaluation of Land Erosion

D. SUB WATERSHED WATER YIELD AND SEDIMENT YIELD ([illegible]

1. Observation of Rainfall
2. Observation of Waterfall
3. Observation / mesurementof discarge ([illegible] d)
4. Obsevation of Sediment Yield

III. CRITICAL LAND IN BRANTAS WATERSHED

Critical land is land which have damage, so that loss or decrease the function of to a point which determined or expected.

Decision of Directorat General of Reboisation and Land Rehabilitation No. 041/Kpts/V/1998 :

1. **Criteria of Critical Land on Existing Protection Forest are :**
   a. Land Cover
   b. Slope
   c. Erosion
   d. Management
2. **Criteria of Critical Land on Agriculture Farming are :**
   a. Productivity
   b. Land Cover
   c. Slope
   d. Bad rock
   e. Management
3. **Criteria of Critical Land on Protection Area Outside Forest are :**
   a. Land cover
   b. Slope
   c. Erosion
   d. Management.

IV. S O L U T I O N

Based on cooperation of Desession of 3 Coordinator Ministry (People Welfare Minister, Security and Political Minister and Economical Minister) on 31'th of March 2003, the Goverment of Indonesia has launched The National Movement for Land and Forest Rehabilitation

Coordination Repair of Environment Team through National Rehabilitation and Reboitation is undertaking :

1. Co-Ordinating compilation of policy and execution stages, evaluation and operation repair of environment through National Rehabilitation and Reboisation as investment effort;
2. Arranging an Guidence and Technical Instruction Repair of Environment through Natio[illegible] Rehabilitation and Reboisation;
3. Finishing the problems for repair of environment through National Rehabilitati[illegible]ation.

Team Work

1. Team Work of Prevention Damage of Environment Sector are :
   a. State Minister of Environment (Chief)
   b. Head Police of Indonesian Repubic
   c. Minister of Judgement and Human Right

2. Team Work of Forest Cultivation and Rehabilitation Sector are :
   a. Minister of Forestry (Chief)
   b. Minister of Agriculture
   c. Minister of Domestic
   d. Minister of National Education
   e. Minister of Research and Technology
   f. Minister of Settlement and Instrument Regional
   g. Minister of Finance
   h. Commander of Indonesian National Military.

Duty and each Role The Team Work of Prevention Damage of Environment Sector are :

- State Ministry of Environment is monitoring execution growth of repair of environment, and also as coordinator in prevention damage of environment.

- The Police of Indonesian Republic undertake to protect execution of The National Movement for Land and Forest Rehabilitation Program.

- Department of Judgement and Human Rights is executing the straightening of law to damage of environment.

Duty and each Role The Team Work of Forest Cultivation and Rehabilitation Sector are :

- Department of Forestry undertake to prepare planning, seed cultivation, and conservancy, and as coordinator in execution forest and land rehabilitation.

- Department of Agriculture undertake to prepare planning of cultivation and construction of conservancy of agriculture crop / plantation and cooperation with the other institute.

- Department of Domestic move the overall local government and society to execute cultivation of seed and
  conservancy of crop, and also execute socialization (awereness public).

- **Department of National Education conscript the students to involve active in the effort this National Movement, and to improve caring of the students for continuity of environment.**

- **Ministry of Research and Technology undertake to provide evaluation and information concerning repair of environmental condition which obtained and Citra Landsat.**

- **Department of Settlement and Instrument Regional choose the Priority Critical Watershed Management to be handled and prepare map of Watershed Management for base planning.**

- **Department of Finance undertake to prepare financing and budgeting for execution of The National Movement for Land and Forest Rehabilitation Program.**

- **Indonesian National Military conscript the personnel to execute cultivation efforts with the society.**

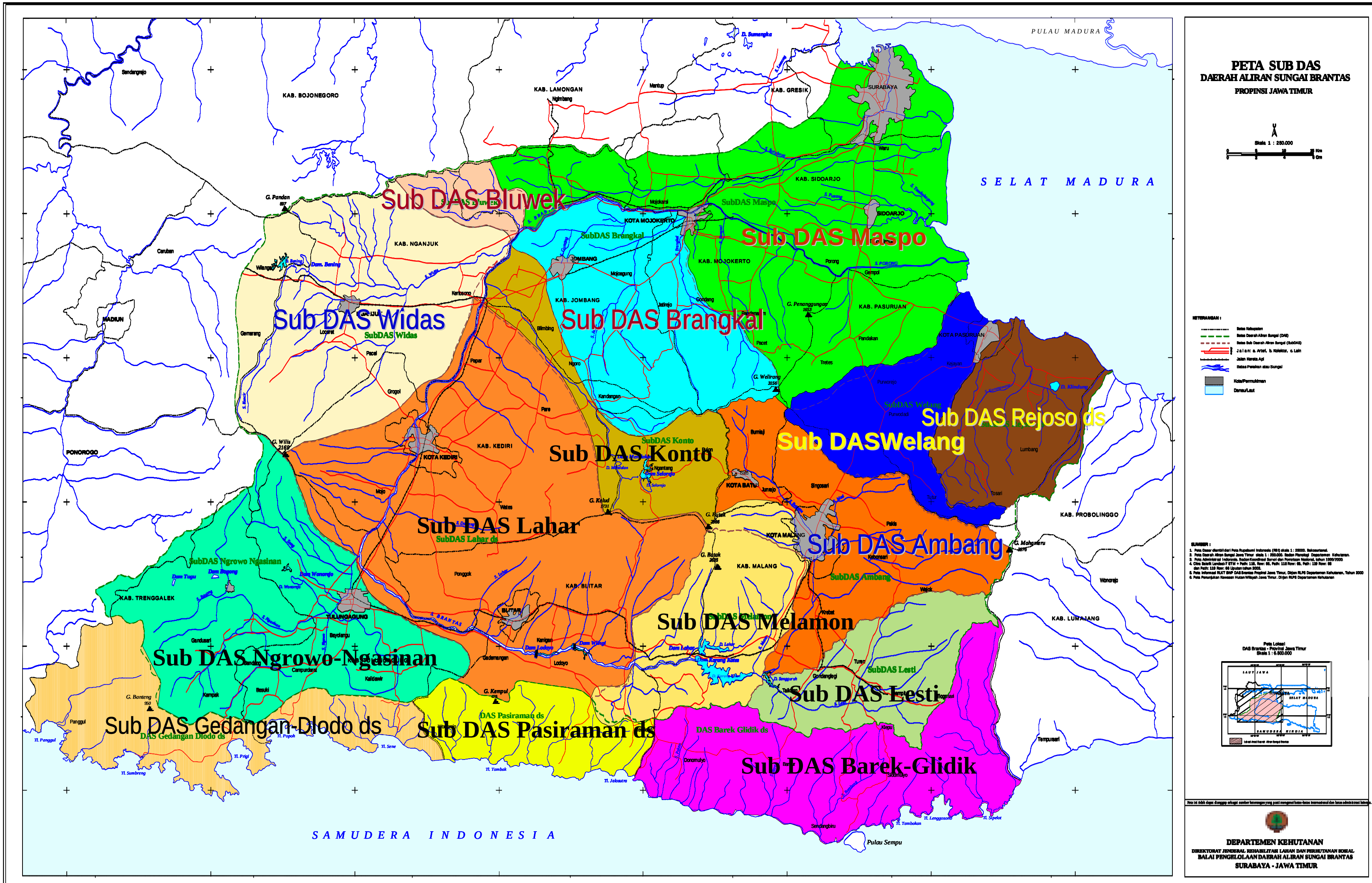
Table 5. Target of Wide and Location

No	Kabupaten / Kota	Dalam Kawasan Hutan						Luar Kawasan Hutan (Ha)	Jumlah (Ha)
		PERHUTANI		HUTAN KONSERVASI			Jumlah DKH (Ha)		
		H L	H P	TN-BTS	TAHURA R. Soeryo	JUMLAH			
1	2	3	4	5	6	7	8	9	10
1	Kota Batu	1,917	640	-	800	800	3,357	917	4,274
2	Kota Malang	-	-	-	-	-	-	820	820
3	Kab. Malang	6,908	8,955	1,596	1,600	3,196	19,059	38,797	57,856
4	Kab. Blitar	2,158	10,102	-	-	-	12,260	26,454	38,714
5	Kota Blitar	-	-	-	-	-	-	364	364
6	Kab. Tulungagung	2,255	12,616	-	-	-	14,871	12,993	27,864
7	Kab. Trenggalek	3,306	4,018	-	-	-	7,324	18,037	25,361
8	Kab. Kediri	1,292	1,472	-	-	-	2,764	14,898	17,662
9	Kota Kediri	-	-	-	-	-	-	815	815
10	Kab. Nganjuk	6,958	9,969	-	-	-	16,927	9,141	26,068
11	Kab. Jombang	3,265	2,961	-	318	318	6,544	10,280	16,824
12	Kab. Mojokerto	1,361	2,738	-	6,971	6,971	11,070	7,758	18,828
13	Kota Mojokerto	-	-	-	-	-	-	195	195
14	Kab. Pasuruan	1,680	1,064	750	335	1,085	3,829	21,890	25,719
15	Kota Pasuruan	-	-	-	-	-	-	1,953	1,953
16	Kab. Sidoarjo	-	-	-	-	-	-	175	175
17	Kota Surabaya	-	-	-	-	-	-	7,486	7,486
	J u m l a h	31,100	54,535	2,346	10,024	12,370	98,005	172,973	270,978


KEGIATAN PENANAMAN DAS BRANTAS
Brantas Watershed Planting

Concerning
Planning Activities
Brantas Watershed Management

Ministry of Forestry
DG Land Rehabilitation and Social Forestry
Brantas Watershed Management Center, Surabaya


PETA SUB DAS
DAERAH ALIRAN SUNGAI BRANTAS
PROPINSI JAWA TIMUR
Skala 1 : 250.000
Sub DAS Bluwek
Sub DAS Maspo
Sub DAS Widas
Sub DAS Brangkal
Sub DAS Rejoso ds
Sub DASWelang
Sub DAS Konto
Sub DAS Lahar
Sub DAS Ambang
Sub DAS Melamon
Sub DAS Ngrowo-Ngasinan
Sub DAS Lesti
Sub DAS Gedangan-Dlodo ds
Sub DAS Pasiraman ds
Sub DAS Barek-Glidik
PULAU MADURA
SELAT MADURA
SAMUDERA INDONESIA
KAB. BOJONEGORO
KAB. LAMONGAN
KAB. GRESIK
SURABAYA
KAB. SIDOARJO
SIDOARJO
KAB. NGANJUK
KOTA MOJOKERTO
KAB. MOJOKERTO
JOMBANG
KAB. JOMBANG
KAB. PASURUAN
KOTA PASURUAN
MADIUN
PONOROGO
KOTA KEDIRI
KAB. KEDIRI
KOTA BATU
KOTA MALANG
KAB. MALANG
KAB. PROBOLINGGO
KAB. LUMAJANG
KAB. TRENGGALEK
TULUNGAGUNG
KAB. BLITAR
BLITAR
Pulau Sempu
KETERANGAN :
SUMBER :
DEPARTEMEN KEHUTANAN
DIREKTORAT JENDERAL REHABILITASI LAHAN DAN PERHUTANAN SOSIAL
BALAI PENGELOLAAN DAERAH ALIRAN SUNGAI BRANTAS
SURABAYA - JAWA TIMUR

Overview

The kinds of watershed plan these provide under outhority of Brantas WMC covering as follow:

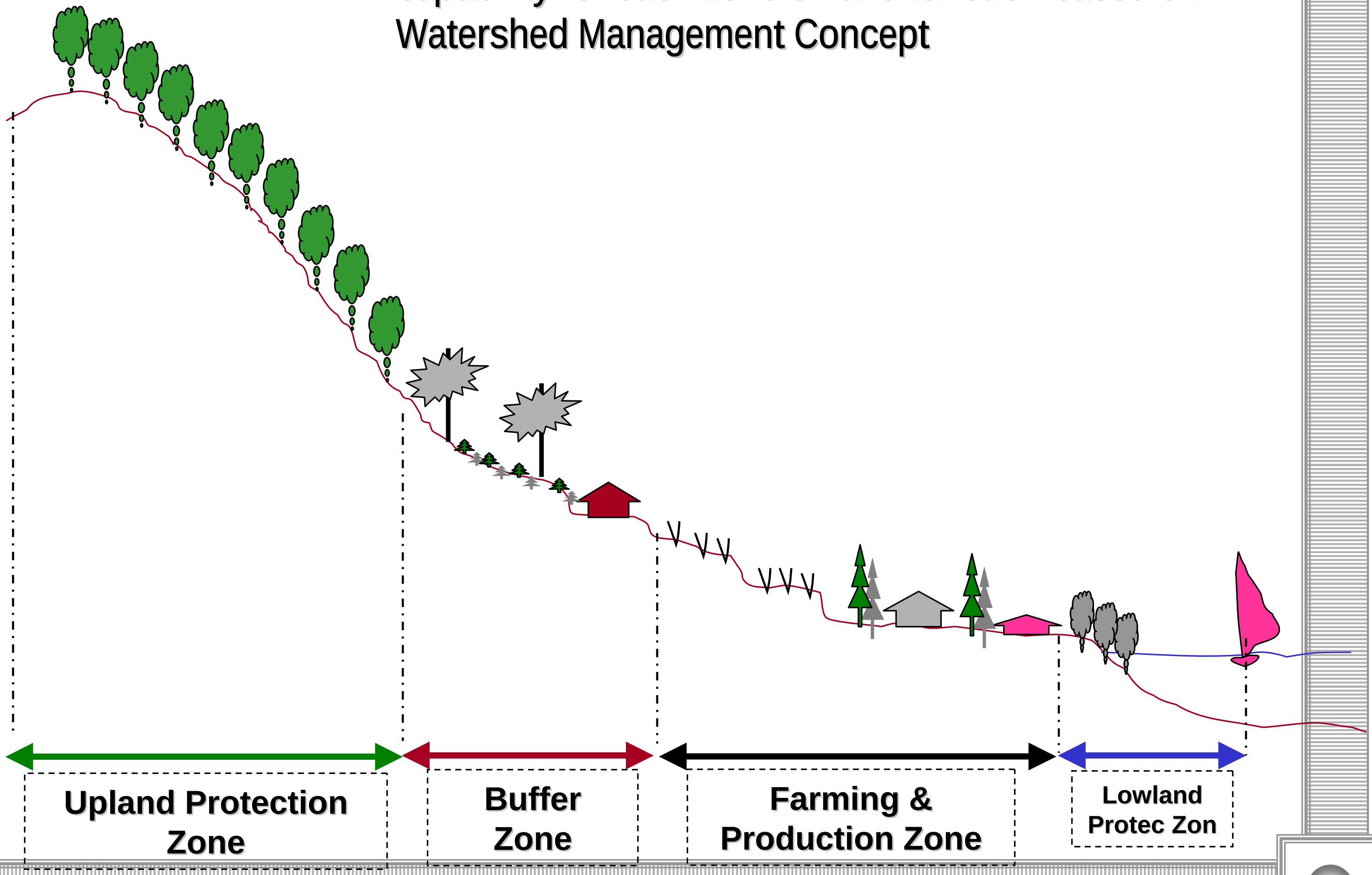
1. Longterm Plan (15-20 yr) as Masterplan of Watershed Management Activities (Pola RLKT DAS)
2. Middterm Plan (5 yr) as Technical Plan for Watershed Management Activities/ Enginering Design to Rehabilitation of Deforested and Critical Land Area (RTL RLKT DAS/ Sub DAS)
3. Project Plan as Technical plan for selected activity which implementable to projection target
4. Annual and Action Plan as Detail of Technical Design and Budgeting for Implementation Activity (Rancangan Kegiatan)

Specification & Content of WM Plan

Longterm WM Plan (Pola RLKT DAS):

1. **Organizing of LT-WM Plan Preparation**
   - Compiled by : WMC (BP-DAS)
   - Assessed by : BAPPEDA Propinsi
   - Ratified by : Gubernur
2. **Main Content of LT-WM Plan**
   - Priority sequence of Sub Watershed handling base on degradation level
   - Suggestion model to improve the present land use according soil capability for each zone of land function
   - Concerning watershed degradation issue and technical assistance to improve land use system, deforested and land rehabilitation

Model to improve the present land use according soil capability for each zone of land function based on Watershed Management Concept



Specification & Content of WM Plan

Middterm WM Plan (RTL RLKT DAS):

1. Organizing of MT-WM Plan Preparation
   - Compiled by : WMC (BP-DAS)
   - Assessed by : BAPPEDA Kabupaten/ Kota (covered area)
   - Ratified by : Bupati/ Walikota
2. Main Content of MT-WM Plan
   - Rate of actual erosion on each land unit
   - Simple and available technologi recomended for forest and land rehabilitation treatment
   - Supporting system for socioeconomic development and comunity enpowering
   - Implementation Project Analisys

Project Plan for Selected WM Activity:

1. **Organizing of Project Plan Preparation**
   - Compiled by : WMC (BP-DAS) Cooperation with local insti
   - Assessed by : BAPPEDA Kabupaten/ Kota (covered area)
   - Ratified by : Bupati/ Walikota
2. **Main Content of Project Plan**
   - Project area and the item of activity
   - Time schedule and the step of activity
   - Organizing and management project
   - Budgeting and project financial system

Technology Support
for
NATIONAL MOVEMENT FOR FOREST AND LAND REHABILITATION

By
Watershed management Technology Research and Development Centre

Regreening

Reforestation

Vegetative method in private land

Vegetative method in forest areas

Enriching
the forest area

Silvopasture
in private land

Mechanical Methods

Sheet and Rill erosion control methods

Mechanical Methods

Sheet and Rill erosion control methods

Mechanical Methods

Sheet and Rill erosion control methods

Mechanical Methods

Gully erosion control methods

Mechanical Methods

Gully erosion control methods

Mechanical Methods

Gully erosion control methods

Mechanical Methods

Gully erosion control methods

Mechanical Methods

Gully erosion control methods

Mechanical Methods

Gully erosion control methods

Mechanical Methods

Gully erosion control methods

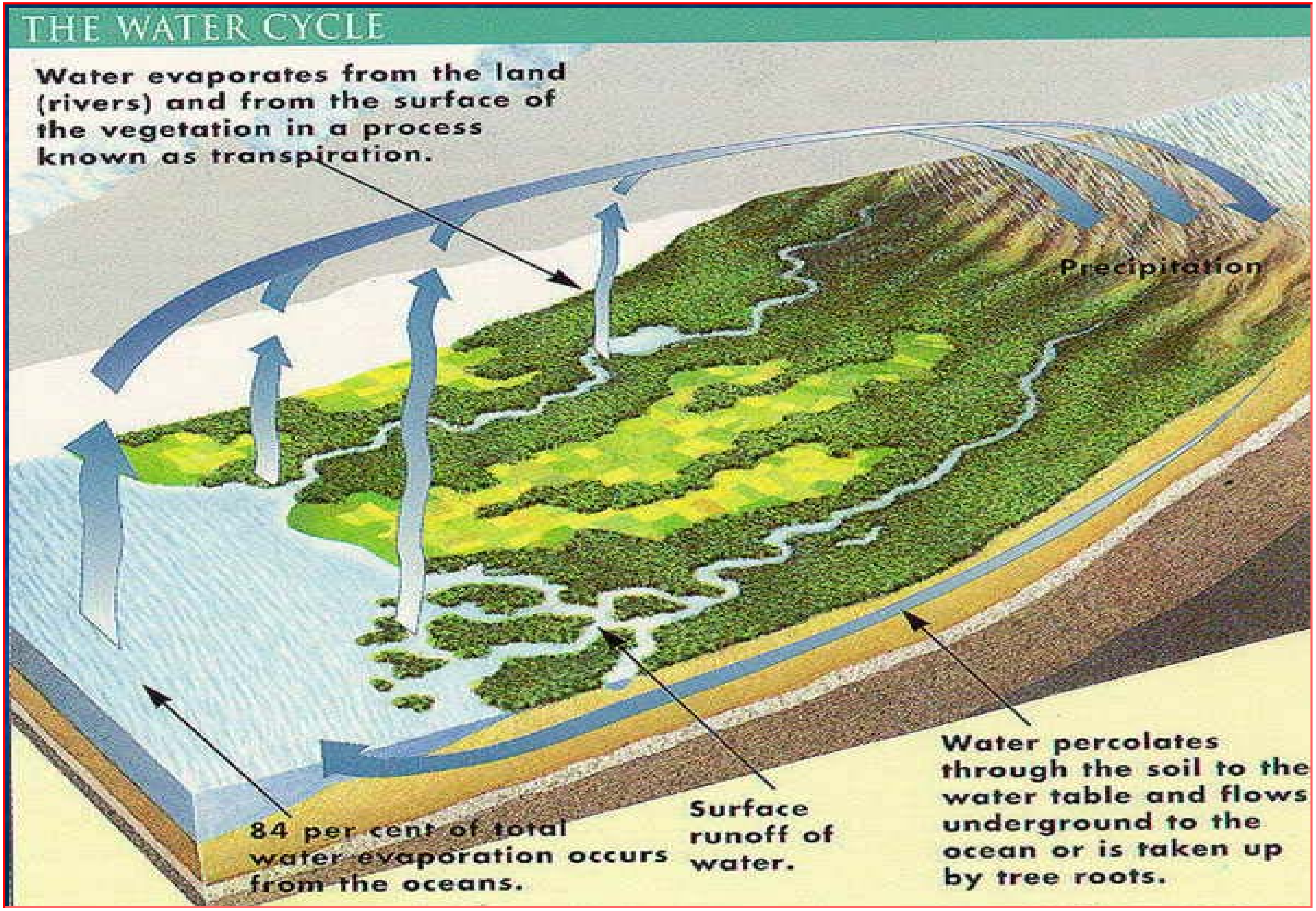
Mechanical Methods

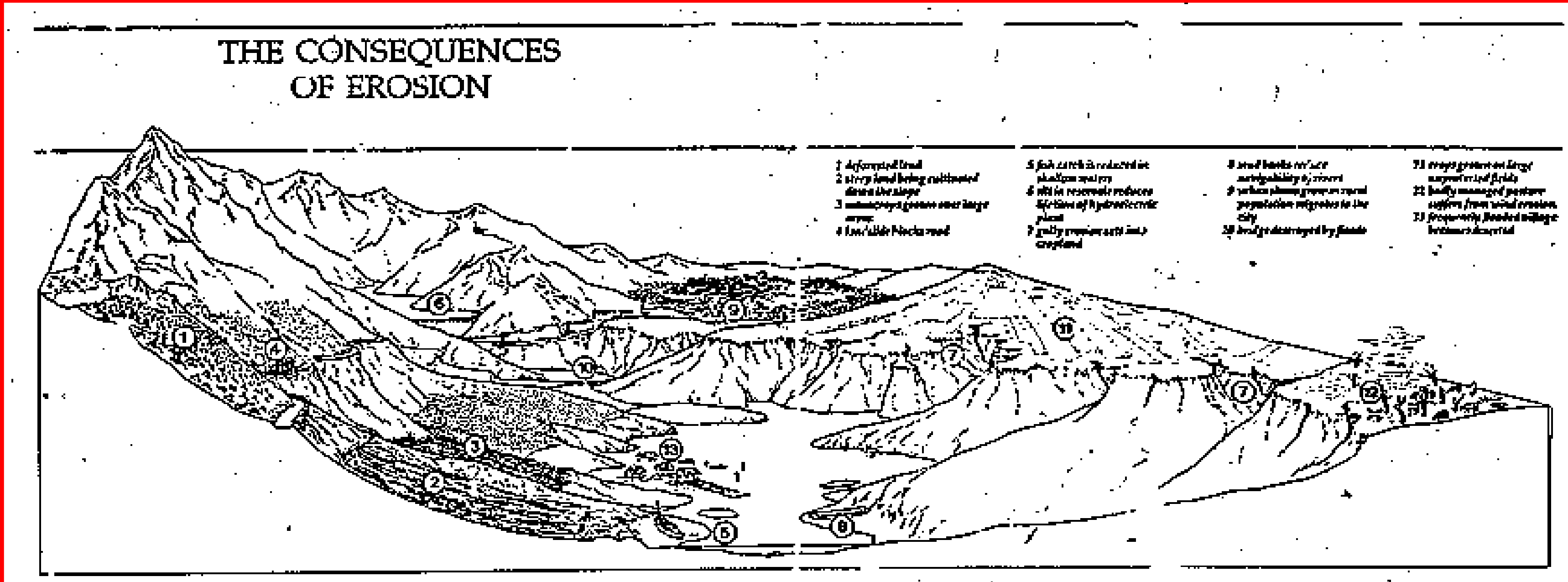
Streambank erosion control methods

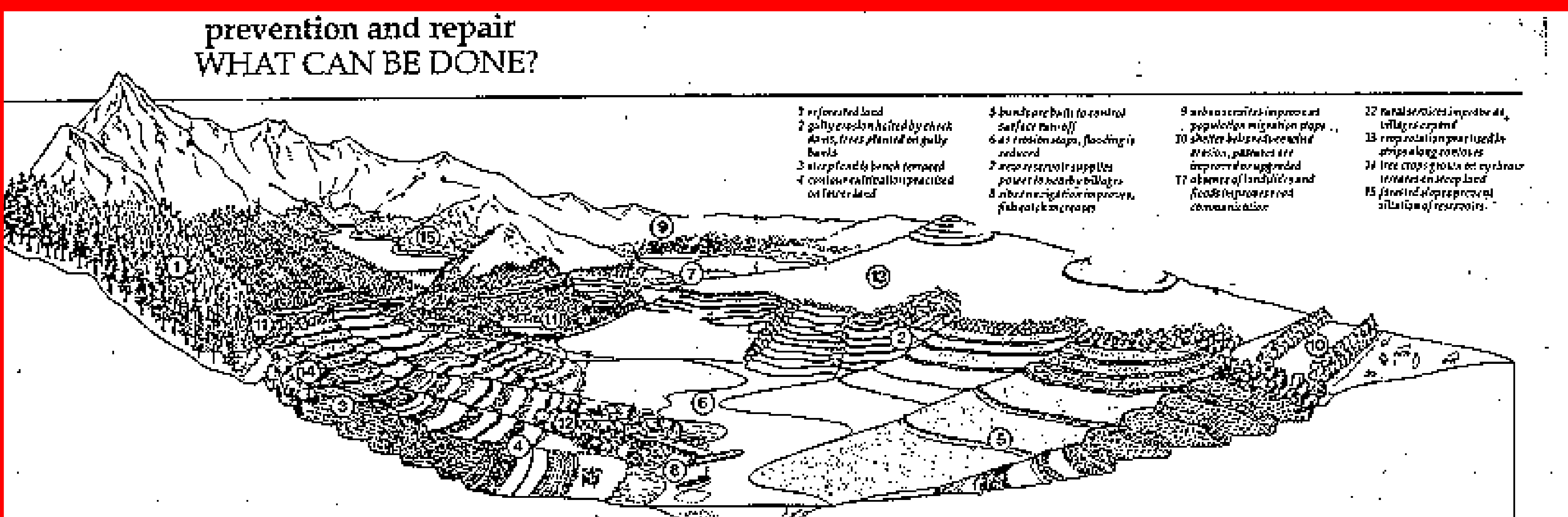
Mechanical Methods
Roadside erosion control methods

Mechanical Methods
Roadside erosion control methods

Basic Principles in Watershed Management




THE CONSEQUENCES OF EROSION
1 deforested land
2 steep land being cultivated down the slope
3 ... crops grown over large areas
4 landslide blocks road
5 fish catch is reduced in shallow waters
6 silt in reservoir reduces lifetime of hydroelectric plant
7 gully erosion cuts into cropland
8 sand banks reduce navigability of rivers
9 urban slums grow as rural population migrates to the city
10 bridge destroyed by floods
11 crops grown on large unprotected fields
12 badly managed pasture suffers from wind erosion
13 frequently flooded village becomes deserted


prevention and repair
WHAT CAN BE DONE?
1 reforested land
2 gully erosion halted by check dams, trees planted on gully banks
3 steep land is bench terraced
4 contour cultivation practiced on lower land
5 bunds are built to control surface runoff
6 as erosion stops, flooding is reduced
7 new reservoir supplies power to nearby villages
8 river navigation improves, fish catch increases
9 urban services improve and population migration stops
10 shelter belts reduce wind erosion, pastures are improved or upgraded
11 absence of landslides and floods improves road communication
12 rural services improve as villages expand
13 crop rotation practised in strips along contours
14 tree crops grown on eyebrow terraces on steep land
15 forested slopes prevent siltation of reservoirs

Hydrologic condition as Watershed Management Indicator



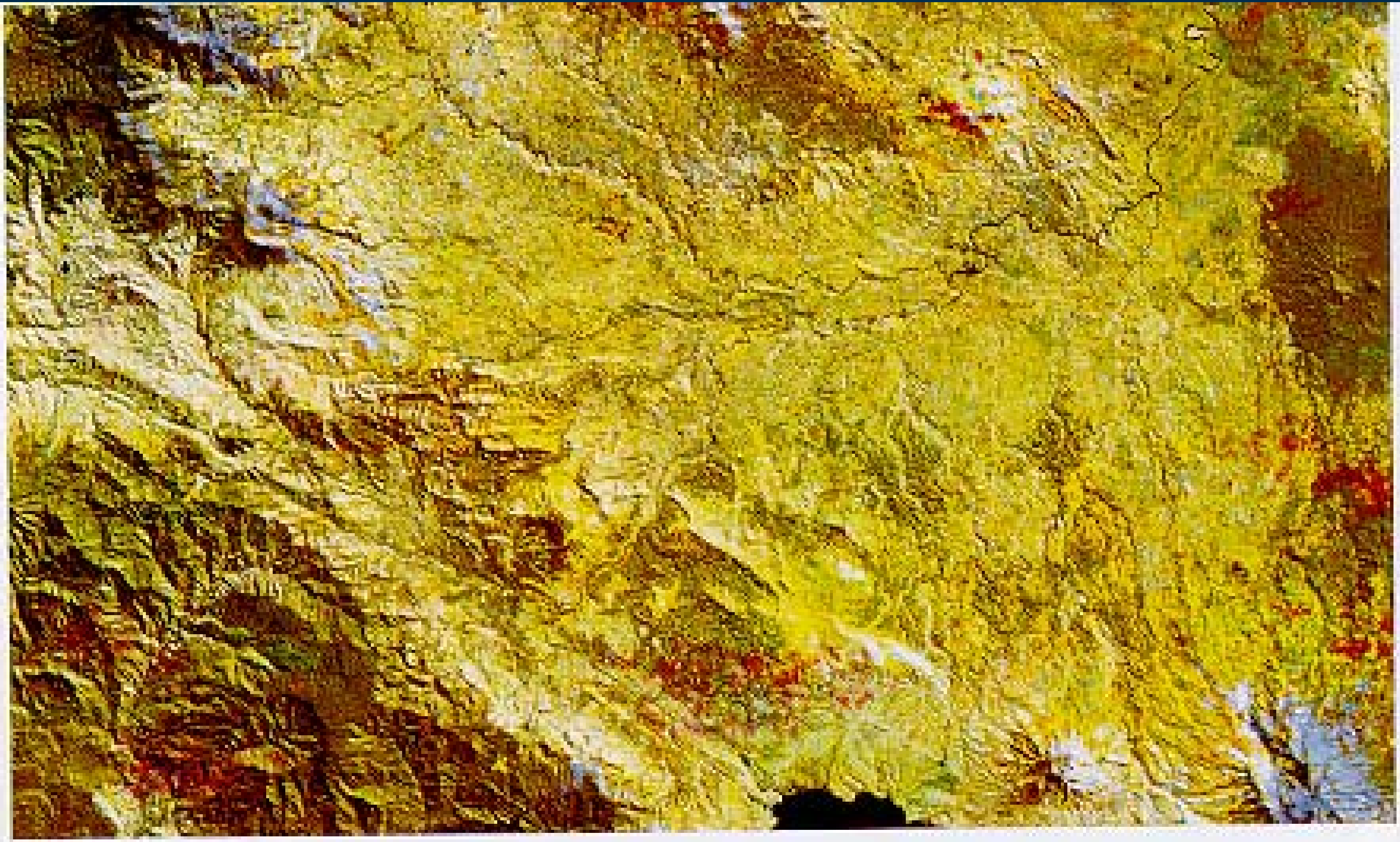



Plate 4.4 Landsat MSS of south Sumatra, for 1973, 1984 and 1986. The contiguous yellowish areas were deforested during 1973-1986 and the reddish areas between 1984 and 1986.

DATA SUPLEMENT for :

HANDLING CRITICAL LAND

PRESENTED

1. CRETERIA of CRITICAL LAND at EXISTING PROTECTION FOREST

No	Creteria (% Weight)	Class	Amount / Description	Score	Note
1	2	3	4	5	6
1	Land Cover (50)	1. Very Good 2. Good 3. Enough 4. Bad 5. Very Bad	> 80 % 61 - 80 % 41 - 60 % 21 - 40 % < 20 %	5 4 3 2 1	Assess by covering percentage of plant crown
2	Slope (20)	1. Flat 2. Gentle 3. Rather Steep 4. Steep 5. Very Steep	< 8 % 8 - 15 % 16 - 25 % 26 - 40 % > 40 %	5 4 3 2 1	
3	Erosion (20)	1. Light	**<u>for Deep Soil</u>** top soil lose < 25 % or slot erosion at distance 20 - 50 m **<u>for Shallow Soil</u>** top soil lose < 25 % and / or slot erosion at distance > 50 m	5	
		2. Moderate	**<u>for Deep Soil</u>** top soil lose 25 - 75 % and / or slot erosion at distance < 20 m **<u>for Shallow Soil</u>** top soil lose 25 - 50 % and / or slot erosion at distance 20 - 50 m	4	
		3. Weight	**<u>for Deep Soil</u>** top soil lose > 75 % and / or slot erosion at distance 20 - 50 m **<u>for Shallow Soil</u>** top soil lose 50 - 75 %	3	
		4. Very Weight	**<u>for Deep Soil</u>** All of top soil lose until > 25 % under top soil and / or slot erosion with moderate deep soil at distance < 20 m	2	

No	Creteria (% Weight)	Class	Amount / Description	Score	Note
1	2	3	4	5	6
			for Shallow Soil top soil lose > 75 %, a part under top soil had been erosion		
4	Management (10)	1. Good 2. Enough 3. Bad	Complete *) No Complete Nothing	5 3 1	*) - Boundary System Existing - Safety / Controling is Exist - To Implemated the desimination

DG RRL, 1998

2 CRETERIA of CRITICAL LAND at PROTECTION AREA out of EXISTING FOREST

No	Creteria (% Weight)	Class	Amount / Description	Score	Note
1	2	3	4	5	6
1	Land Cover (50)	1. Very Good 2. Good 3. Enough 4. Bad 5. Very Bad	> 80 % 61 - 80 % 41 - 60 % 21 - 40 % < 20 %	5 4 3 2 1	Assess by covering percentage of plant crown
2	Slope (10)	1. Flat 2. Gentle 3. Rather Steep 4. Steep 5. Very Steep	< 8 % 8 - 15 % 16 - 25 % 26 - 40 % > 40 %	5 4 3 2 1	
3	Erosion (10)	1. Light	**for Deep Soil** top soil lose < 25 % or slot erosion at distance 20 - 50 m **for Shallow Soil** top soil lose < 25 % and / or slot erosion at distance > 50 m	5	
		2. Moderate	**for Deep Soil** top soil lose 25 - 75 % and / or slot erosion at distance < 20 m **for Shallow Soil** top soil lose 25 - 50 % and / or slot erosion at distance 20 - 50 m	4	
		3. Weight	**for Deep Soil** top soil lose > 75 % and / or slot erosion at distance 20 - 50 m **for Shallow Soil** top soil lose 50 - 75 %	3	
		4. Very Weight	**for Deep Soil** All of top soil lose until > 25 % under top soil and / or slot erosion with moderate deep soil at distance < 20 m	2	

No	Creteria (% Weight)	Class	Amount / Description	Score	Note
1	2	3	4	5	6
			<u>for Shallow Soil</u> top soil lose > 75 %, a part under top soil had been erosion		
4	Management (30)	1. Good	Implementation Soil Conservation are complete and suitable with Technical Instruction	5	
		2. Enough	No Complete / No Conservatoin	3	
		3. Bad	Nothing	1	

DG RRL, 1998

3 CRETERIA of CRITICAL LAND at FARMING CULTIVATION AREA

No	Creteria (% Weight)	Class	Amount / Description	Score	Note
1	2	3	4	5	6
1	Productivity *) (30)	1. Very High 2. High 3. Enough 4. Low 5. Very Low	> 80 % 61 - 80 % 41 - 60 % 21 - 40 % < 20 %	5 4 3 2 1	*) Assess by ratio toward optimal general commodity production at traditional management
2	Slope (20)	1. Flat 2. Gentle 3. Rather Steep 4. Steep 5. Very Steep	< 8 % 8 - 15 % 16 - 25 % 26 - 40 % > 40 %	5 4 3 2 1	
3	Erosion (15)	1. Light	**for Deep Soil** top soil lose < 25 % or slot erosion at distance 20 - 50 m **for Shallow Soil** top soil lose < 25 % and / or slot erosion at distance > 50 m	5	
		2. Moderate	**for Deep Soil** top soil lose 25 - 75 % and / or slot erosion at distance < 20 m **for Shallow Soil** top soil lose 25 - 50 % and / or slot erosion at distance 20 - 50 m	4	
		3. Weight	**for Deep Soil** top soil lose > 75 % and / or slot erosion at distance 20 - 50 m **for Shallow Soil** top soil lose 50 - 75 %	3	
		4. Very Weight	**for Deep Soil** All of top soil lose until > 25 % under top soil and / or slot erosion with moderate deep soil at distance < 20 m **for Shallow Soil** top soil lose > 75 %, a part under top soil had been erosion	2	

No	Creteria (% Weight)	Class	Amount / Description	Score	Note
1	2	3	4	5	6
4	Bad Rock (5)	1. Little	< 10 % land surface to covered by bad rock	5	
		2. Enough	10 - 30 % land surface to covered by bad rock	3	
		3. Many	> 30 % land surface to covered by bad rock	1	
5	Management (30)	1. Good	Implementation Technology of of Soil Conservation are complete and suitable with Technical Instruction	5	
		2. Enough	No Complete / No Conservatoin	3	
		3. Bad	Nothing	1	

DG RRL, 1998

1. CRITICALLY LAND CLASSIFICATION for EXISTING PROTECTION FOREST

No	Land Critically Catagories	Amount Value
1	Very Critical	120 - 180
2	Critical	181 - 270
3	Rather Critical	271 - 360
4	Potensial Critical	361 - 450
5	Not Critical	451 - 500

2. CRITICALLY LAND CLASSIFICATION for PROTECTION AREA out of EXISTING FOREST

No	Land Critically Catagories	Amount Value
1	Very Critical	110 - 200
2	Critical	201 - 275
3	Rather Critical	276 - 350
4	Potensial Critical	351 - 425
5	Not Critical	426 - 500

3. CRITICALLY LAND CLASSIFICATION for FARMING CULTIVATION AREA

No	Land Critically Catagories	Amount Value
1	Very Critical	115 - 200
2	Critical	201 - 275
3	Rather Critical	276 - 350
4	Potensial Critical	351 - 425
5	Not Critical	426 - 500

DG RRL, 1998

Just for Example :

One of Land Unit for Critical Land at Protection Area out of Existing Forest

Creteria	% Weight	Score	Amount
- Land Covering by plant crown 50 %	50	3	150
- Slope > 40 %	10	1	10
- Erosion at Shallow Soil that Top Soil lose 50 - 75 %	10	3	30
- Management is not complete	30	3	90
			280

The result is **RATHER CRITICAL**

Comprehensive Basin-wide Sediment Management Study on the Brantas River Basin

under

Water Resources Existing Facilities Rehabilitation and Capacity Improvement Project (WREFR&CIP)

Implemented by DGWR-PU

Financed by JBIC

Water Resources Existing Facilities Rehabilitation and Capacity Improvement Project (WREFR&CIP)

- To strengthen the O&M capacity of the responsible organizations

- To restore the capacity and function of the existing damaged facilities

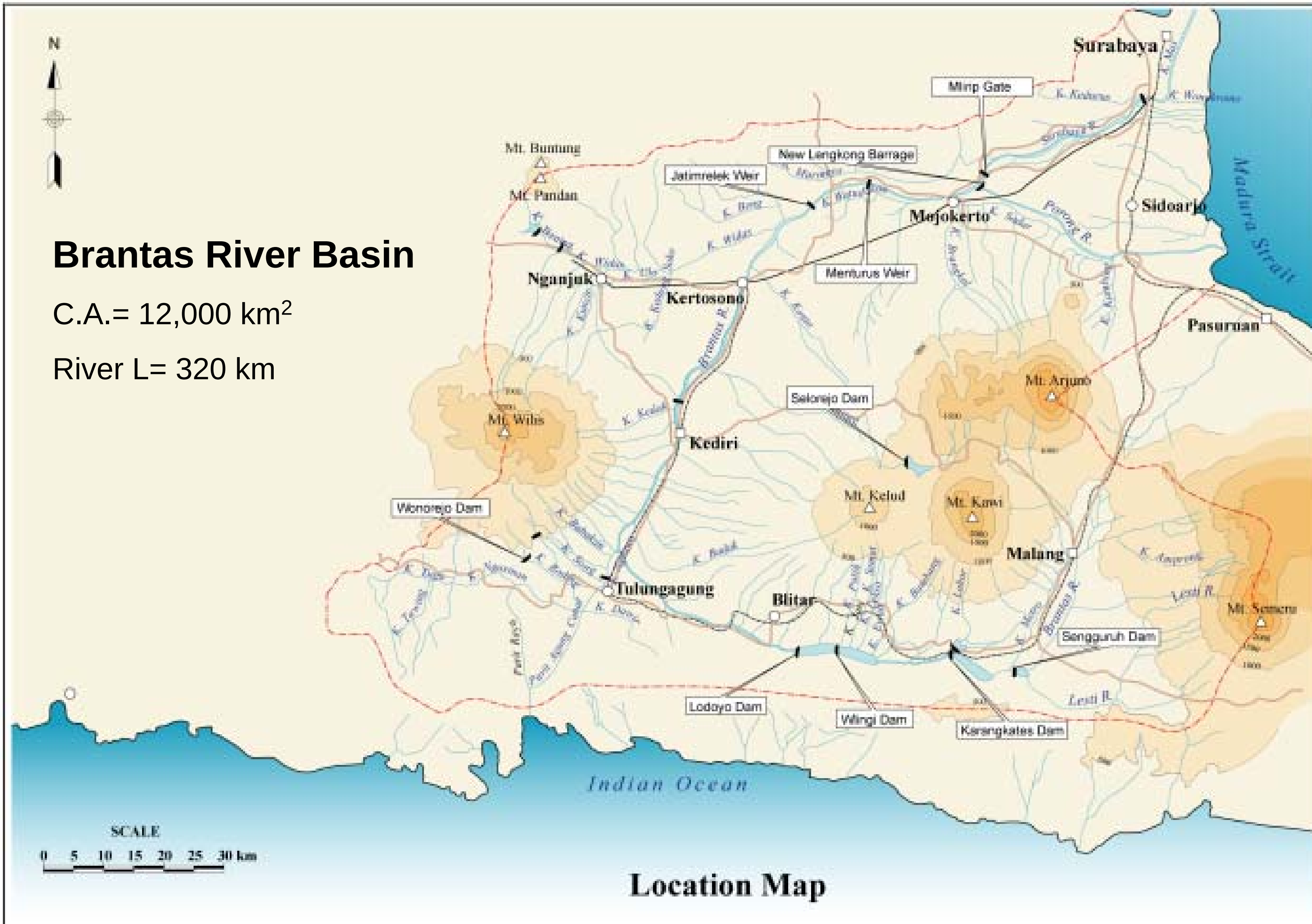
  (Dam, River, Sabo and Irrigation)

  Brantas River, Upper Solo and Madiun Rivers, **Mt. Kelud Sabo** and Ular Irrigation (North Sumatra)

Brantas River Basin

C.A.= 12,000 km^2

River L= 320 km



Location Map

OBJECTIVE OF THE STUDY

1. **To formulate a comprehensive basin-wide sediment management plan for the Brantas River basin to solve the sediment management issues in the basin.**

   - Induction of "Sediment Flow System" –

2. **To formulate a riverbed management plan for the Upper Bengawan Solo River and the Madiun River basins.**
3. **To formulate a watershed conservation master plan for the four(4) target area; Upper Brantas River basin, Lekso River basin, Upper Konto River basin and Brangkal River basin.**
4. **To conduct the survey on solid waste disposal into the Upper Brantas River for river environmental improvement and reduction of solid waste inflow in the reservoirs.**

Damage of structures in the Brantas River

There are many damaged or deteriorated river structures in the Brantas River basin.

Upper Brantas Area

- Sedimentation in check dams, sand pockets and sabo dams on mountain slopes
- Serious sedimentation in the Sengguruh Dam, Karangkates Dam, Wlingi Dam, and Lodoyo Dam reservoirs

Brantas middle reach

- Damaged rubber dam (Jatimlerek rubber dam)
- Exposed Watudakon Syphon
- River bank collapse

Porong River

- Damaged ground sills
- Washed away ground sill on downstream section of toll road bridge
- River bank collapse

In the past ...

Countermeasures, restoration and rehabilitation plans for sediment related issues in the basin have been formulated **individually**.

→ *Lack of view of basin-wide sediment management*

Induced by **unbalanced sediment flow** between upper reach and lower reach

Factors causing unbalanced sediment flow

- Eruption of Mt. Kelud and Mt. Semeru,
- Blocking of sediment flow by dams and sabo facilities, and
- Sand mining, etc.

↓

Necessity of comprehensive basin-wide sediment management

Present Situation in the Brantas River

- Sediment and Solid Waste flown into the Reservoir
- Sediment Deposit in the Reservoirs
- Excessive Sand Mining on the Rivers
- Riverbed Degradation
- Damages on the River Structures

Solid Waste Disposal into Rivers

The Study estimated the present volume of waste disposal in Malang City as 60 m^3/day (=13.5 ton/day) based on the study by the Merdeka University and the Study Team.

Solid Waste in the Reservoirs

Plastic waste in spoil bank of Sengguruh reservoir

Sedimentation in Reservoirs

Sengguruh Reservoir

Dredging in reservoir

Incidence of water hyacinth due to eutrophication

Since completion of dam reservoirs, sediment accumulation has significantly reduced their original capacities.

Excessive Sand Mining

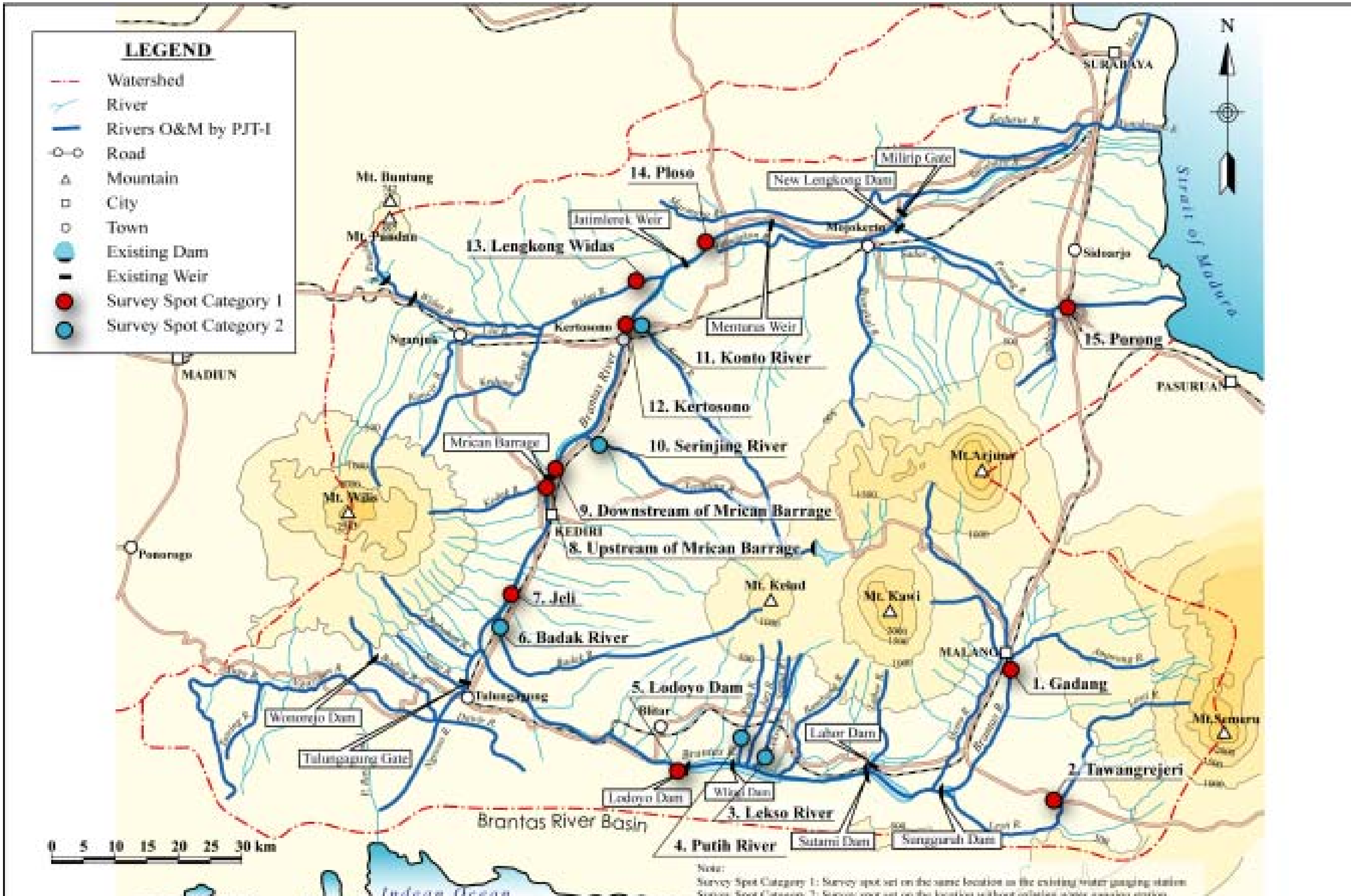
Damages Caused by Riverbed Degradation

Damaged Jatimlerek Rubber Dam,
Brantas River

Exposed foundation (Cepiples railway bridge),
Porong River

Survey and Investigation

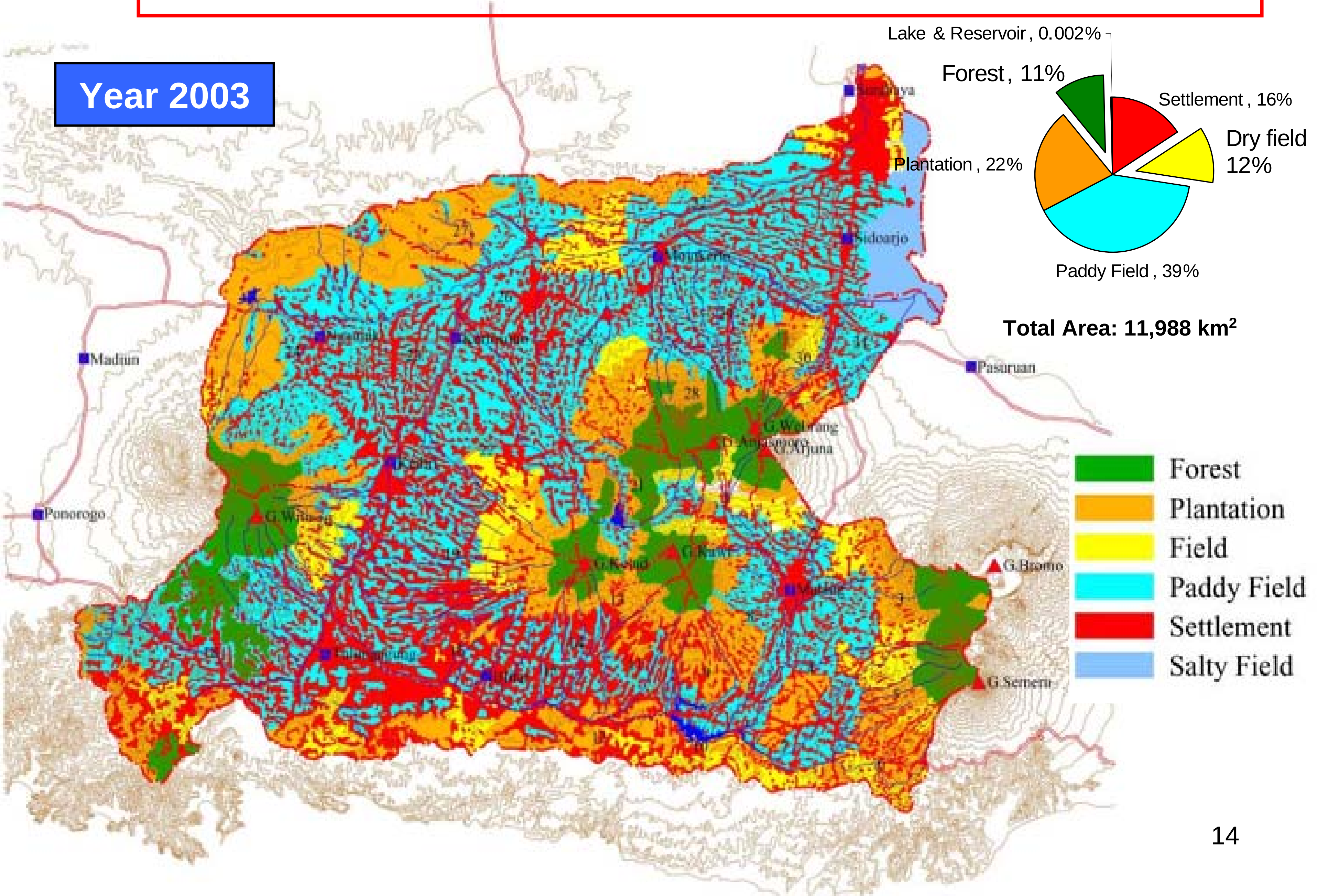
- **River Survey : Brantas River (Main and some tributaries)**
  - River cross section data
- **Geological Investigation and Laboratory Test**
  - Reservoir and riverbed material
- **Bathymetric Survey and Estuary Survey (Porong River)**
  - Reservoir storage capacity and Effect of sand flushing
- **Sediment Survey and Laboratory Test**
  - Sediment material of river water in Main/tributaries of Brantas
- **Sand Mining and Market Survey**
- **Environmental Investigation and Evaluation**
  - Effect of sand flushing
- **Aerial-photo Shooting : Upper Brantas area**
- **Purchase of Satellite Image**
- **Purchase of Aerial Photograph**
- **Purchase of Topographic map**
  - GIS Analysis
  - Present watershed condition; (4) Target area



Location of Sediment Survey

Present Land Use in the Brantas River Basin

Year 2003



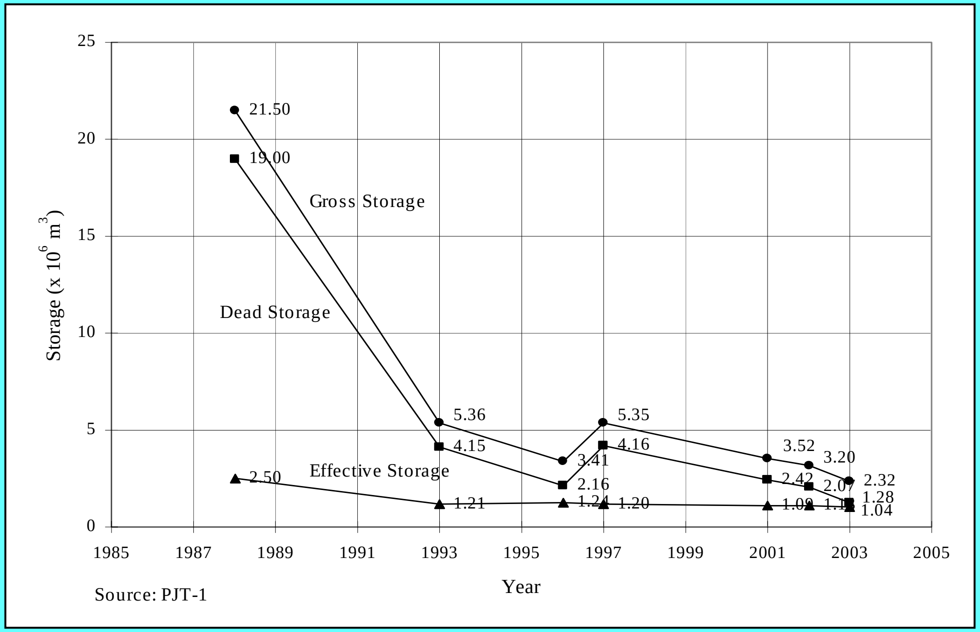
Total Area: 11,988 km^2

Sedimentation in the Reservoirs

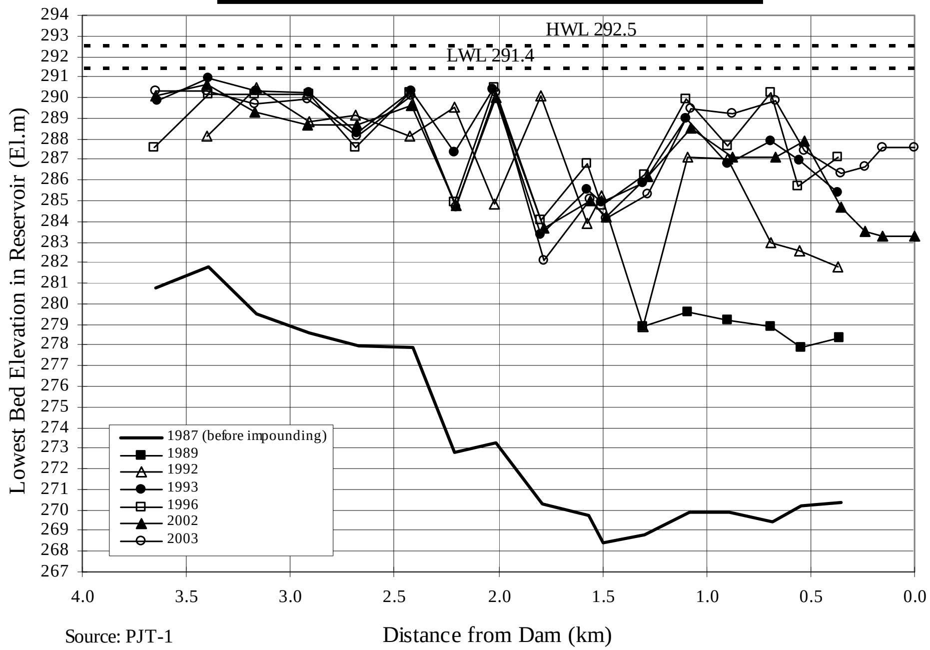
Reservoir	Com-pletion Year	Dam Height (m)	Reservoir Level (m)		Original Srorage Capacity (million m3)			Present Condition (million m3)		Gross Vol. of Removed Sediment by Dredging and Flushing (million m3)
			HWL	LWL	Gross	Effective	Dead	Effective Vol.	Deposit Sediment Vol.	
Sengguruh	1988	33.0	292.5	291.4	21.5	2.5	19.0	1.04	19.18	2.05
Sutami	1973	97.5	272.5	246.0	343.0	253.0	90.0	145.20	168.43	
Lahor	1977	74.0	272.5	253.0	36.1	29.4	6.7			
Wlingi	1977	28.0	163.5	162.0	24.0	5.2	18.8	2.01	19.59	13.60
Lodoyo	1983	11.3	136.0	125.5	5.2	5.0	0.2			
Selorejo	1972	48.0	620.0	598.0	62.3	50.1	12.2	50.10	18.29	0.20

Storage Capacity Transition

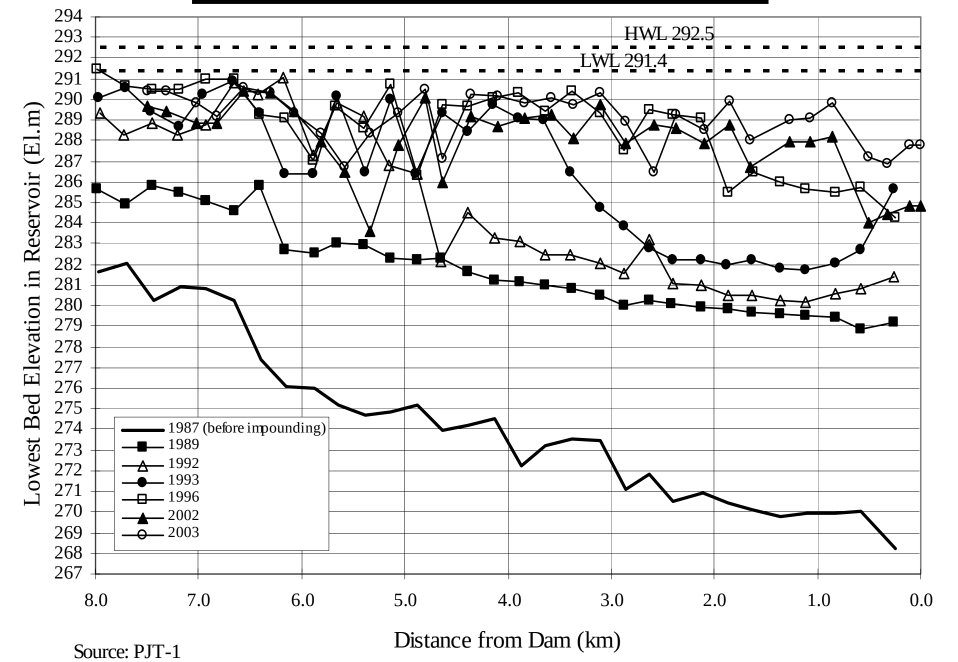
Sengguruh Reservoir



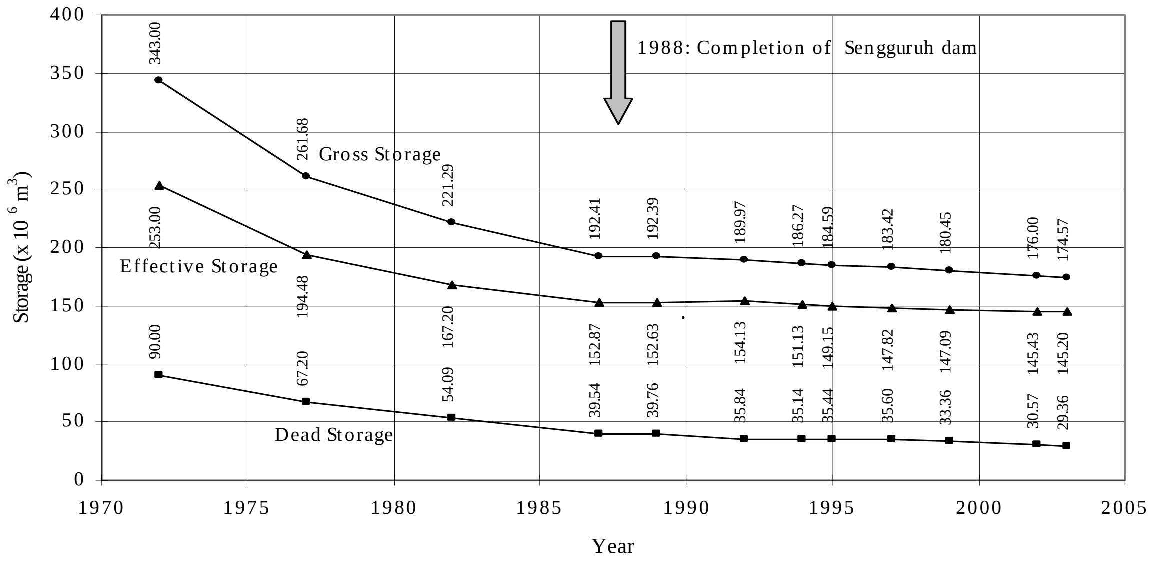
Brantas River

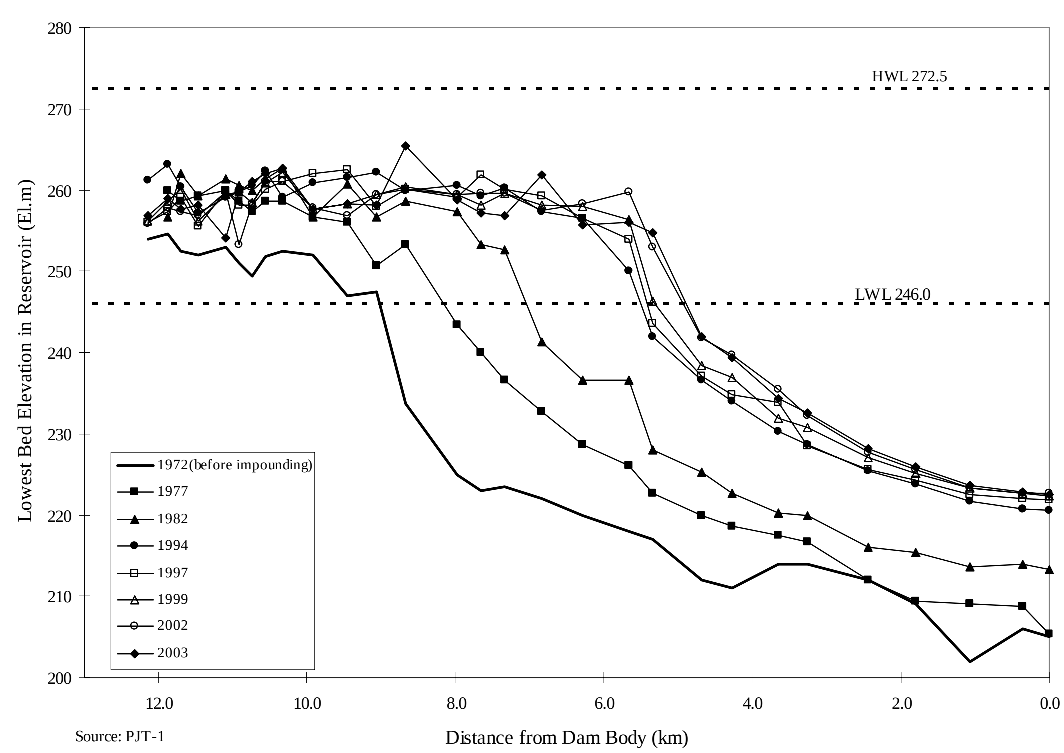


Lesti River

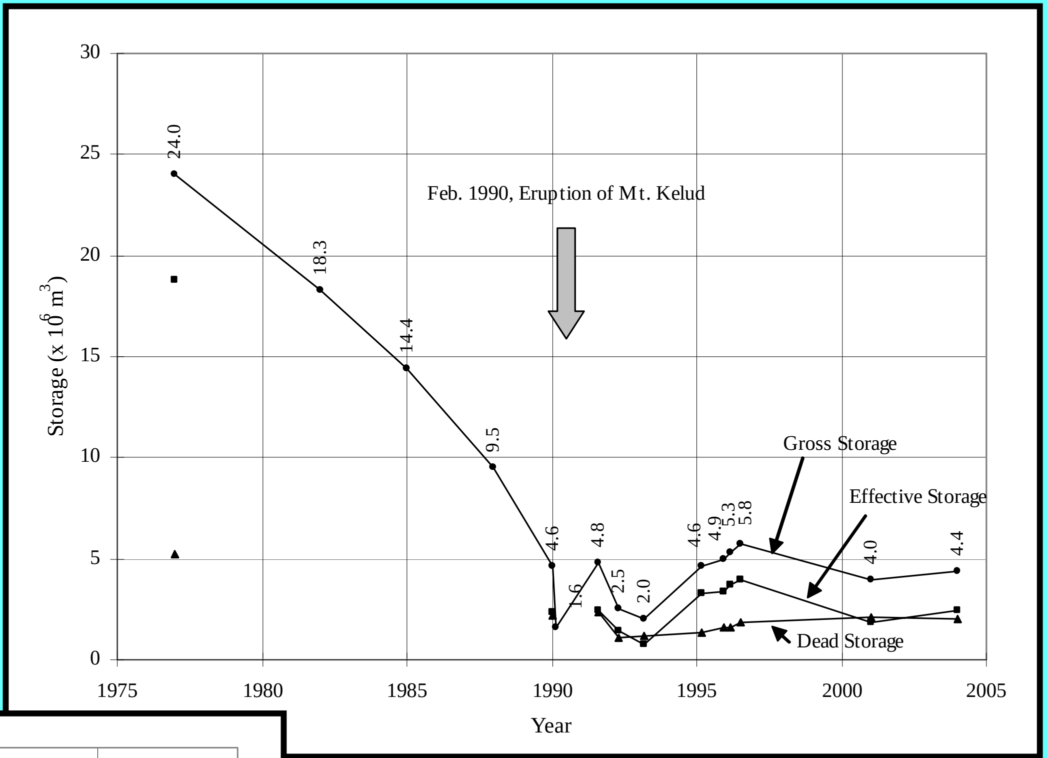


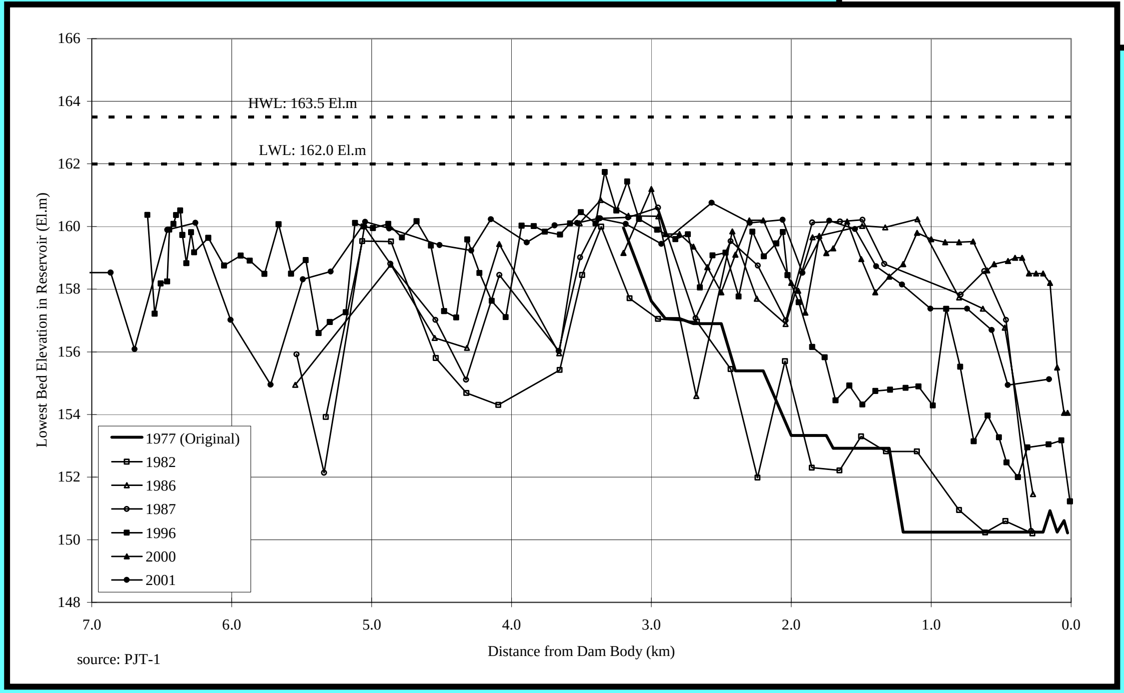
Sutami Reservoir





Wlingi Reservoir





Dredged Sediment Volume in Reservoirs

Year	Dredged Sediment Volume (m^3)			
	Sengguruh	Wlingi	Lodoyo	Selorejo
1988/1989		400,000		
1990/1991		1,708,000		
1991/1992		800,000		
1993	69,490	3,203,600		
1994	63,075	379,000		
1995	352,038	330,000		
1996	233,575	1,070,000		
1997	266,573	75,000		
1998	200,000	247,000		
1999	200,729	250,000		
2000	187,070	200,000		
2001	165,510	170,000		101,100
2002	110,000	110,000		70,050
2003	42,900	110,000	282,400	
2004	160,000	110,000	65,000	
Total (m^3)	2,050,960	9,162,600	347,400	171,150
Max Volume (m^3)	352,038	3,203,600	282,400	101,100
Min Volume (m^3)	42,900	75,000	65,000	70,050
Average Volume (m^3)	170,913	610,840	173,700	85,575

Source : PJT-I (as of Aug. 2004)

Sediment Flushing

Sediment flushing has been carried out in the Wlingi and the Lodoyo reservoirs since August 1990 immediately after the 1990 eruption of Mt. Kelud,

Sediment flushing, generally two times a year, has been conducted mostly in rainy season by coordinated gate operation of two dams, and

Sediment flushing by gate operation has been , in terms of removed sediment volume, proved to be an effective measure to maintain reservoir storage capacity.

Sediment Flushing Implemented in the Wlingi and Lodoyo Reservoirs

Flushing Implementation		Flushed Sediment Volume (m^3)	
Year	Time	Wlingi dam reservoir	Lodoyo dam reservoir
1990	4	1,900,000	
1992	1	215,000	
1993	1	189,000	
1999	1	479,900	65,200
2000	1	363,600	276,300
2001	2	715,000	52,300
February 2004	1	679,000	769,000
May 2004	1	219,000	106,000
Total Volume (m^3)		4,760,500	1,268,800
Max Volume (m^3)		715,000	769,000
Min Volume (m^3)		189,000	52,300
Average Volume (m^3)		396,700	211,500

Source : PJT-I Malang, blanks mean data not available.

Wlingi Reservoir (Sediment flushing on Feb.22, 2004)

Sediment on left bank

Sediment around power and irrigation intakes

Lodoyo Reservoir (Sediment flushing on Feb.22, 2004)

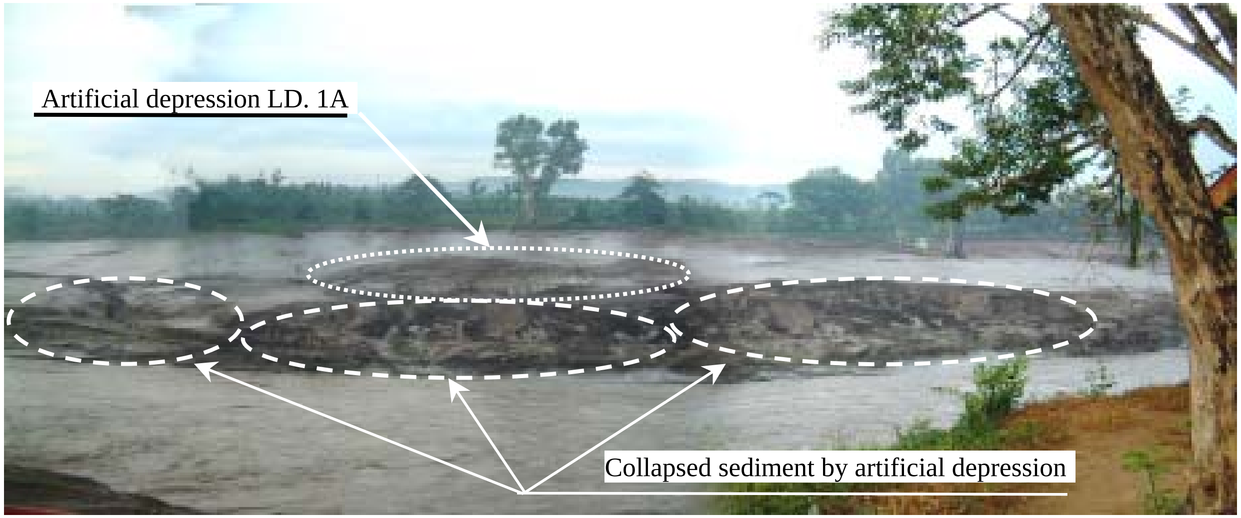
Sediment around upstream section of power intake

Sediment on left bank (on high water channel)

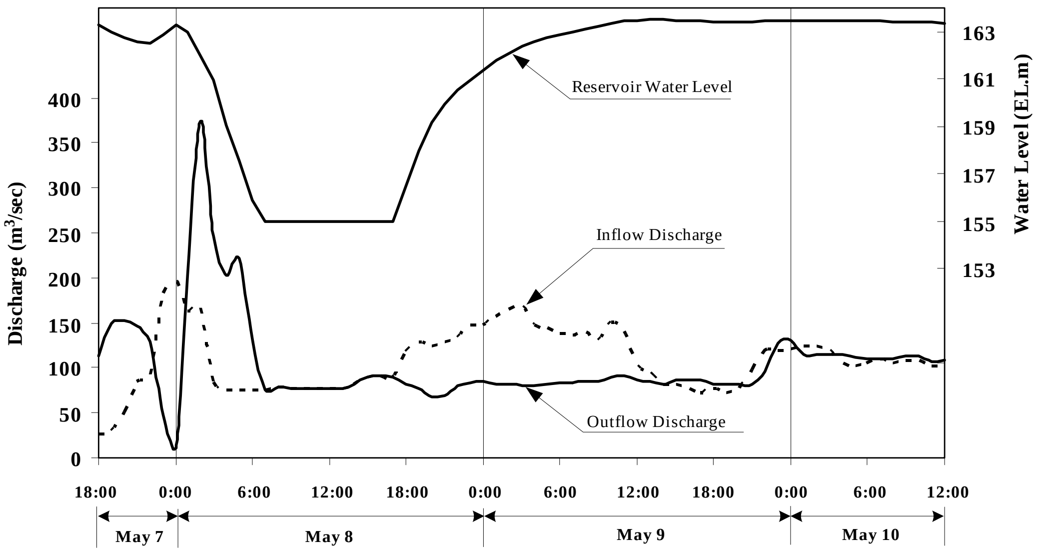
Coordinated Sediment Flushing Experiment

Date of experiment	May 7th to 10th, 2004	
Objective reservoirs	Wlingi reservoir	Lodoyo reservoir
Date of gate operation	From : 00:00, May 8 To : 14:00, May 9 (38 hours)	From : 19:00, May 7 To : 21:00, May 10 (74 hours)
Fluctuation of Water level Highest (before flushing) Lowest (during flushing)	 163.5m 155.0m	 136.0m 126.0m

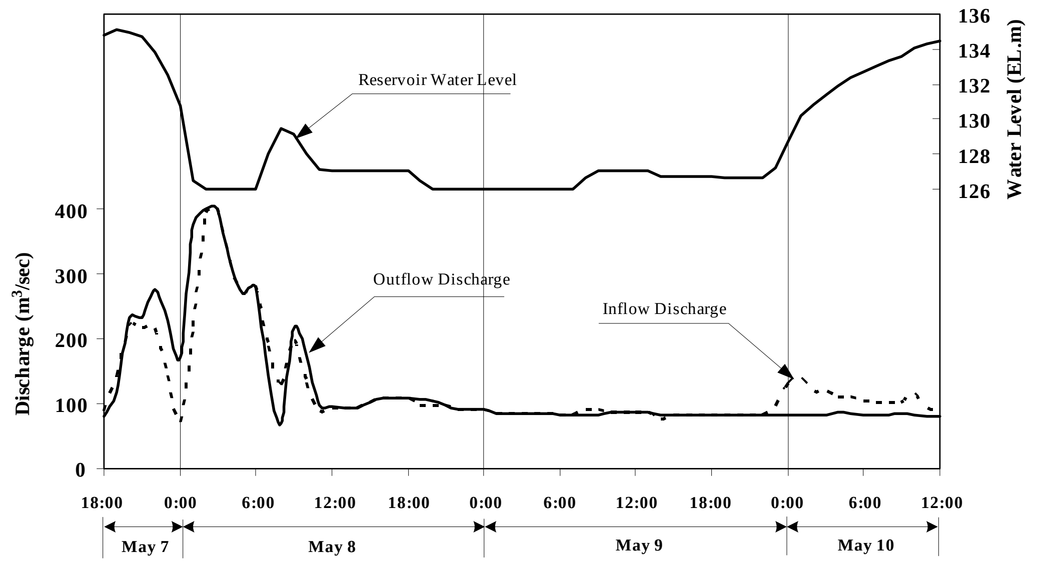
Flushing with combination measure (May 8, 2004)



Wlingi Reservoir



Lodoyo Reservoir



Operation Record of Reservoirs during the May 2004 Flushing

Sand Mining in the Brantas River

Sand mining volume has been increasing mainly by expanding utilization of pumping equipment.

Present Sand Mining Volume (1)

River Name	Sand Mining Volume (m^3/year)	No. of Workers (person/day)
Brantas Middle Reach (Tulungagung – New Lengkong Barrage)	**2,702,000**	**6,280**
Porong River (New Lengkong Barrage – Estuary)	**217,600**	**540**

Source: Estimated by the Study based on the result of sand mining survey.

Sand mining is dominant in Nganjuk, Jombang and Mojokerto Regencies in the Brantas River

Present Sand Mining Volume (2)

- Estimated based on the field investigation - as of 2004

Brantas River (179 locations)

Regency	Sand Mining Volume (m^3/year)			Nos. of Workers (Person/day)
	Manual (m^3/year)	Pumping (m^3/year)	Total (m^3/year)	
Sidoarjo	42,500	0	42,500	150
Mojokerto	151,500	111,000	262,500	1,060
Jombang	822,600	168,200	990,800	3,220
Nganjuk	267,100	383,000	650,100	720
Kediri	200,800	135,700	336,500	510
Kota Kediri	47,900	182,800	230,700	220
Tulungagung	0	188,900	188,900	400
Total	1,532,400	1,169,600	2,702,000	6,280

Porong River (35 locations)

as of 2004

Regency	Sand Mining Volume (m^3/year)			Nos. of Workers (Person/day)
	Manual (m^3/year)	Pumping (m^3/year)	Total (m^3/year)	
Sidoarjo	22,200	79,100	101,300	270
Mojokerto	2,100	113,000	115,100	260
Pasuruan	1,200	0	1,200	10
Total	25,500	192,100	217,600	540

Sand mining activities in the river has a significant influence on the riverbed change in the Brantas middle reaches and the Porong River.

Influence of Sand Mining Activities on Riverbed after 30 Years

River Section Calculated Case	Porong Estuary •		New Lengkong Barrage •		Menturus Rubber Dam •		Jatimlerek Rubber Dam •		Mrican Barrage •
With Sand Mining Activities		- 1.3 m (- 4.4 m)		- 0.6 m (- 3.3 m)		- 1.8 m (- 4.4 m)		- 1.6 m (-3.9 m)	
Without Sand Mining Activities		+ 1.4 m		+ 0.6 m		- 0.5 m		+ 0.7 m	
Difference		2.7 m		1.2 m		1.3 m		2.3 m	

Note: 1) Figures in the table show the mean difference between calculated riverbed elevation and present average riverbed by river section.
2) Figures in parentheses show the maximum difference between calculated riverbed elevation and present average riverbed by river section.

Regulation Relevant to Sand Mining

East Java Provincial Governor Decree No.36/1994

The sand mining activities in the main rivers had been completely prohibited . However it had been conducted even after the enforcement of the Decree.

East Java Provincial Governor Decree No.29/2003

- The promulgated in April 2003 stipulates about sand mining license in the Brantas, Surabaya, Porong, and Marmoyo Rivers.

- Aiming at keeping employment opportunities for sand mining workers, and controlling sand mining volume by prohibiting utilization of sand pumps.

Riverbed Degradation in the Middle and Lower Reaches

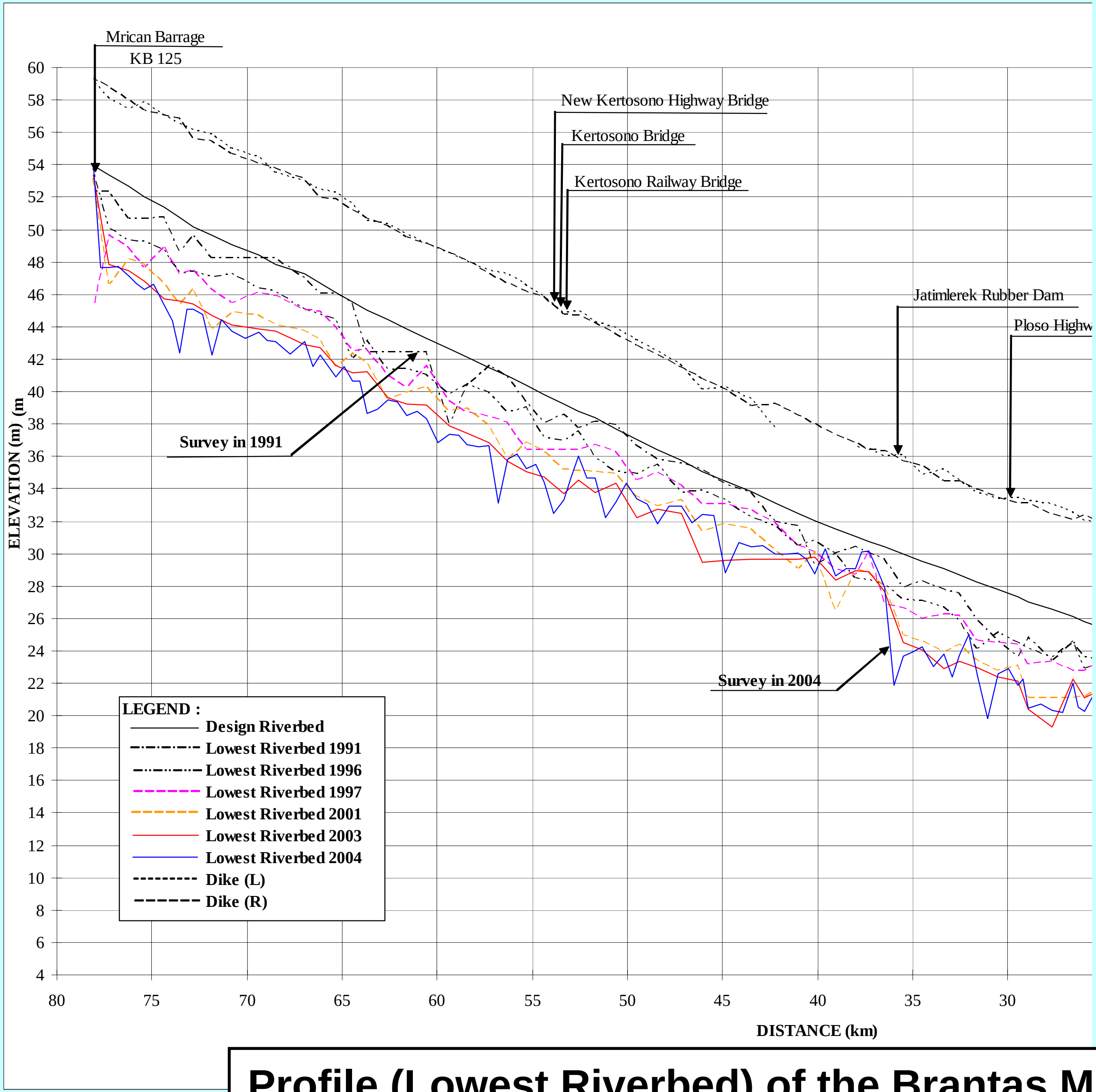
The Brantas middle and lower reaches have been suffering from the degradation of riverbed since the late 1980s, and the degradation of riverbed is still under progress in those reaches.:

Brantas River **(KB54+290, Watudakon)**

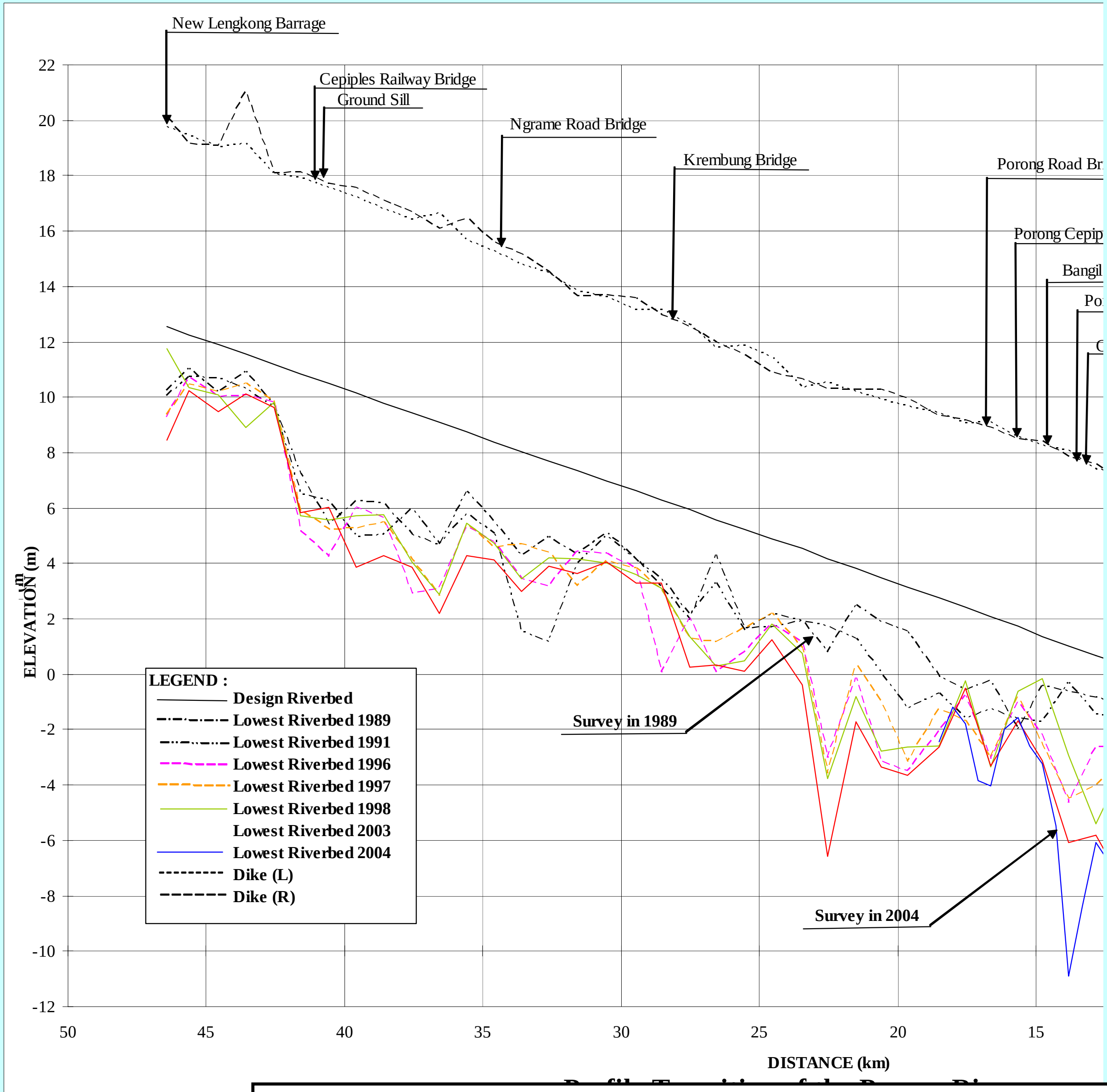
Degradation of riverbed in downstream section of Watudakon Siphon

Porong River **(KP 159, Pejarakan)**

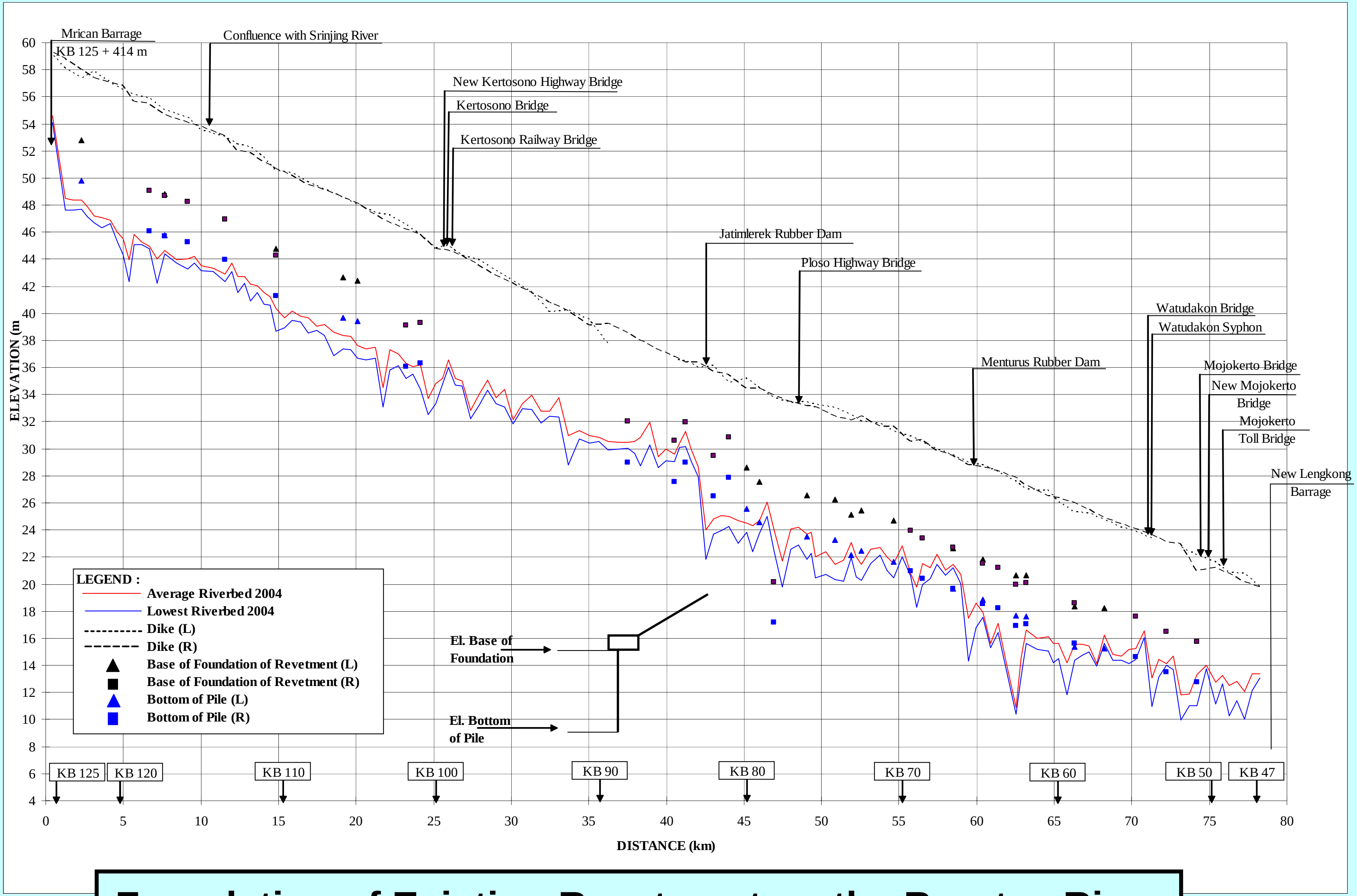
Degradation of riverbed and exposed conduit (old Bangil Taak Siphon)



Profile (Lowest Riverbed) of the Brantas Middle Reaches



Profile (Lowest Riverbed) of the Porong Rivers



Foundation of Existing Revetment on the Brantas River

Collapse of River Bank and Damage of Structures due to Riverbed Degradation (1)

Brantas River

Damaged Jatimlerek Rubber Dam

Damaged dike revetment (Right)
KB 85, KB 86 (Megaluh)

Collapse of River Bank and Damage of Structures due to Riverbed Degradation (2)

Porong River

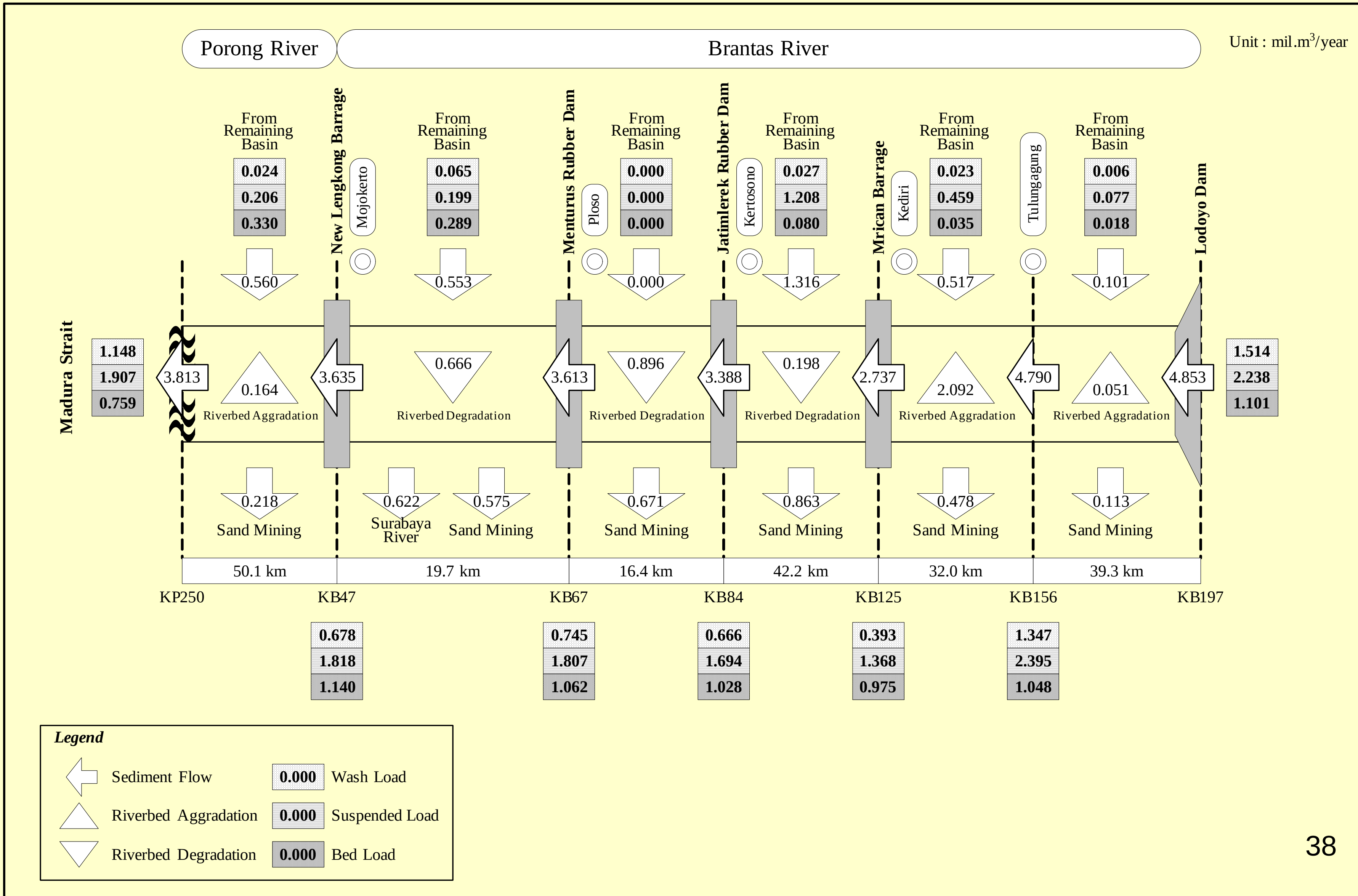
Exposed Foundation (Cepiples Railway Bridge)

KP 24 (Cepiples)

Collapsed revetment and dike (Right)

KP158 (Gempoljoyo)

Sediment Balance under Present River Condition (2004)

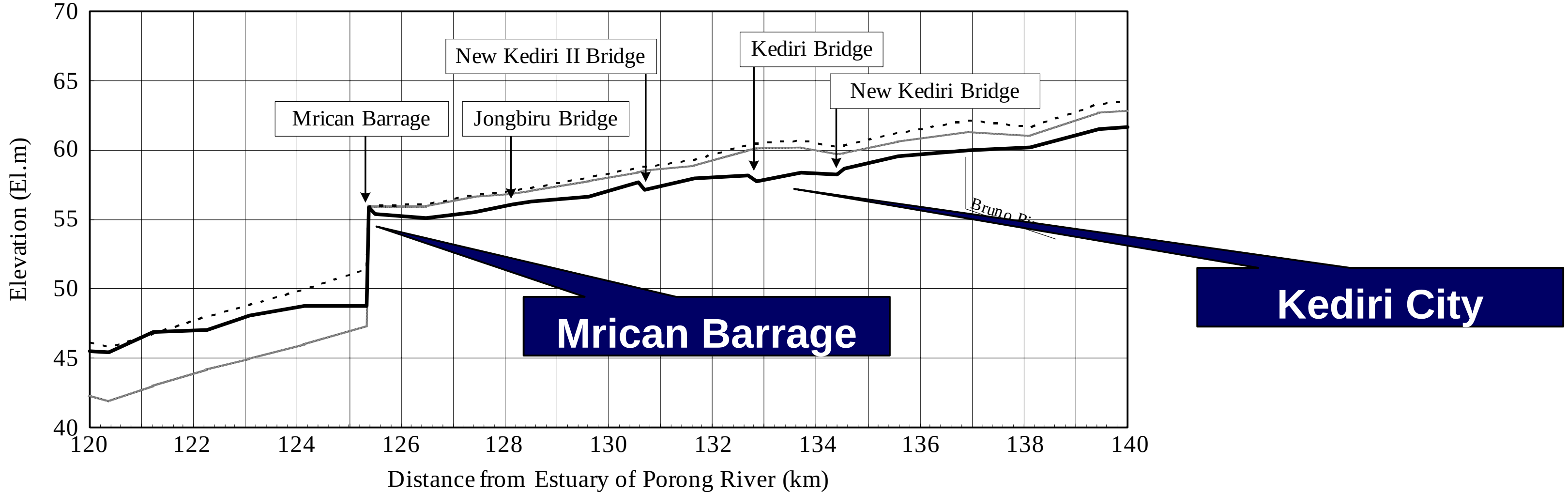


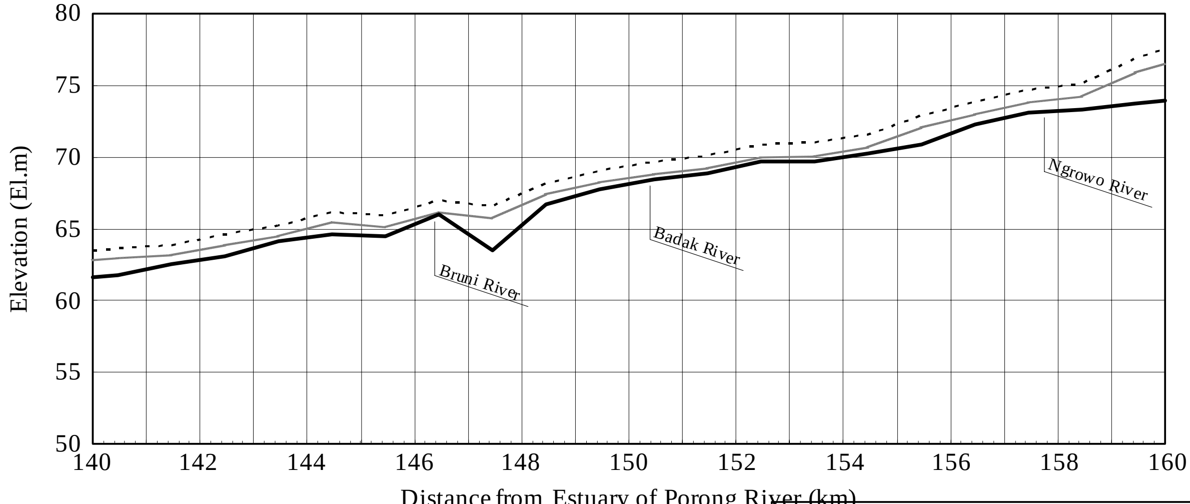
Riverbed Fluctuation Study

- One dimensional riverbed fluctuation model -

To examine:
- Future riverbed change,
- Influence of sand mining on the riverbed degradation
- Effectiveness of planned sediment control measures.

Using long term discharge for the period of 30 years including past major floods such as floods occurred in 1991, 1992, 1994, 1995 and 1998.





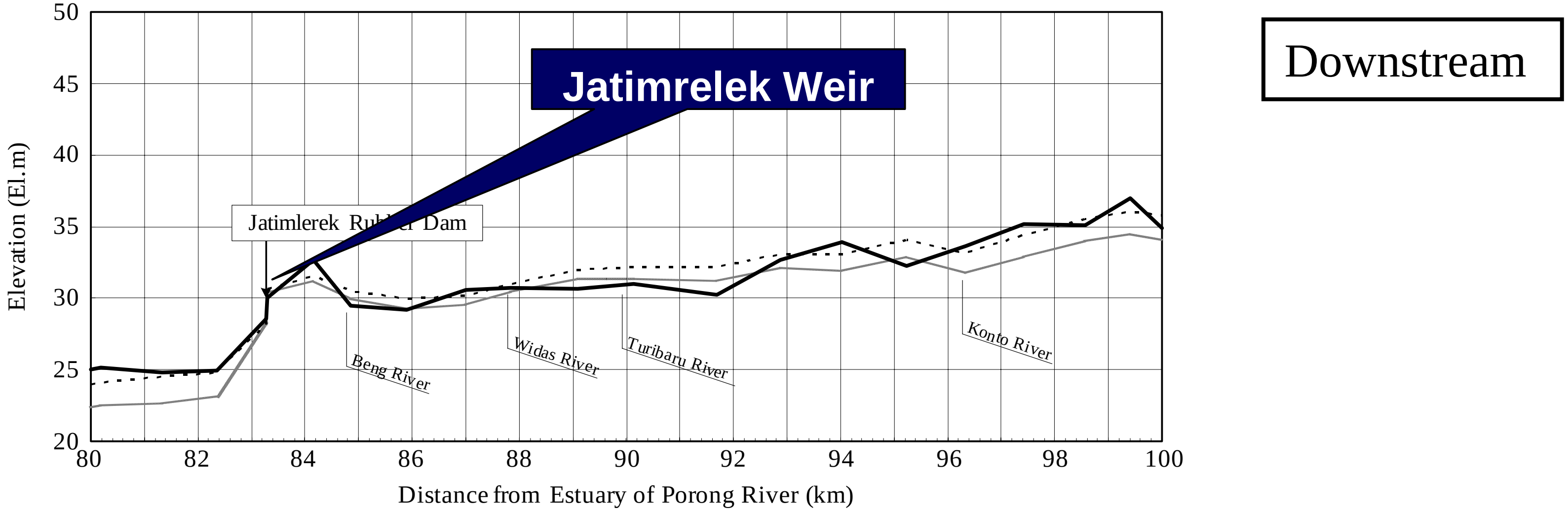
Upstream of Kediri

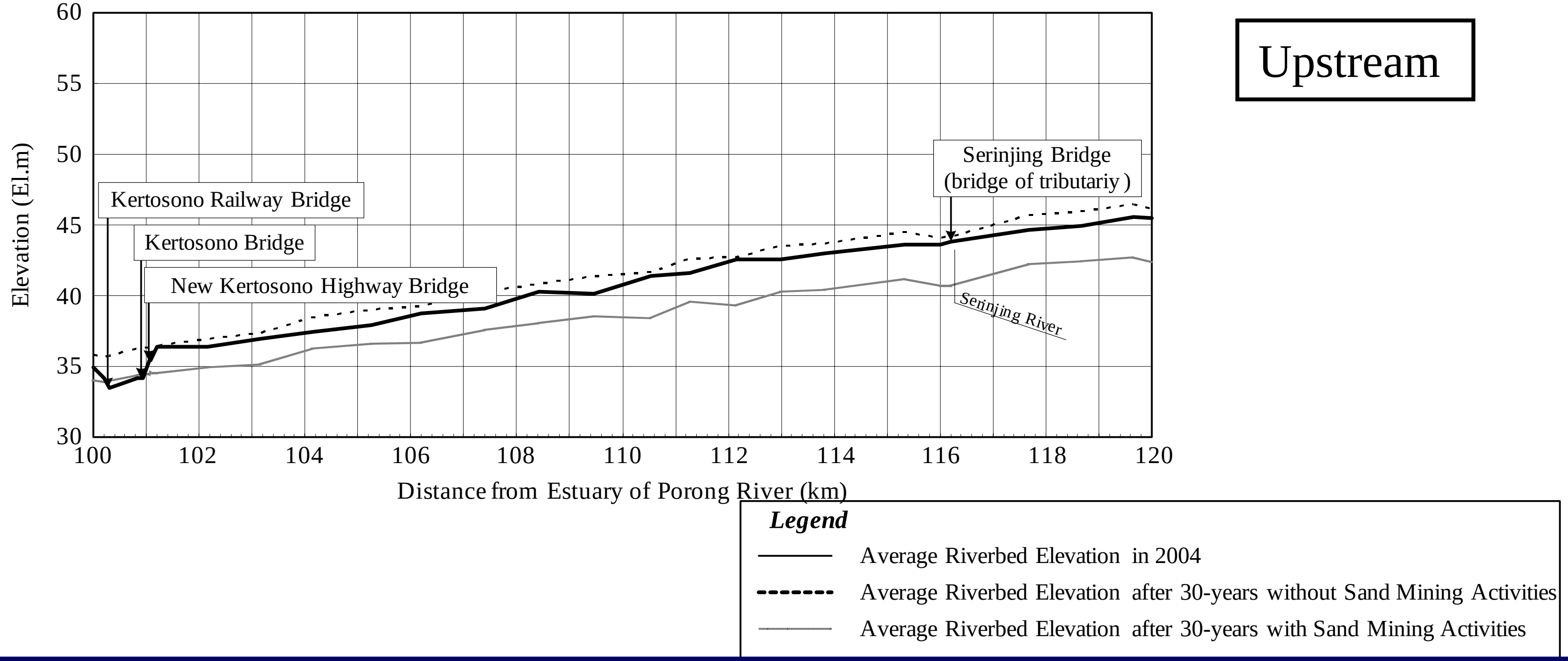
Riverbed Aggradation

Legend

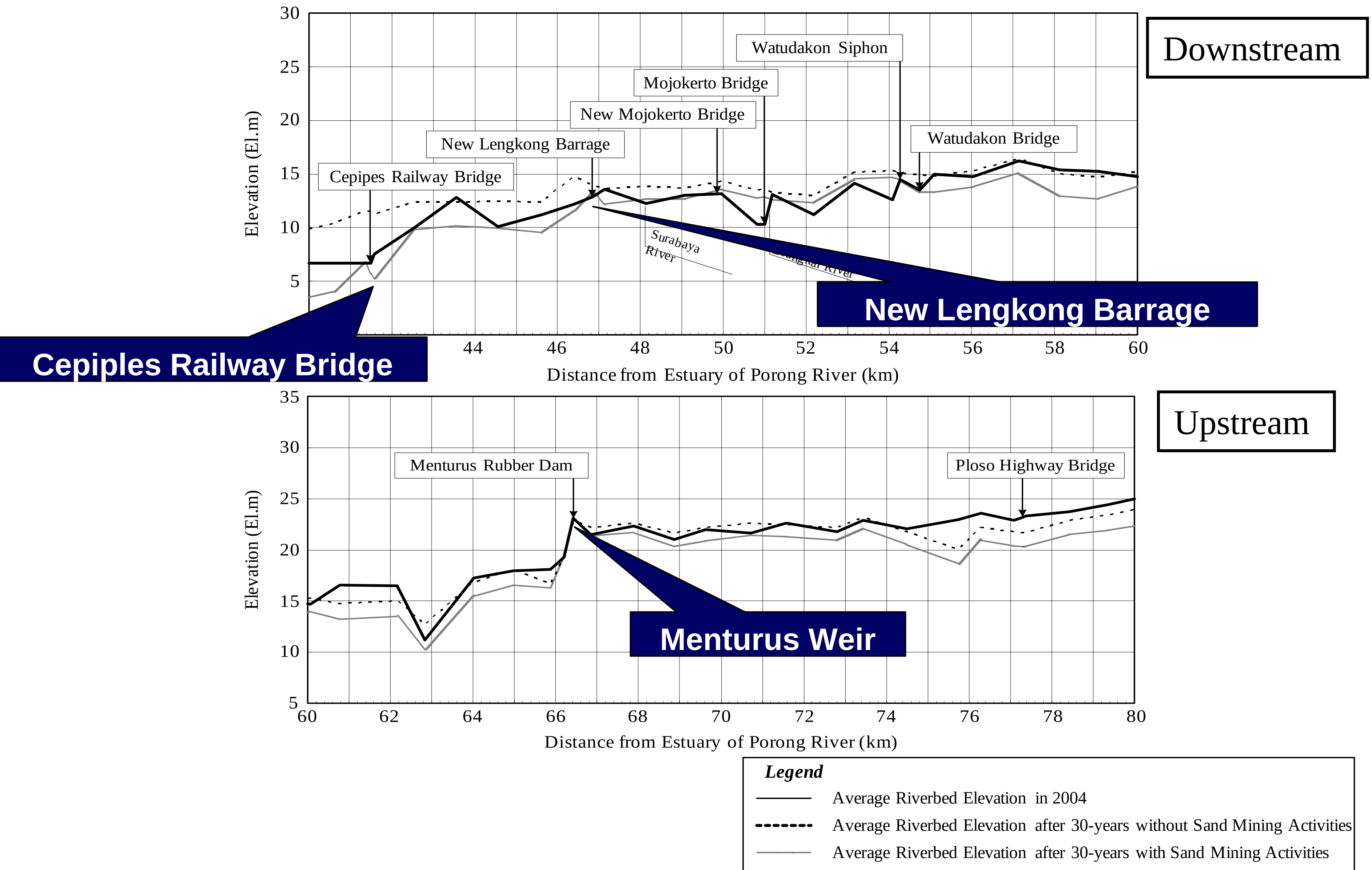
- Average Riverbed Elevation in 2004
- Average Riverbed Elevation after 30-years without Sand Mining Activities
- Average Riverbed Elevation after 30-years with Sand Mining Activities

Simulated Riverbed Fluctuations under Present River Condition (1/4)

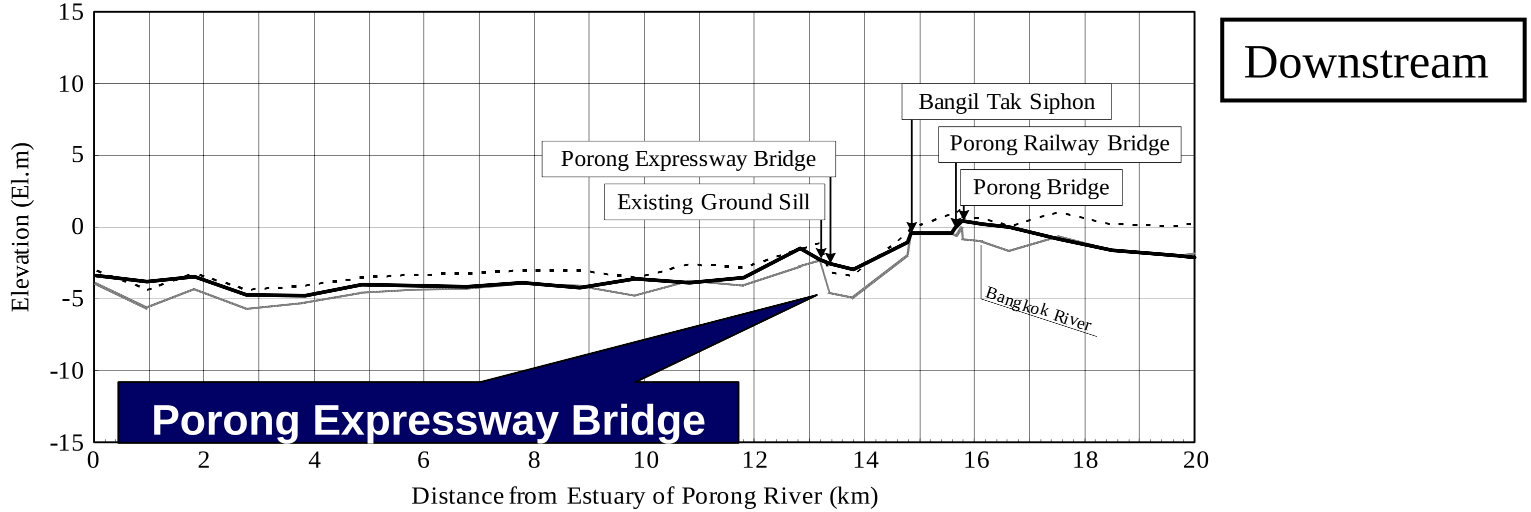


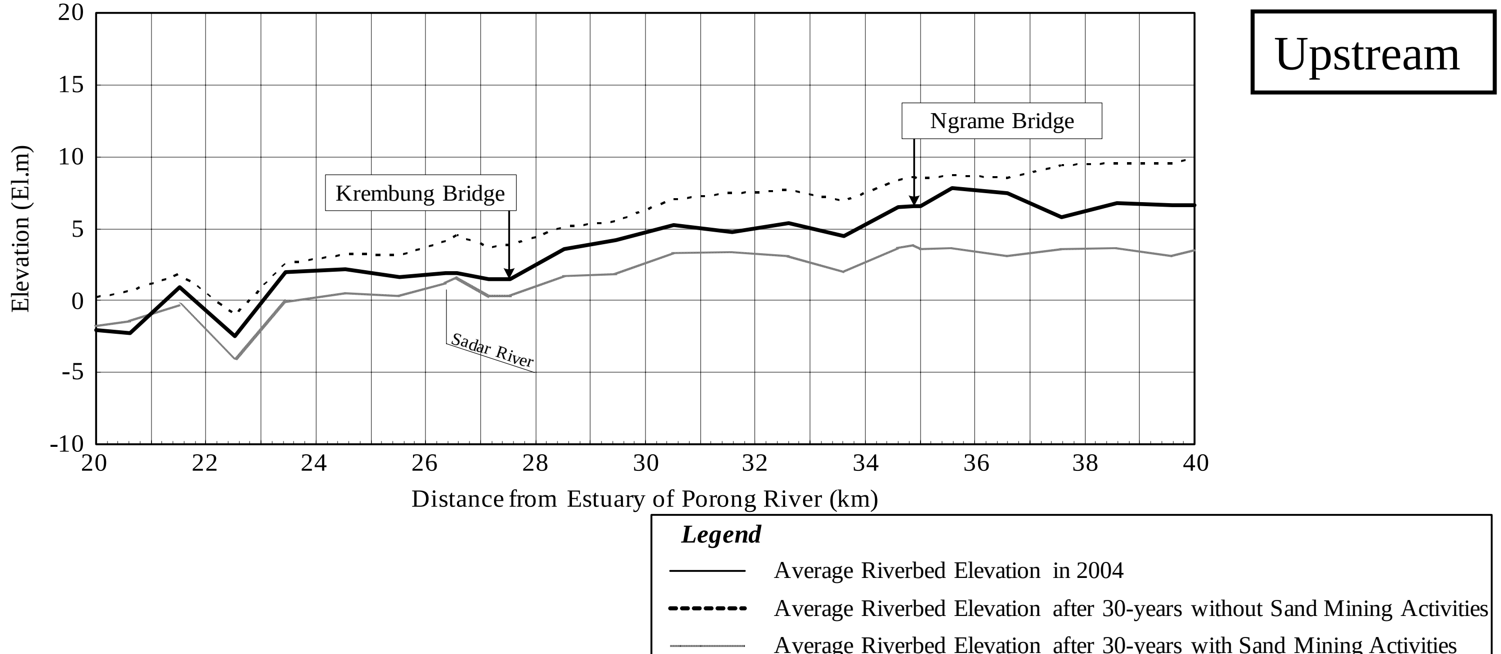


Simulated Riverbed Fluctuations under Present River Condition (2/4)



Simulated Riverbed Fluctuations under Present River Condition (3/4)





Simulated Riverbed Fluctuations under Present River Condition (4/4)

Brantas River Basin Development Programs
Present And Future

1. Brantas River Basin

The Brantas river is the second largest river on the Java Island. Its length is 320 km and catchment area is about 11,800 km^2 lying on east Java Province. Originates from the southastern of Mt. Arjuno

2. Volcanic Activity

Ther exist many volcanoues in the Brantas river basin. Those are Mt. Arjuno , Mt. Semeru and Mt. Kelud in the Upper reach.

Mt. Semeru produsces pyroclastic flow frequently in southern slope, however only a few ash affect the Lesti river basin and deposits are composed of fine material

In the middle reach, one of sediment sources is pyroclastic flow deposits and ash fall deposits from Mt. Kelud, has erupted every 15 years.

3. Major Issues

- The Sengguruh and Sutami Dams have been suffering from sediment inflows originating from Mt. Semeru as well as erosive watershed.
- Pyroclastic flows due to eruption of Mt. Kelud have caused dreadfull disasters in the Wlingi Dam and Lodoyo Reservoirs
- The Brantas middle reach have been suffering from the degradation of the riverbed, various river structures including revetments, weir, etc. have been damaged

4. Solve the sediment related issues :

- Sutainable use of dams by restoration of reservoir functions,
- Stability river structures, and
- Disaster prevention

Result Of Water Resources Development In Brantas River Basin up to 2004

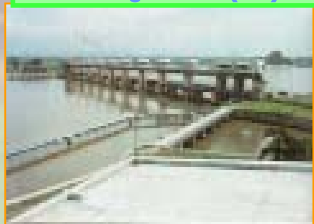
Master Plan I (1961 - 1973)

Master Plan II (1974 - 1985)

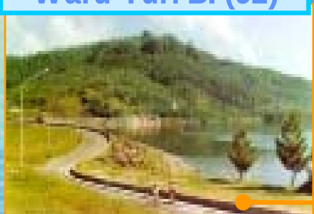
Master Plan III (1986 - 1998)

Master Plan IV (1999 - 2010)

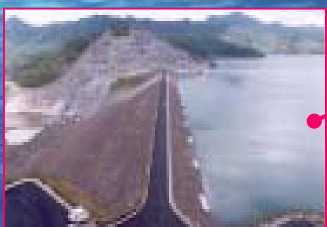
Bening Dam (84)



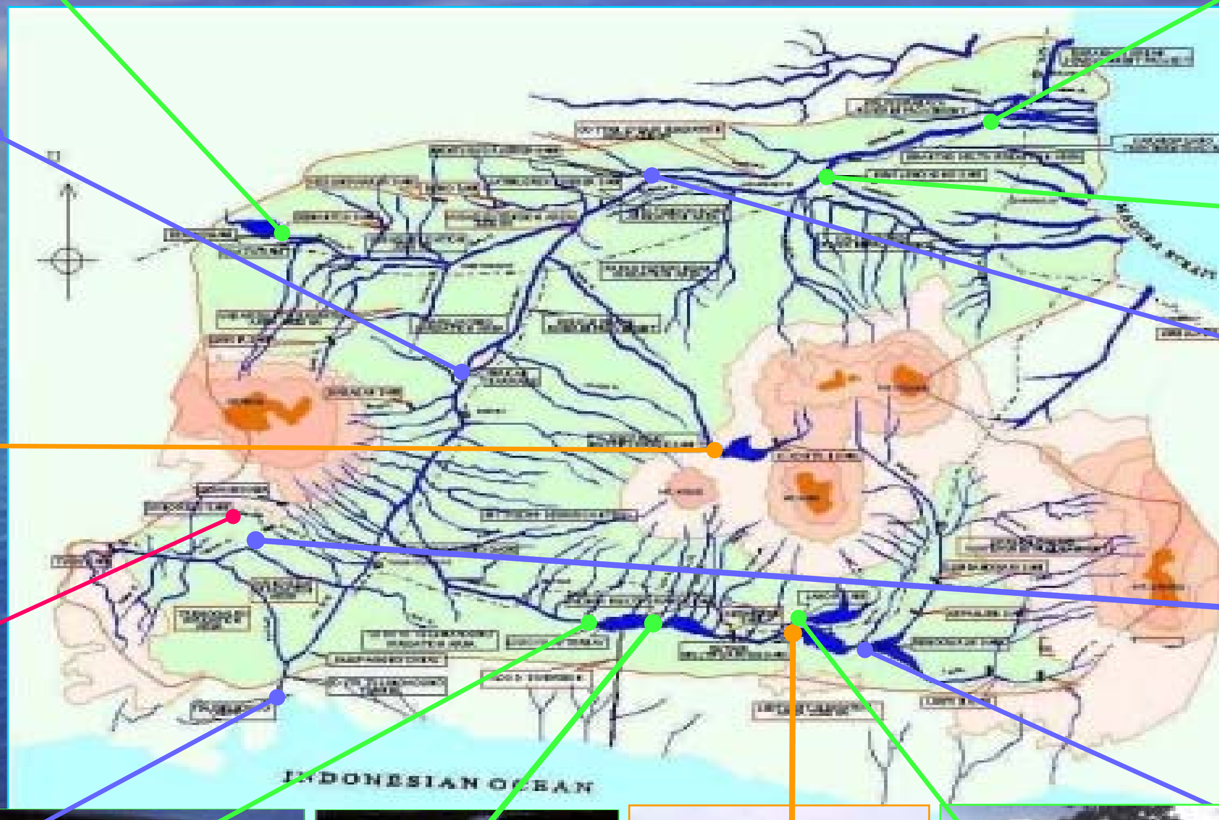
Waru-Turi B. (92)



Selorejo Dam (72)



Wanorejo Dam (00)



Gunungsari B. (81)

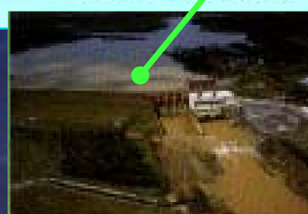
New Lengkong B (74)

Jatimlerek R.D (93)

E mb. Watulimo (98)

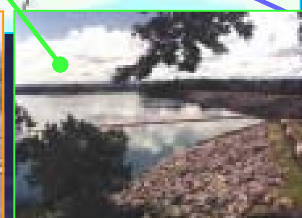
T.Agung Tunnel (91)

Lodoyo Dam (83)

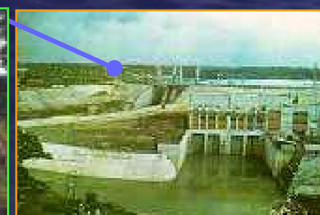


Wlingi Dam (78)

Sutami Dam (72)



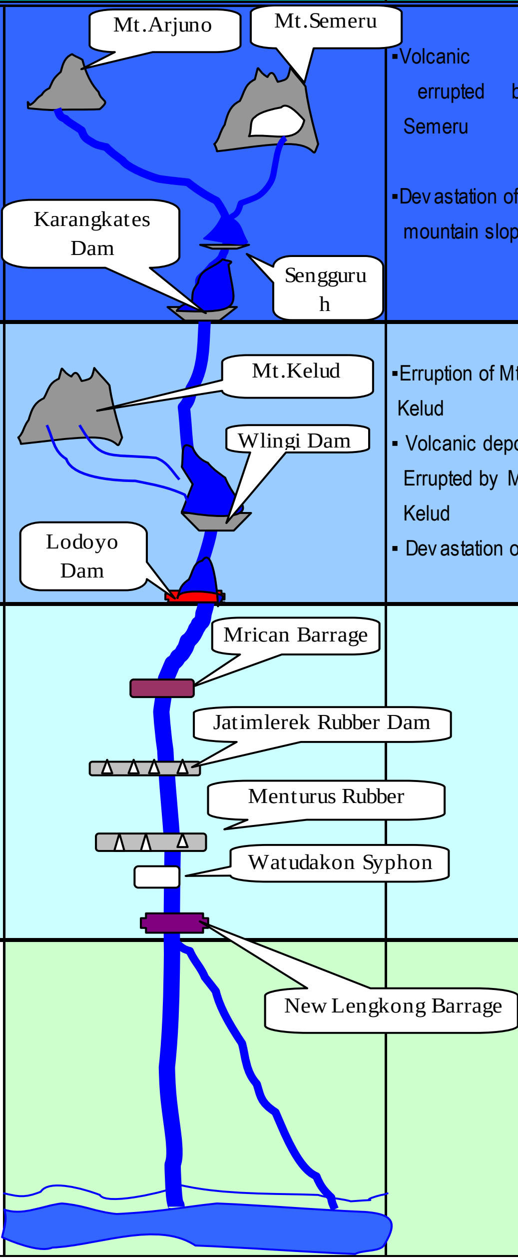
Lahor Dam (77)



Sengguruh Dam (88)


Location of Projects in Brantas River Basin
Projects Realized in 1961-2001
N
SURABAYA
Sidoarjo
Majokerto
Kertosono
Nganjuk
Kediri
Tulungagung
Blitar
Malang
Pasuruan
MADURA STRAIT
INDONESIAN OCEAN
Mt. Wilis
Mt. Kelud
Mt. Kawi
Mt. Arjuno
Mt. Semeru
New Gunungsari Barrage
Surabaya River Improvement
Mentikan Barrage
New Lengkong Barrage
Brantas Delta Irrigation Rehabilitation
Porong River Improvement
Jatimlerek Barrage
Widas River Improvement
Bening Dam
Widas Irrigation
Warujayeng Irrigation
Kediri-Nganjuk Groundwater Irrigation
Brantas Middle Reach River Improvement
Mrican Barrage
Selorejo Dam
Mt. Kelud Debris Control
Wonorejo Dam
Tulungagung Gate
Tiudan Headworks
Tulungagung Irrigation
Lodoyo Irrigation
Lodoyo Dam
Wlingi Dam
Lahor Dam
Sutami Dam
Sengguruh Dam
Tulungagung Tunnel -2
Tulungagung Tunnel -1
Tulungagung HEPP
LEGEND
River Basin Boundary
Dam / Barrage (existing)
Dam / Barrage (plan)
Hydropower Plant (existing)
Diversion Tunnel (existing)
Diversion Tunnel (plan)
Dam, Hydropower
River/Drainage Improvement
Irrigation/Water Supply
Debris Control/Sabo
Construction Period
Source of Foreign Finance
SCALE
0
10
20
30
40
50 km
Brantas

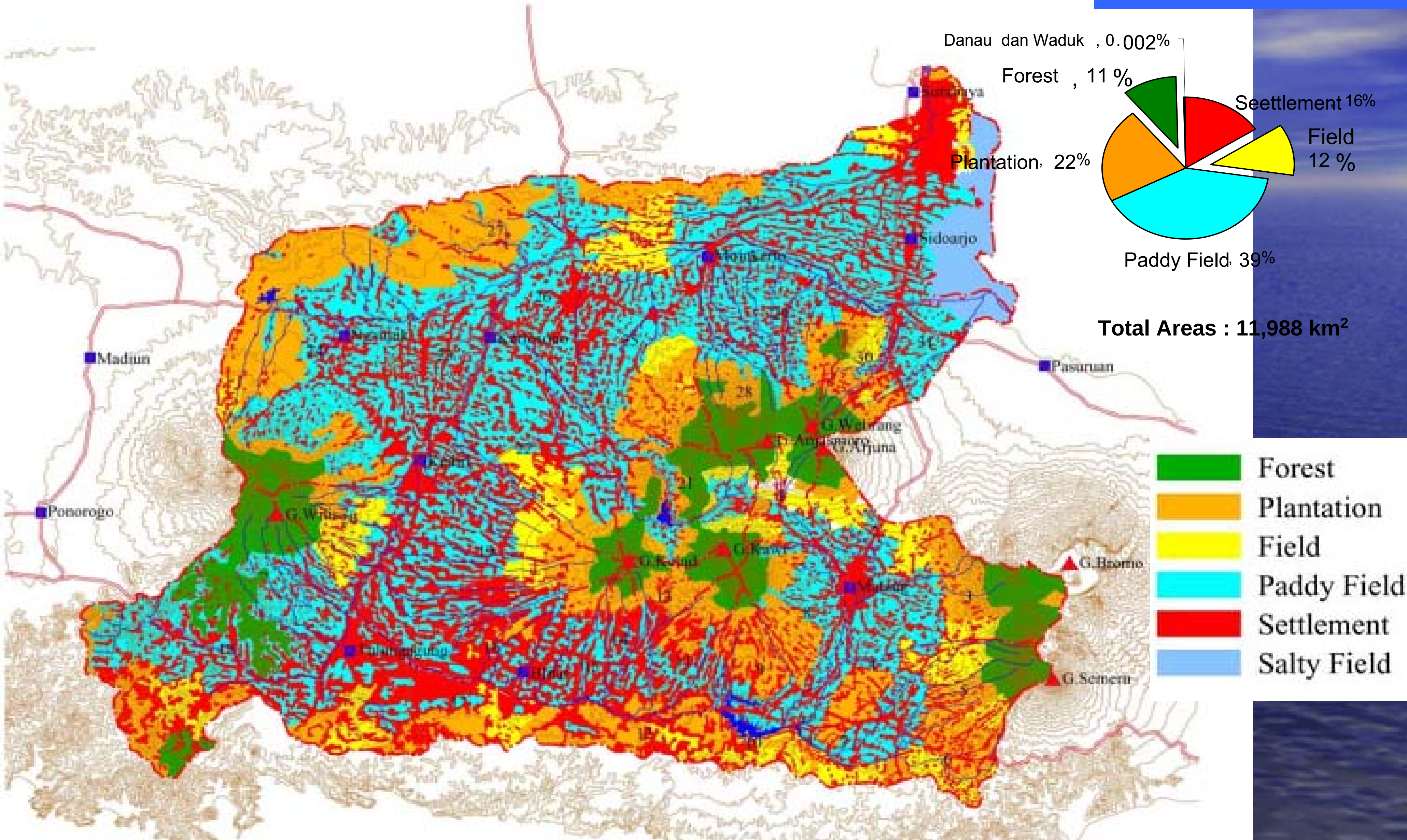
Impacts and Changes on Sediment Movement and Sediment Related Issues in the Brantas River Basin



Area	Impacts on Sediment Movement: Nature Caused	Impacts on Sediment Movement: Man Caused	Changes on Sediment Movement	Induced Issues: Flood Control/Disaster Prevention	Induced Issues: Water Use
Upper Brantas Area	▪Volcanic deposit errupted by Mt. Semeru ▪Devastation of mountain slope	▪ Construction of Sabo structures ▪ Construction of dams (Sengguruh, Lahor, Karangkates)	▪ Large amount of Volcanic debris on mountain slope ▪ Deposition of fine volcanic materials (easy to move) ▪ Erosion from erosif lands ▪ Agradation of riverbed ▪ Increase of sediment discharge ▪ Blocking of sediment flow by ▪ Sedimentation in reservoir of sabo structure and dams	▪ Decreasing of storage capacity of Karangkates dam ▪ Decreasing of sediment storage ▪ capacity of sabo dams, the Sengguruh dam and the Wlingi dam ▪ Damage of sabo dams due to local scouring ▪ Increasing of sediment disaster risk ▪ Increasing of flood disaster risk ▪ Insufficient storage capacity of sand pockets for next eruption of Mt. Kelud	▪ Decreasing of efective storage capacity of dams due to sedimentation ▪ Frequent interuption of power generation ▪ Decreasing of water supply capacity of dams for domestic, industrial and irrigation ▪ Increasing of sediment flowing into the Karangkates reservoir due to lowering of sediment flow blocking ▪ High sediment level exeeding on sill elevation of power intake of the Wlingi dam dam as an afterbay
Mt. Kelud	▪Erruption of Mt. Kelud ▪ Volcanic deposit Errupted by MT. Kelud ▪ Devastation of	▪ Construction of Sabo Structures ▪ Construction of Dams (Wlingi, Lodoyo) ▪ Construction of channel			
Brantas Middle Reach		▪ Dredging by river improvement project (1980-1985) ▪ Construction of Weirs (Mrican, Jatimlerek, Menturus) ▪ Sand minning	▪ Decreasing of sediment flow from upsream ▪ Blocking of sediment flow by weir ▪ Local scouring on downstream section of weir ▪ Removal of riverbed material by sand minning ▪ Degradation of riverbed	▪ River bank collapse due to significant riverbed degradation (downstream strech of Mrican Barrage) ▪ Possibility of furthermore damage of riverbank and revetment due to riverbed degradation	▪ Damaged river structure due to down stream riverbed degradation (Jatimlerek weir, the Menturus weir, the Watudakon syphon)
Brantas Lower Reach		▪ Construction of weirs ▪ Sand minning	▪ Decreasing of sediment flow from upsream ▪ Blocking of sediment flow by weir ▪ Local scouring on downstream section of weir ▪ Removal of riverbed material by sand minning ▪ Degradation of riverbed	▪ Damaged dike and revetment due to riverbed degradation ▪ Increasing of flood disaster risk ▪ Exposed foundation of the railway bridge and toll way bridge due to riverbed degradation	

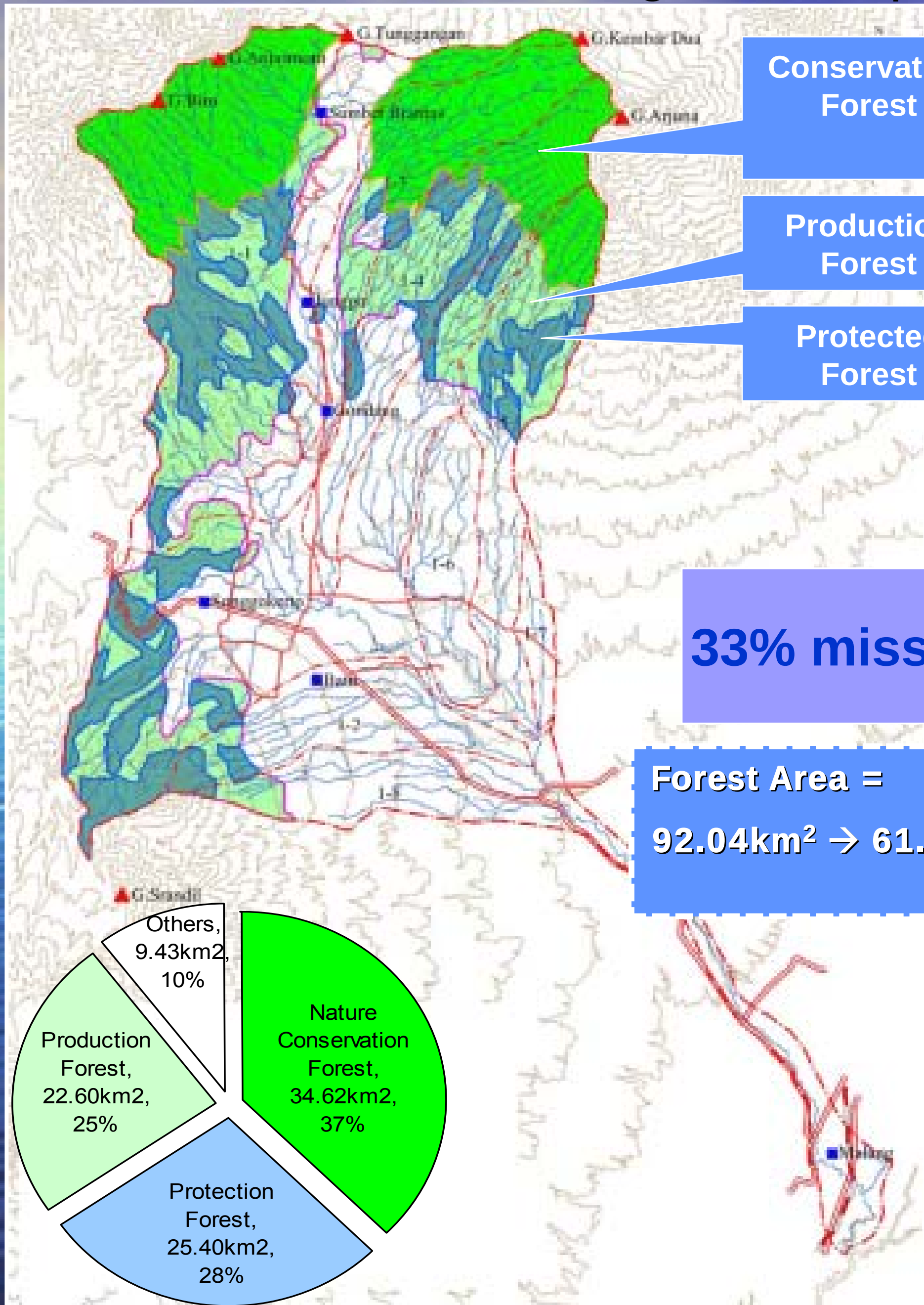
Land Use Map at Brantas River Basin

Year 2003



Total Areas : 11,988 km^2

Forest condition changes at Upper Brantas



Conservation Forest

Production Forest

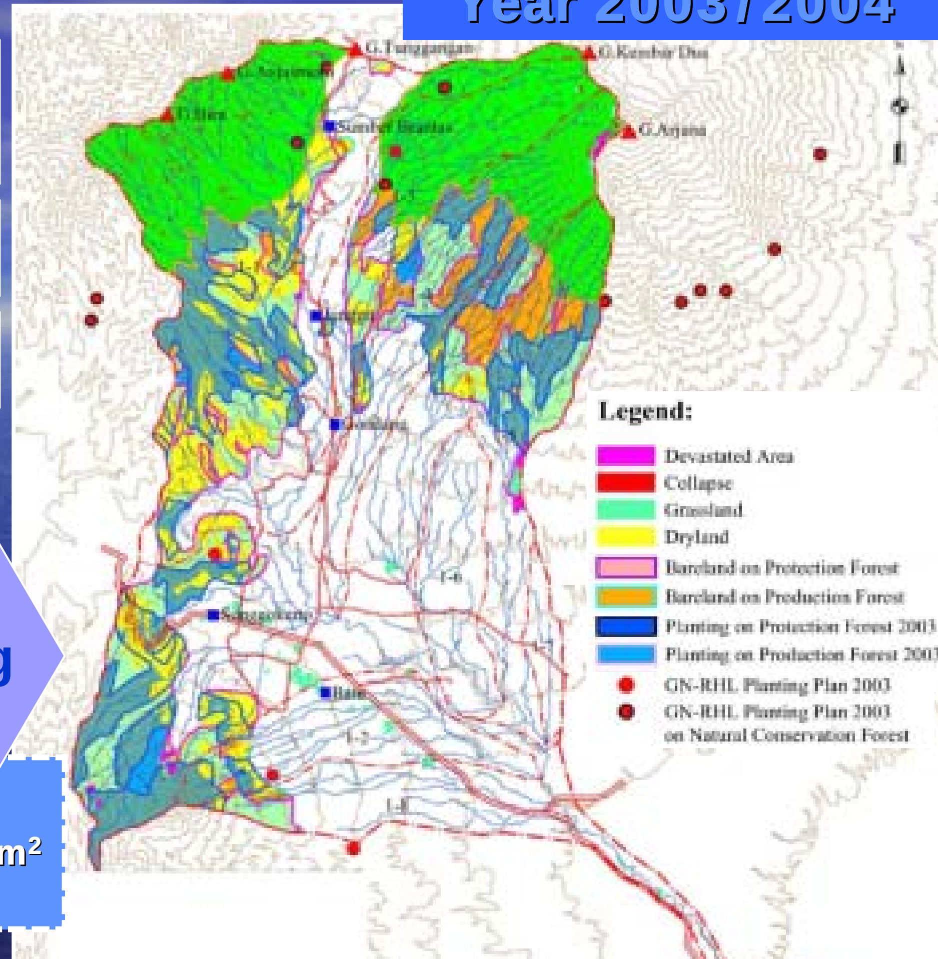
Protected Forest

33% missing

Forest Area =

92.04km² → 61.38km²

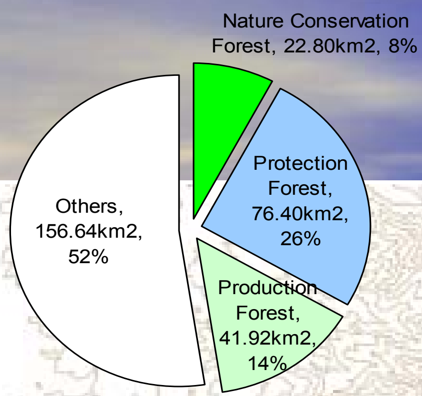
Year 2003/2004



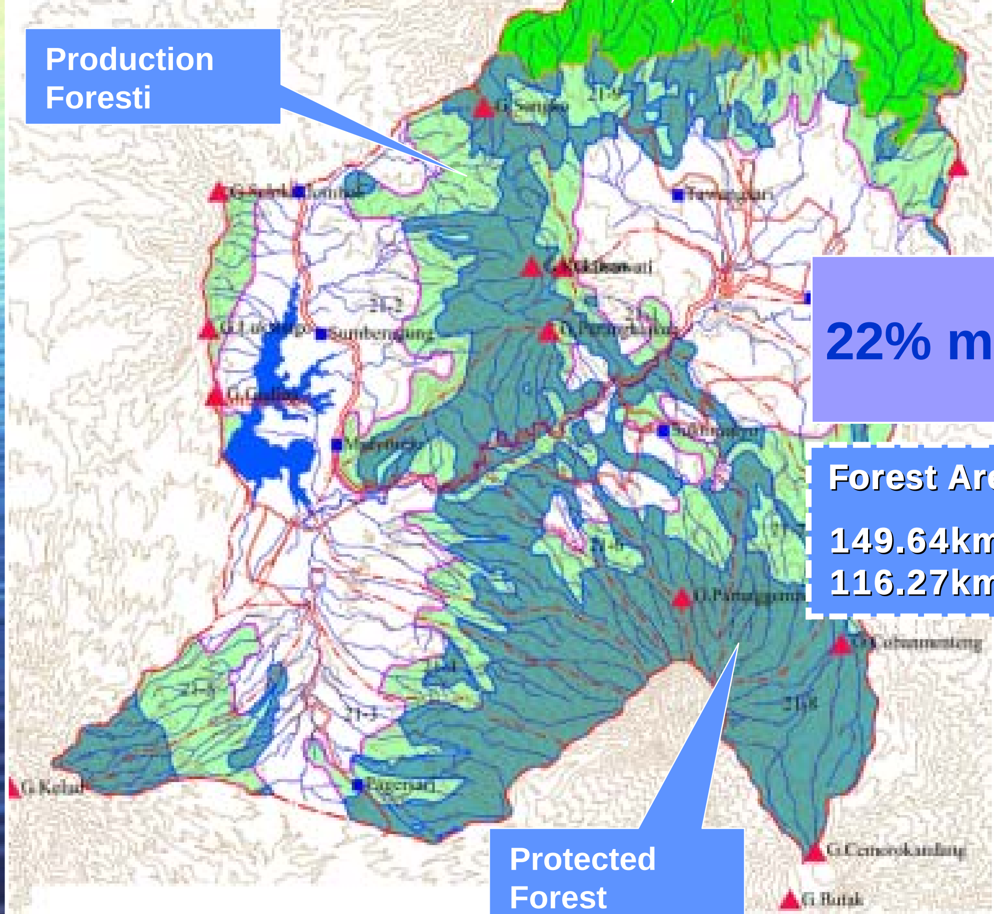
Description	Area (km^2)	Persentage to the forest
Critical Area	0.63	0.7%
Empty Area	13.18	14.3%
Savannah	0.80	0.9%
Dried Area	16.05	17.4%
Total	30.66	33.3%

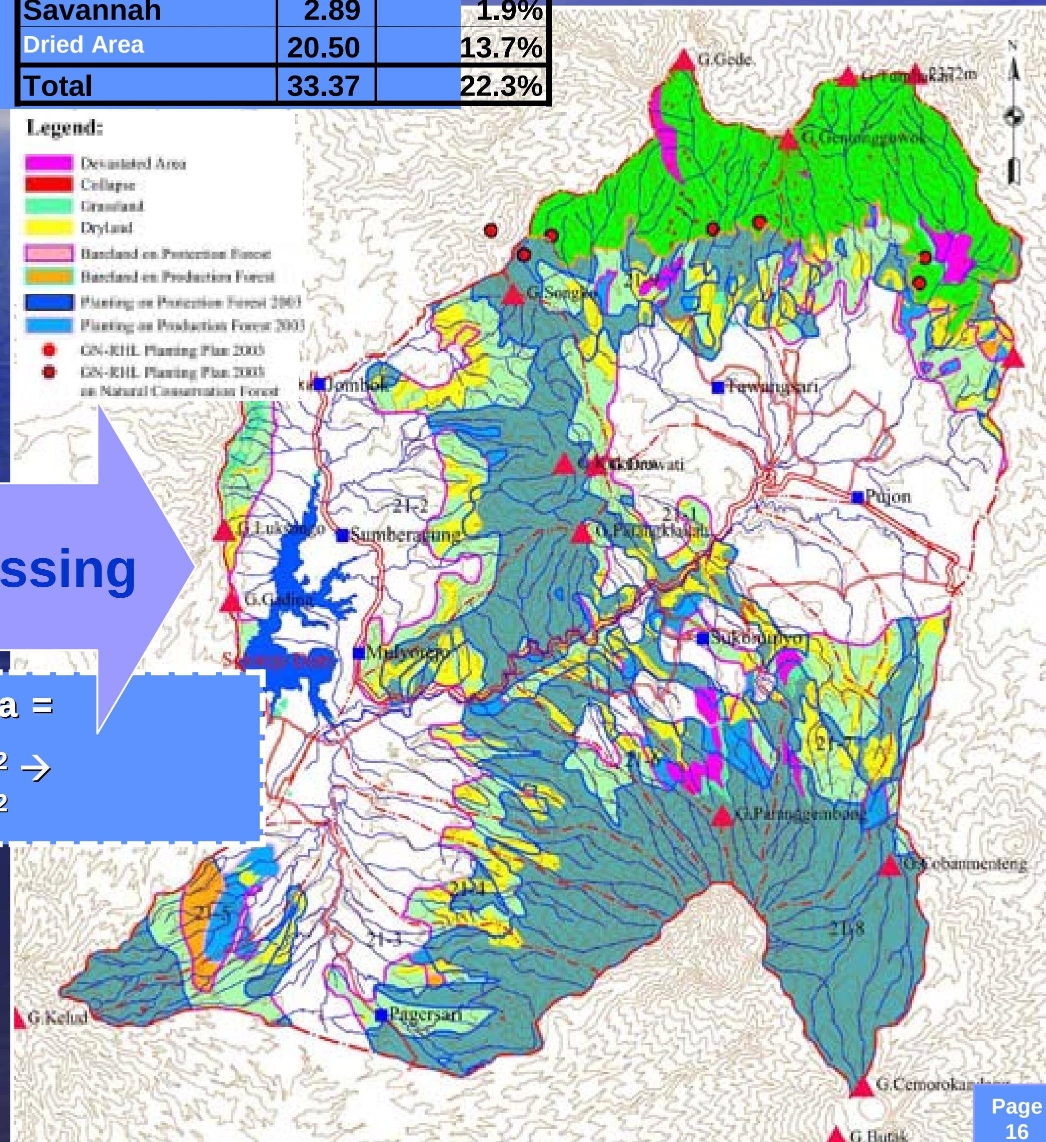
The Changes of Forest Condition at Konto Hulu

Year 2003/2004



Description	Area (km^2)	Percentage to the forest
Critical Area	1.54	1.0%
Empty Area	8.44	5.6%
Savannah	2.89	1.9%
Dried Area	20.50	13.7%
Total	33.37	22.3%





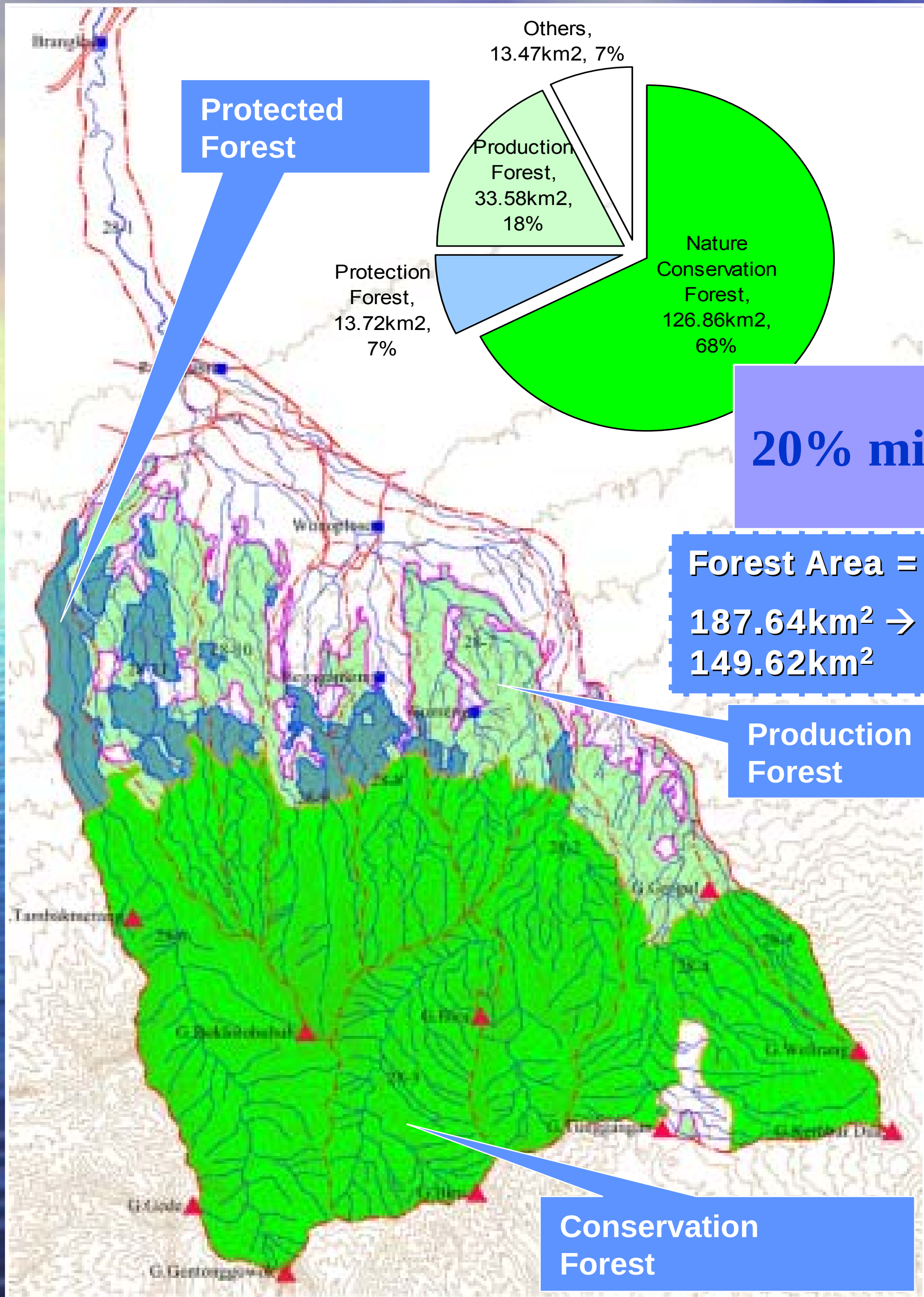
22% missing

Forest Area =

149.64km² → 116.27km²

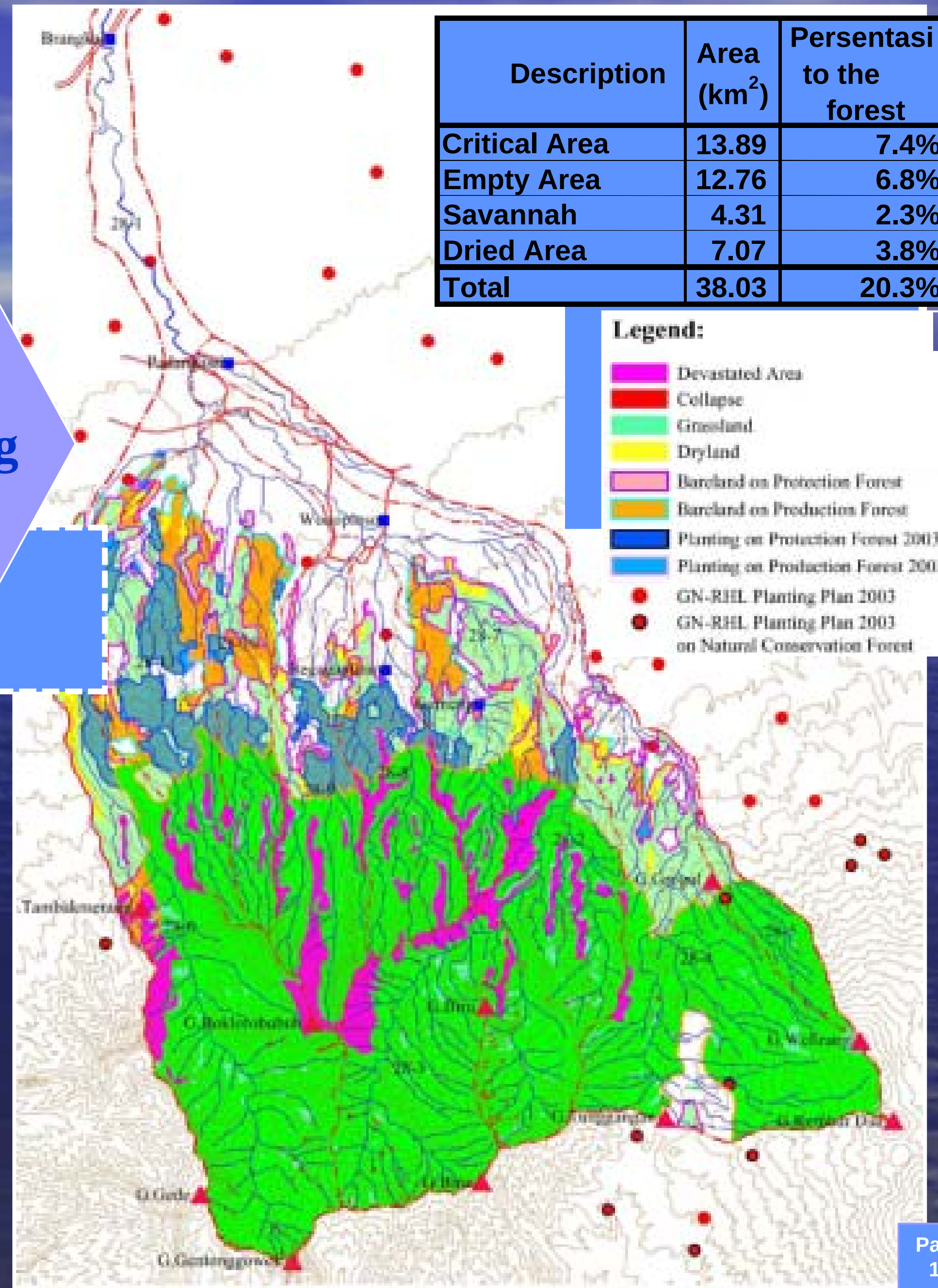
Changes of Forest Condition at Brangkal

Year 2003/2004



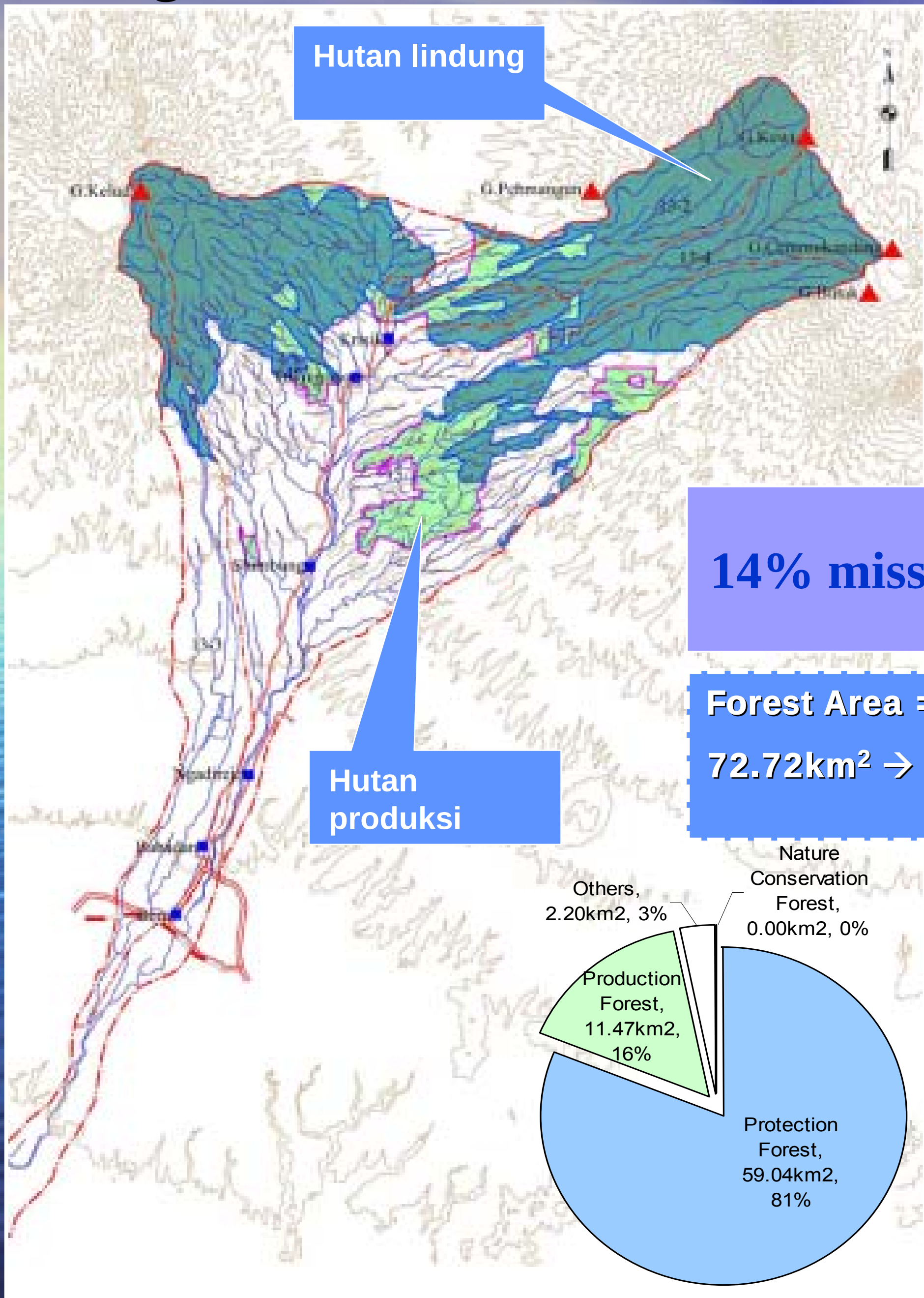
20% missing

Forest Area = 187.64km² → 149.62km²



Description	Area (km^2)	Persentasi to the forest
Critical Area	13.89	7.4%
Empty Area	12.76	6.8%
Savannah	4.31	2.3%
Dried Area	7.07	3.8%
Total	38.03	20.3%

Changes of Forest Condition at Lekso River

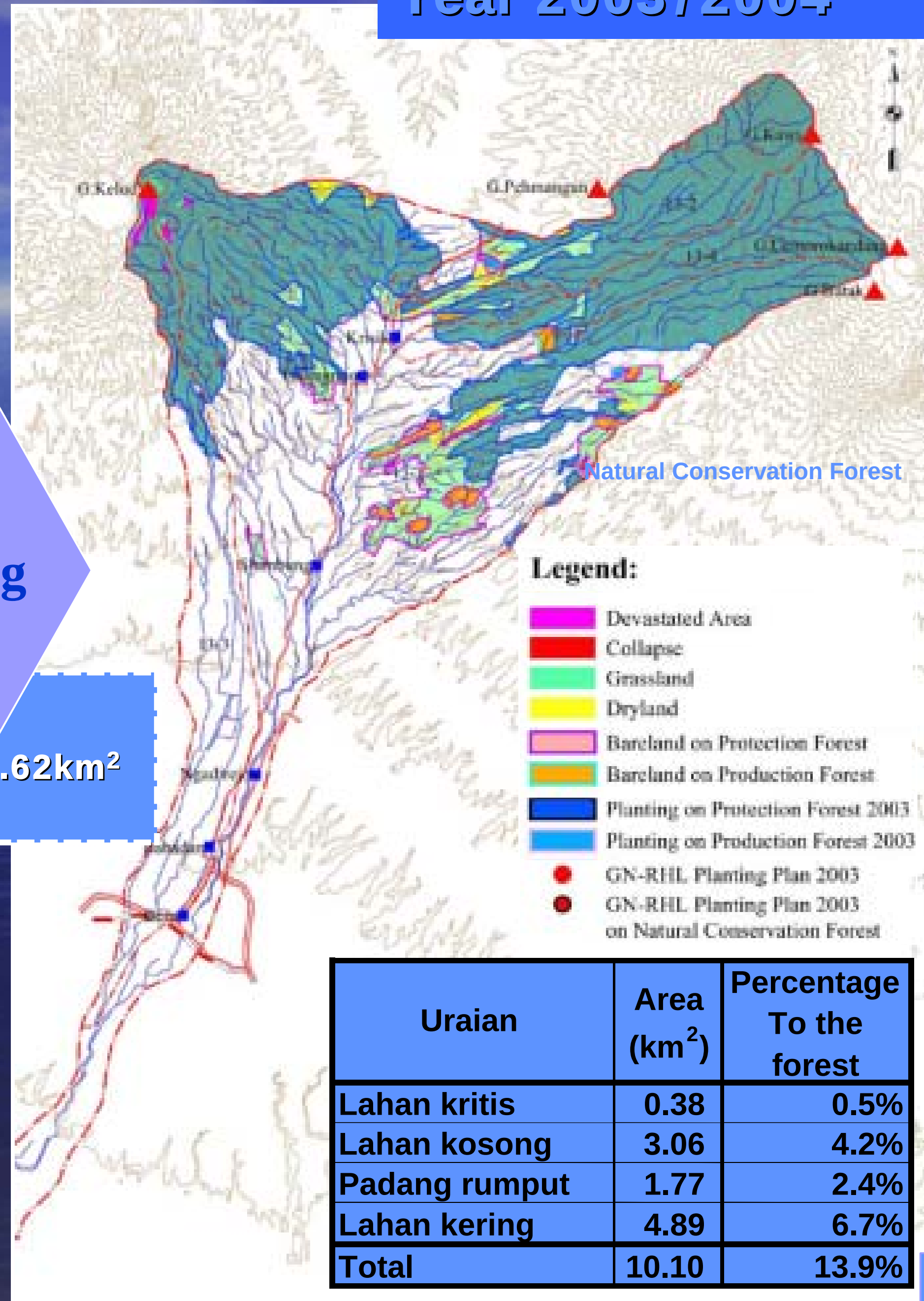


14% missing

Forest Area =

72.72km^2 → 62.62km^2

Year 2003/2004



Uraian	Area (km^2)	Percentage To the forest
Lahan kritis	0.38	0.5%
Lahan kosong	3.06	4.2%
Padang rumput	1.77	2.4%
Lahan kering	4.89	6.7%
Total	10.10	13.9%


Mergosono Distric,
Malang City
Brantas River

Rubbish Sediment at Sengguruh Dam

Storage Capacity Condition of Dam

Condition		Sengguruh	Sutami	Wlingi	Selorejo
Dam Function		1988	1973	1977	1972
River Flow		1.659 km^2	2.052 km^2	2.890 km^2	236 km^2
Effective Capacity	Original	2,50 x $10^6 m^3$	253,0 x $10^6 m^3$	5,20 x $10^6 m^3$	50,1 x $10^6 m^3$
	Present	1,04 x $10^6 m^3$	145,2 x $10^6 m^3$	2,01 x$10^6 m^3$	41,5 x$10^6 m^3$
	Remain (%)	41,5	57,4	38,6	82,9
	Year	2003	2003	2004	2003
Sediment Volume Duration		19,18 x$10^6 m^3$ 15 th	168,4 x $10^6 m^3$ 30 th	19,6 x$10^6 m^3$ 27 th	18,3 x$10^6 m^3$ 31 th
Dredging and Flushing		2,05 x $10^6 m^3$	-	13,6 x$10^6 m^3$	0,20 x $10^6 m^3$

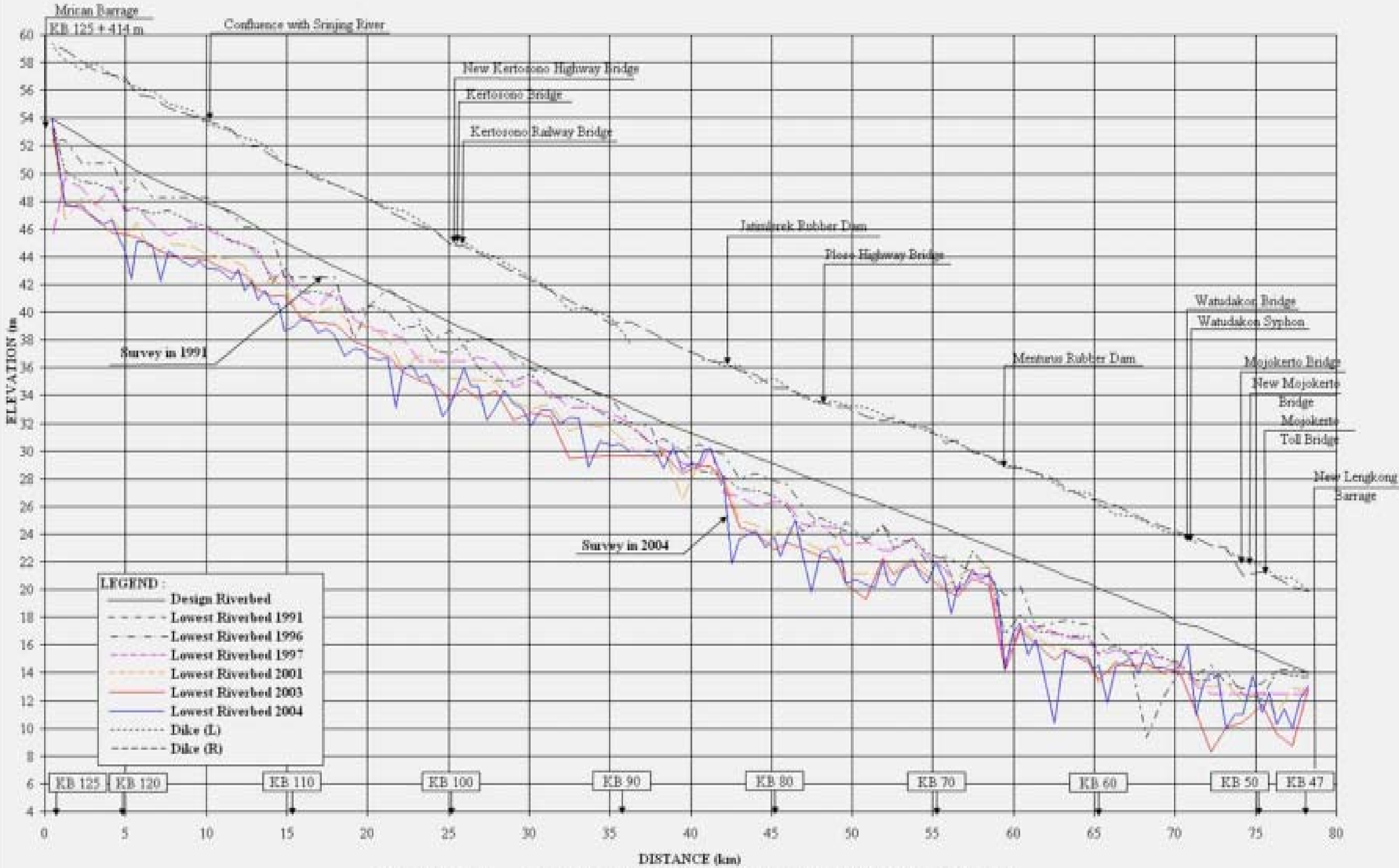
Activities Inventory of Sand Mining at Brantas and Porong River

Brantas River (179 locations)

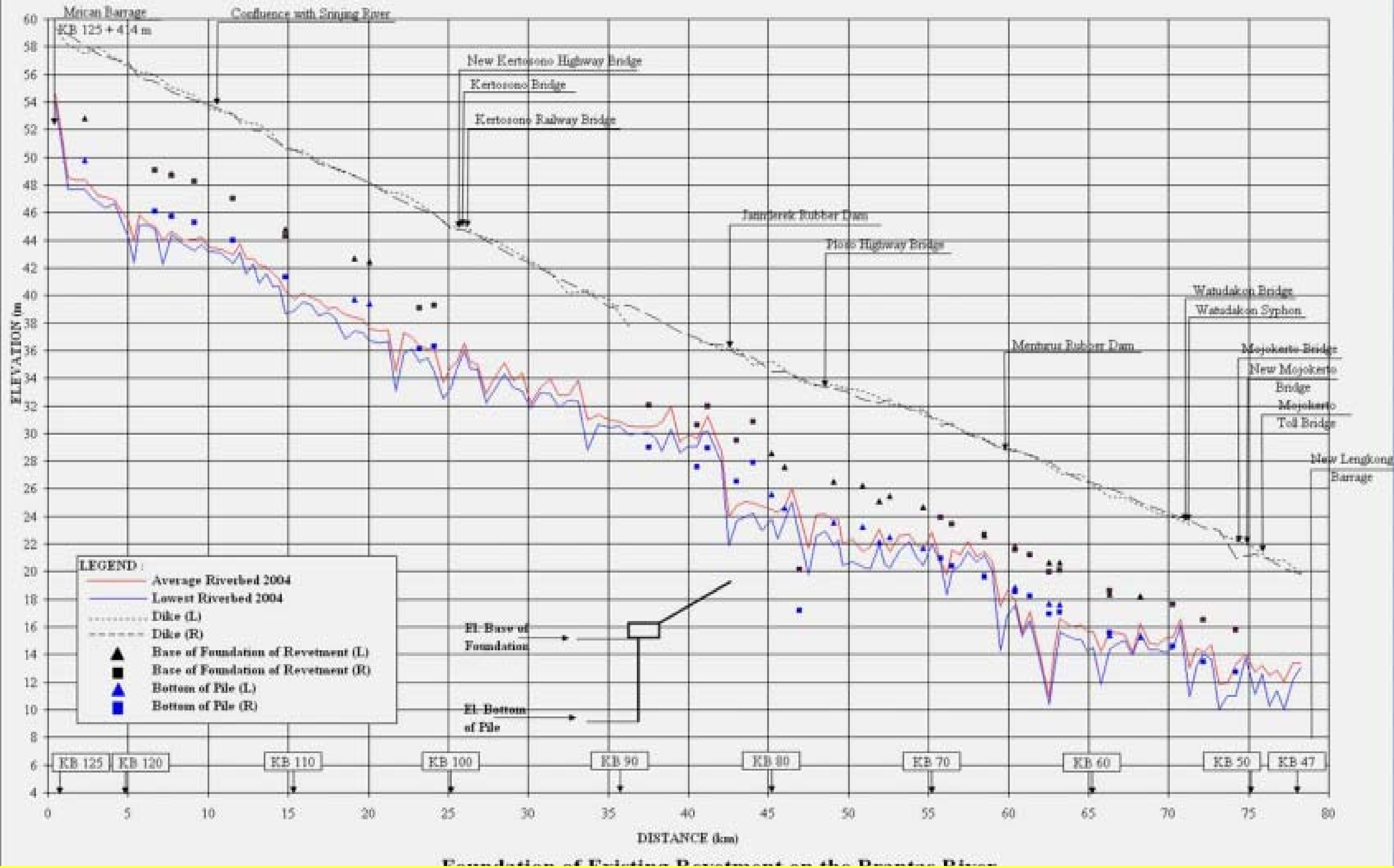
Regency	Sand Mining Volume (m^3/year)			Nos. of Workers (Person/day)
	Manual (m^3/year)	Pumping (m^3/year)	Total (m^3/year)	
Sidoarjo	42,500	0	42,500	150
Mojokerto	151,500	111,000	262,500	1,060
Jombang	822,600	168,200	990,800	3,220
Nganjuk	267,100	383,000	650,100	720
Kediri	200,800	135,700	336,500	510
Kota Kediri	47,900	182,800	230,700	220
Tulungagung	0	188,900	188,900	400
Total	1,532,400	1,169,600	2,702,000	6,280

Porong River (35 locations)

Regency	Sand Mining Volume (m^3/year)			Nos. of Workers (Person/day)
	Manual (m^3/year)	Pumping (m^3/year)	Total (m^3/year)	
Sidoarjo	22,200	79,100	101,300	270
Mojokerto	2,100	113,000	115,100	260
Pasuruan	1,200	0	1,200	10
Total	25,500	192,100	217,600	540



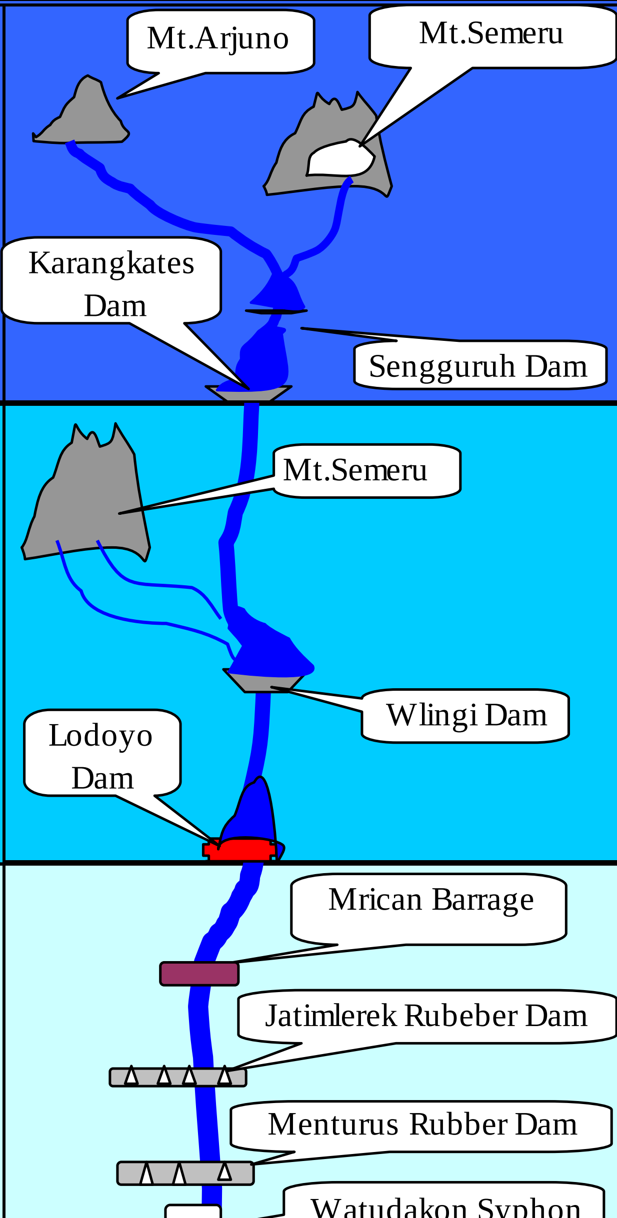
Profile Riverbed Transation of the Brantas Middle Reach



Foundation of Existing Revetment on the Brantas Middle Reach

Approach Concept of Reestablishment and Maitenance of the Continuity of Sediment Flow System

Area | Eruption of Mt. Kelud | Time passage after eruption of Mt. Kelud | Next eruption of Mt. Kelud



Upper Brantas Area

- Watershed conservation in the upper Brantas River and the Lesti River Areas
- Storege of sediment by Sabo structures
- Dredging of sediment in dam reservoir
- Utilization of sediment in Sabo facilities and dam reservoir
- Monitoring of sediment movement

Mt.Kelud Area

- Watershed conservation in Mt. Kelud Area
- Trapping of sediment by Sabo structures
- Release of sediment in sabo structures
- Dredging of sediment in dam reservoirs
- Bypassing and flushing of sediment
- Utilization of sediment in Sabo facilities and dam reservoirs (Alternative supply to sand minning in river)
- Monitoring of sediment movement
- Preparation for next eruption

rantas Middle Reach

- Flushing of sediment in upstream section of weirs
- Control of sand minning
- Supervision of sand minning (location, volume)
- Control of sediment tractive force in river (groin, foot protection, grounsill)
- Monitoring of sediment movement

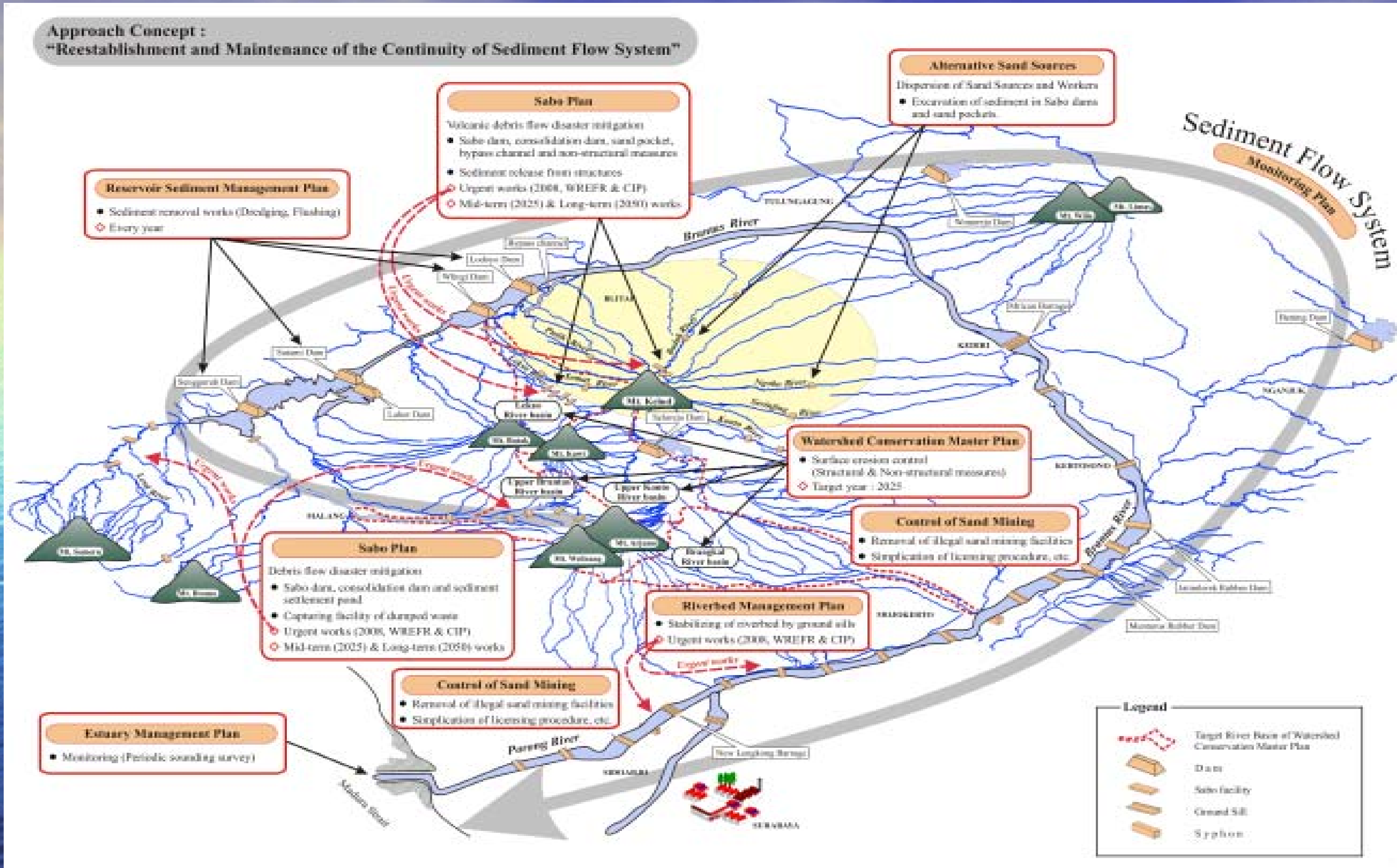
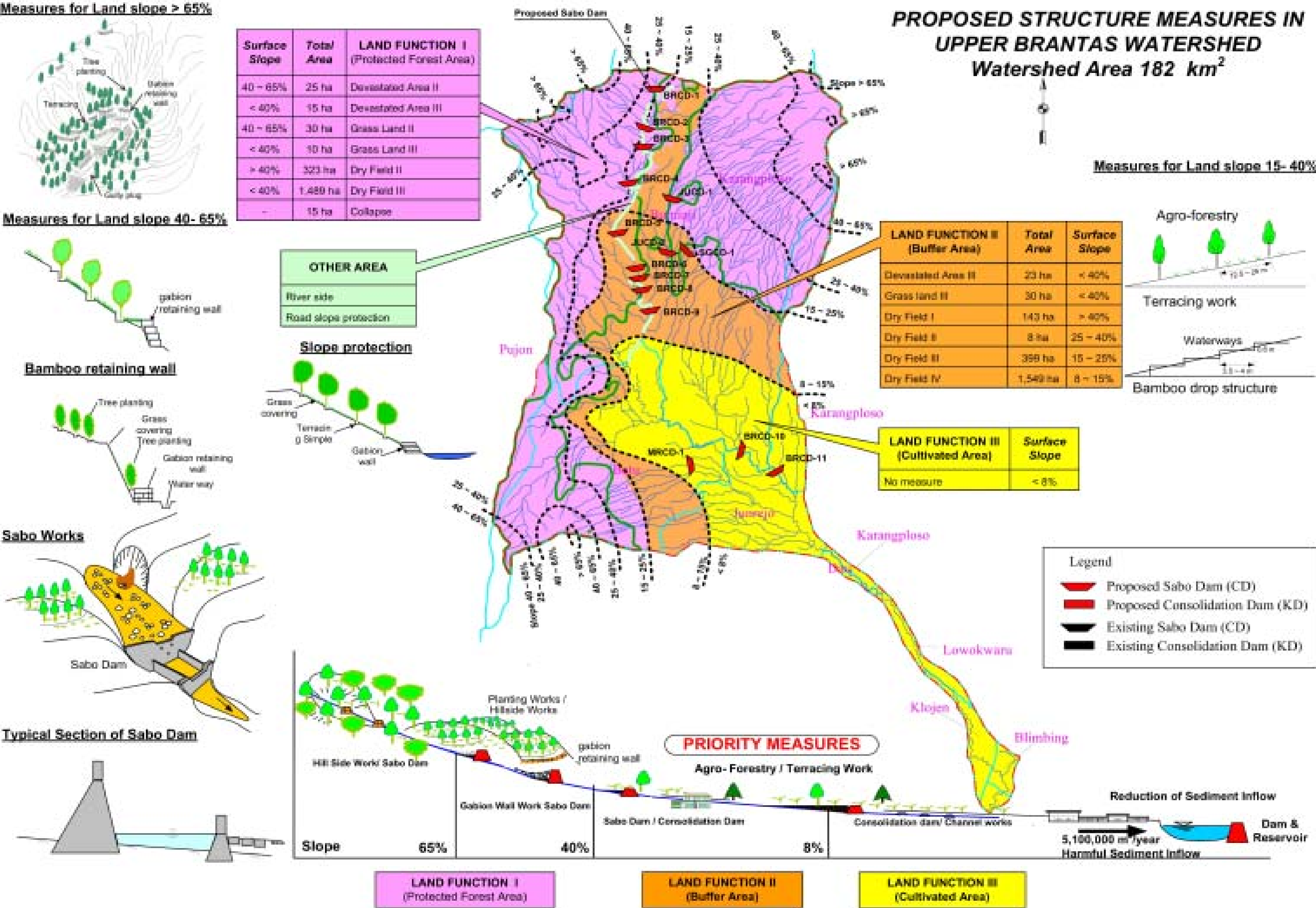


Figure 3.67 Comprehensive Basin-wide Sediment Management Plan in the Brantas River Basin

PROPOSED STRUCTURE MEASURES IN UPPER BRANTAS WATERSHED

Watershed Area 182 km^2

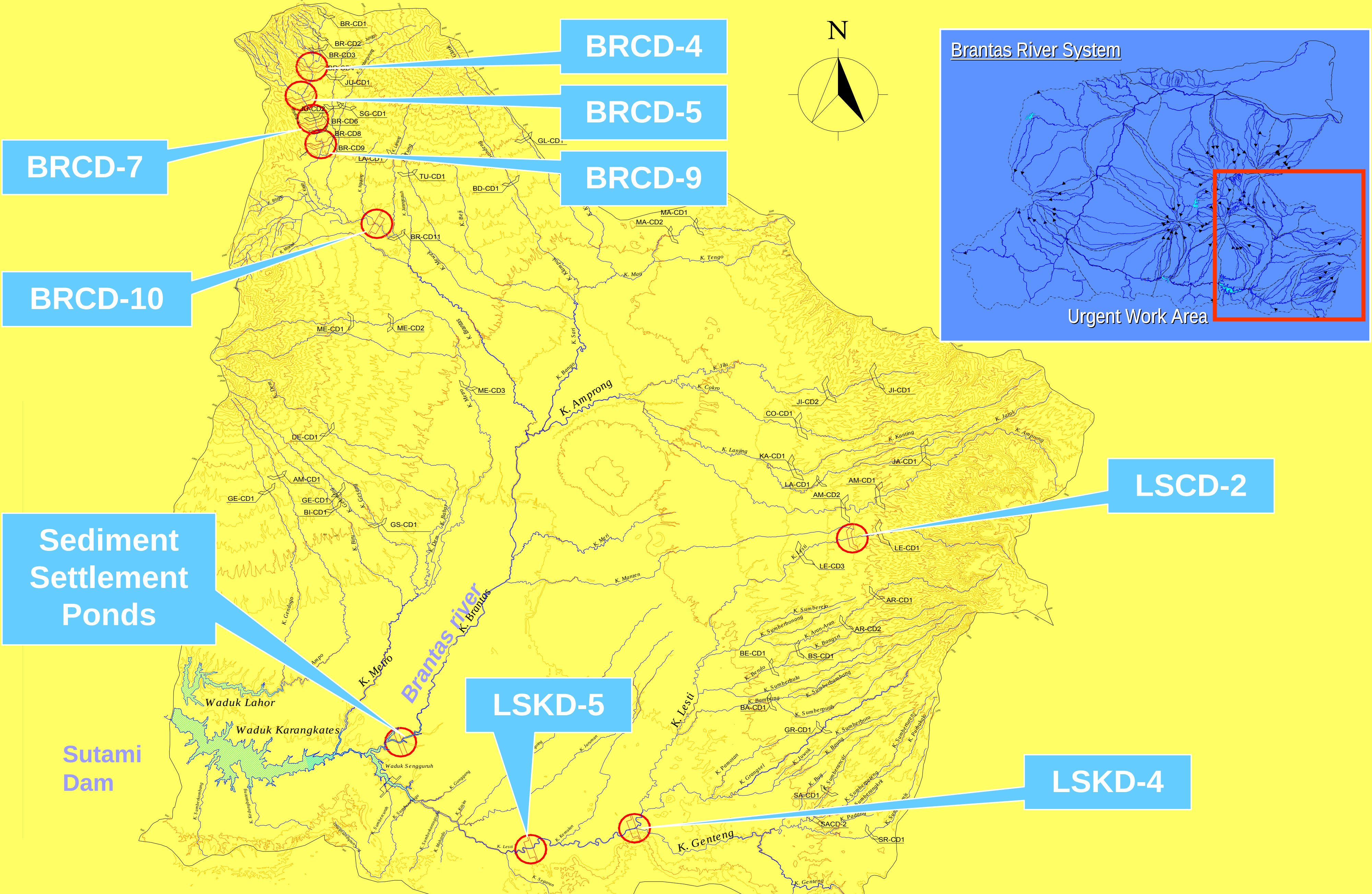


Surface Slope	Total Area	LAND FUNCTION I (Protected Forest Area)
40 ~ 65%	25 ha	Devastated Area II
< 40%	15 ha	Devastated Area III
40 ~ 65%	30 ha	Grass Land II
< 40%	10 ha	Grass Land III
> 40%	323 ha	Dry Field II
< 40%	1,489 ha	Dry Field III
-	15 ha	Collapse

OTHER AREA
River side
Road slope protection

LAND FUNCTION II (Buffer Area)	Total Area	Surface Slope
Devastated Area III	23 ha	< 40%
Grass land III	30 ha	< 40%
Dry Field I	143 ha	> 40%
Dry Field II	8 ha	25 ~ 40%
Dry Field III	399 ha	15 ~ 25%
Dry Field IV	1,549 ha	8 ~ 15%

LAND FUNCTION III (Cultivated Area)	Surface Slope
No measure	< 8%



Location Map of Proposed Sabo Facility in Upper Brantas <Urgent Work>

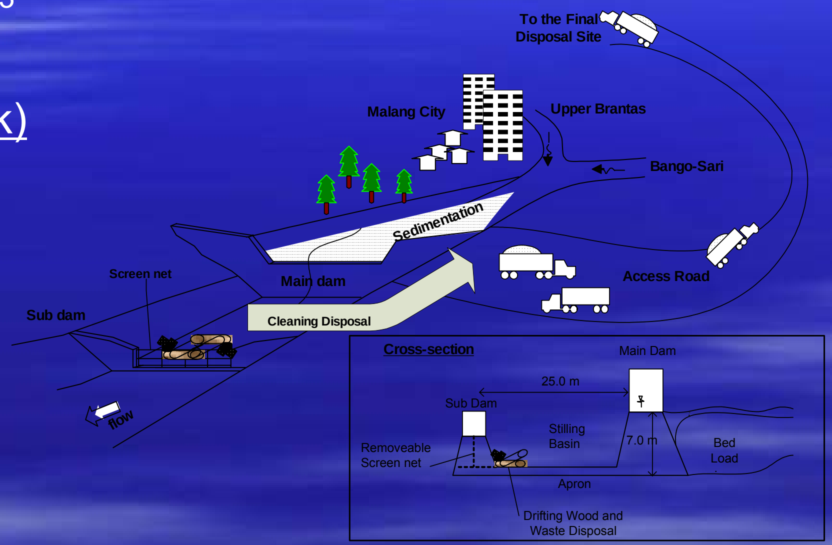
Disposal Site

Capturing Facility for Waste Disposal

Dumping Waste Disposal Volume
30m^3/day

Capturing Capacity 87m^3

7.5 truck /day (4 m^3 truck)



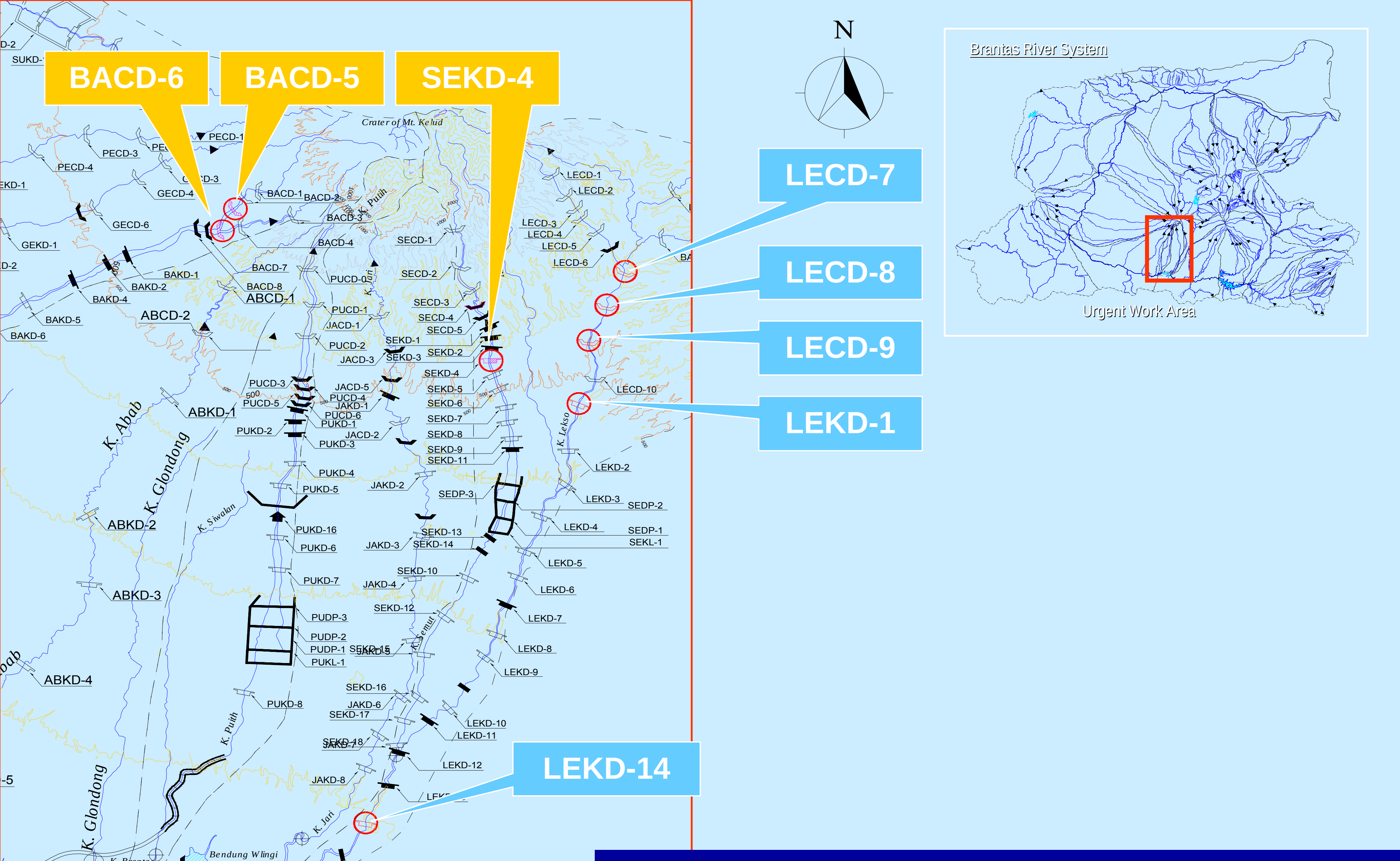
Sengguruh Reservoir

Target of Sediment Control Upper Brantas

	Name of Facility	Height of Dam H (m)	Height of Slit h (m)	Length of Dam L (m)	Riverbed Gradient Initial Condition I_o (%)	Total of Sediment (m^3)
Original Target	BRCD-4	14.00	7.00	70.00	4.8195	495,900
	BRCD-5	10.00		70.00	4.8200	246,500
	BRCD-7	12.00		80.00	4.6000	269,600
	BRCD-9	10.00		60.00	2.6300	249,700
	BRCD-10	10.00		70.00	3.7250	208,900
	Settlement Pond	5.00		90.00	1.9254	315,000
Total						**1,785,600**
Revised Capacity	BRCD-4	14.00	7.00	125.00	3.4342	881,400
	BRCD-5	10.00		83.00	4.5270	206,700
	BRCD-7	14.00		70.00	5.1575	280,200
	BRCD-9	7.00		90.00	3.0468	147,400
	BRCD-10	10.00		114.00	2.6493	495,800
	Settlement Pond	5.00		70.00	1.9254	315,000
Total						**2,326,500**

Target of Sediment Control
Lesti River

	Name of Facility	Height of Dam H (m)	Height of Slit h (m)	Length of Dam L (m)	Riverbed Gradient Initial Condition I_o (%)	Total of Sediment (m^3)
Original Target	LSCD-2	12.00	6.00	70.00	4.8900	348,000
	LSKD-4	7.00		80.00	0.3560	1,112,000
		7.00		70.00	0.2419	1,415,600
	LSKD-5	7.00		81.00	0.1200	2,268,800
Total						**5,144,400**
Revised Capacity	LSCD-2	12.00	6.00	70.00	3.6676	317,600
	LSKD-4	8.00		90.00	0.3788	1,623,300
		8.00		90.00	0.3875	1,586,700
	LSKD-5	7.00		115.00	0.3054	1,909,500
Total						**5,437,100**

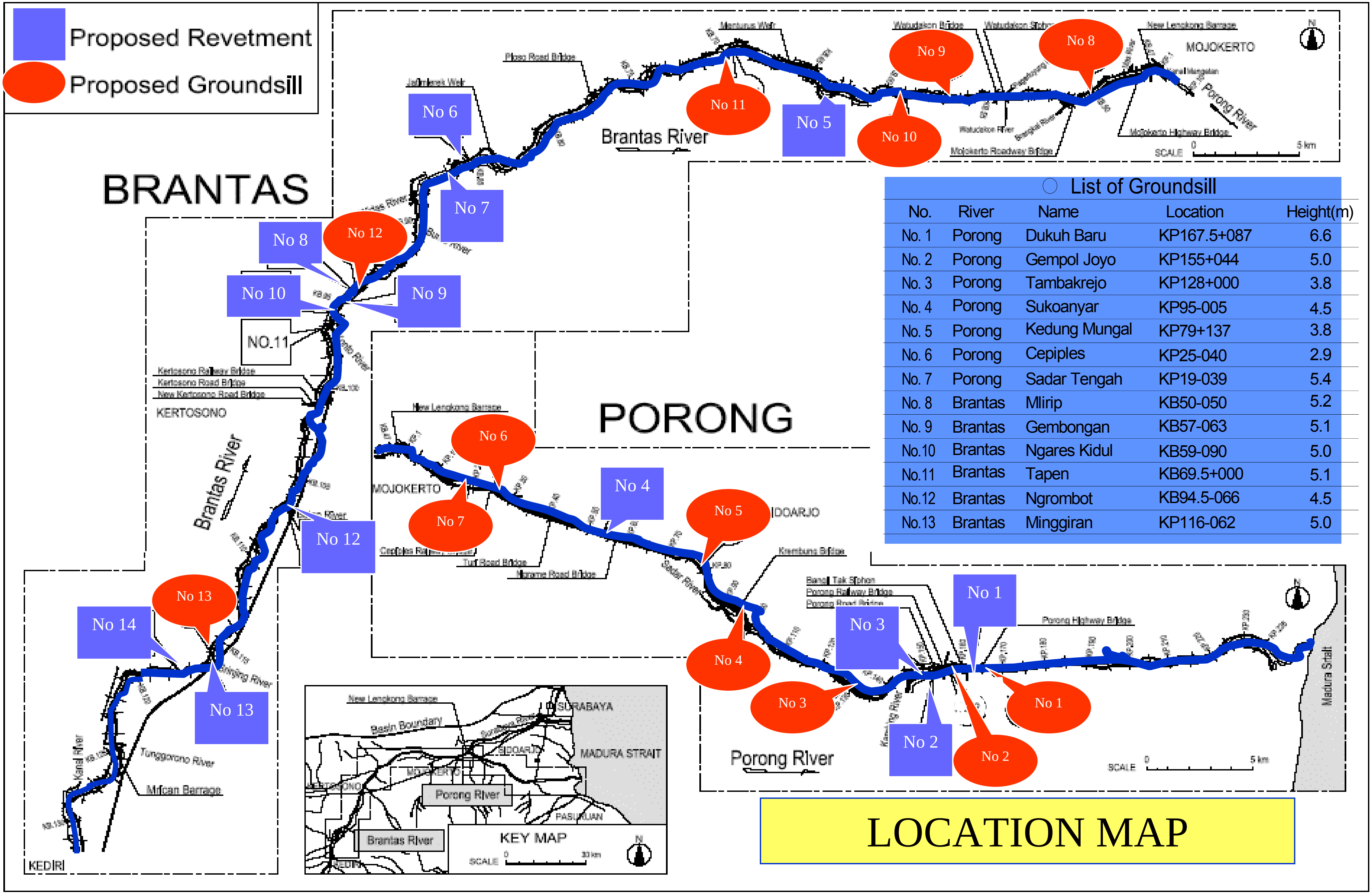


Location Map of Proposed Sabo Facility in Mt. Kelud Area <Urgent Work>

Target of Sediment Control
Lekso river

	Name of Facility	Height of Dam H (m)	Height of Slit h (m)	Length of Dam L (m)	Riverbed Gradient Initial Condition I_o (%)	Total of Sediment (m^3)
Original Target	LECD-7	14.00		110.00	2.8945	803,100
	LECD-8	14.00		100.00	2.8945	787,300
	LECD-9	10.00		70.00	2.6832	289,900
	LEKD-1	7.00		70.00	2.3109	148,100
	LEKD-14	7.00		70.00	0.6570	405,900
Total						**2,434,300**
Revised Capacity	LECD-7	12.00	7.00	135.00	3.4918	668,700
	LECD-8	12.00	7.00	135.00	3.0602	766,700
	LECD-9	8.00	5.00	150.00	2.7239	387,200
	LEKD-1	8.00		125.00	3.5376	246,200
	LEKD-14	8.00		125.00	2.3606	369,100
Total						**2,437,900**

LAYOUT OF BYPASS CHANNEL



○ List of Groundsill				
No.	River	Name	Location	Height(m)
No. 1	Porong	Dukuh Baru	KP167.5+087	6.6
No. 2	Porong	Gempol Joyo	KP155+044	5.0
No. 3	Porong	Tambakrejo	KP128+000	3.8
No. 4	Porong	Sukoanyar	KP95-005	4.5
No. 5	Porong	Kedung Mungal	KP79+137	3.8
No. 6	Porong	Cepiples	KP25-040	2.9
No. 7	Porong	Sadar Tengah	KP19-039	5.4
No. 8	Brantas	Mlirip	KB50-050	5.2
No. 9	Brantas	Gembongan	KB57-063	5.1
No.10	Brantas	Ngares Kidul	KB59-090	5.0
No.11	Brantas	Tapen	KB69.5+000	5.1
No.12	Brantas	Ngrombot	KB94.5-066	4.5
No.13	Brantas	Minggiran	KP116-062	5.0

LOCATION MAP

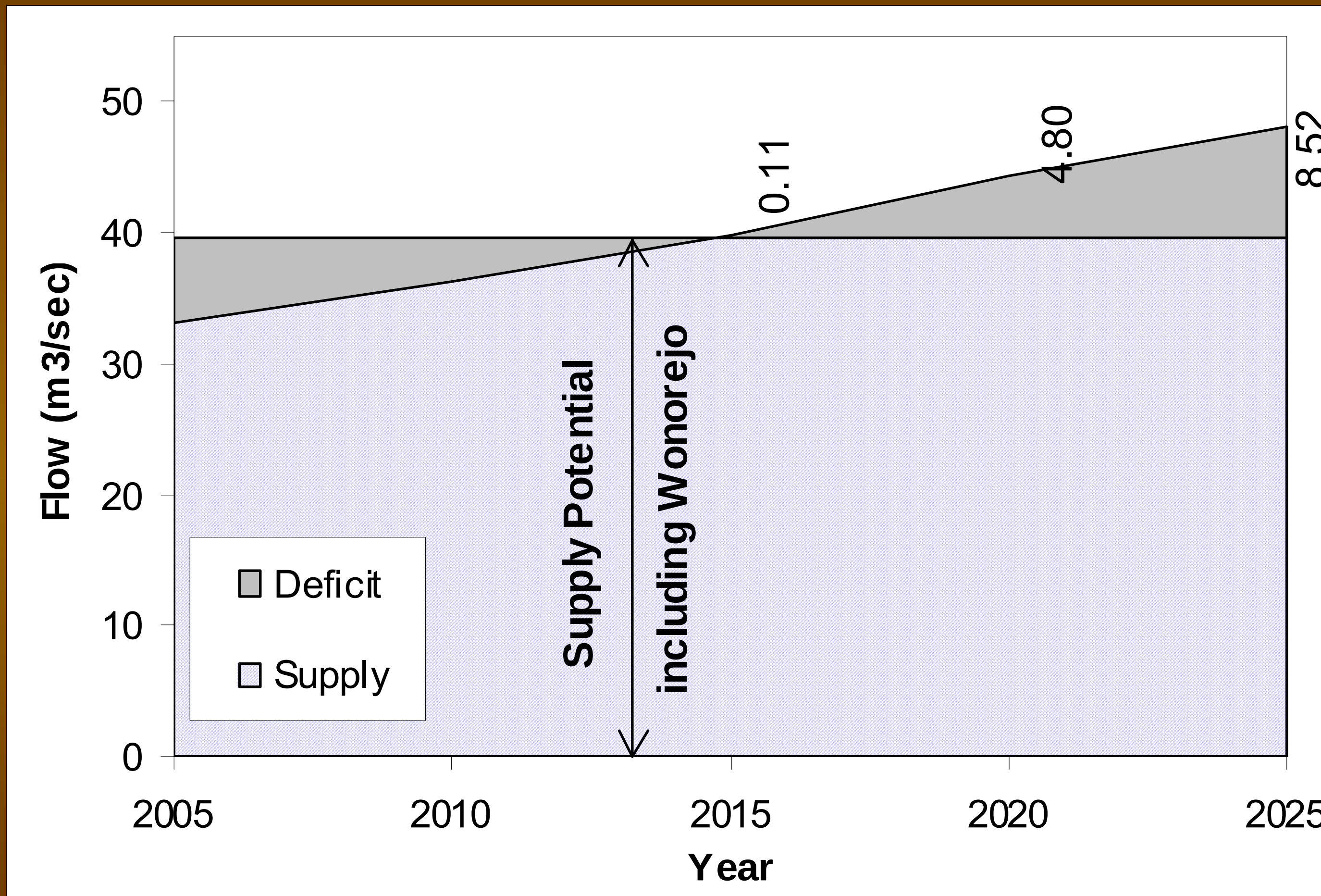
Estimation on Water Demand

Demand and Supply Projections at the Balance Point
(Upstream Conjuction of Porong and Surabaya Rivers)

Item	2005	2010	2015	2020	2025
Irrigation	10.17	10.09	10.02	9.95	9.86
PDAM [1)]	8.48	10.40	12.52	15.24	16.87
Industry	2.75	3.03	3.39	4.43	5.61
Maintenance Flow	11.80	12.80	13.80	14.80	15.80
Demand Total	33.20	36.32	39.73	44.42	48.14
Supply [2)]	39.62	39.62	39.62	39.62	39.62
Deficit (-)	6.42	3.30	-0.11	-4..80	-8.52

1) PDAM Surabaya, Gresik and Sidoarjo
2) Potensial supply based on 90 % dependability dry season incl. Wonorejo supply 8 m^3/s

Forecast of Water Demand



Potential Water Resources in Brantas River Basin Developing for Large Dam

No.	Water Resources	Raw Water (m^3/dt)	Irrigation (ha)	PLTA mW	Study Status
1.	Beng Dam	4,3	334	0,67	F/S, IRR = 19,07 %
2.	Genteng Dam	6	-	4,8	F/S, IRR = 13,00 %
3.	Tugu Dam	2,15	250	-	F/S, IRR = 15,97 %
4.	Kedungwarak Dam	3,5	-	7,6	M/P. IV, 1998
5.	Babadan Dam	5,4	-	9,4	M/P. IV, 1998

BrantasRiver Basin Development Programs 2005 - 2020

No.	Programs	Budget Source	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1	Non Permanent Working Unit Brantas Conservation																	
	- Watershed Conservation	LB	x	x	x	x	x	x	x	x	x	x	x	x				
	- Small Ponds (Irrigation)	LB	x	x	x	x	x	x	x	x								
	- Bajulmati Dam	Loan		x	x	x	x	x										
	- Beng Dam	Loan						x	x	x	x	x						
	- Genteng Dam	Loan										x	x	x	x	x		
2	Non Permanent Working Unit Brantas Water Reources Infrastucture Rehabilitation	IP-510																
	- Procurement of Dredging System																	
	- Karangkates Reservoir		x	x														
	- Wlingi Reservoir		x	x														
	- Sabo dams in upper Brantas and Sediment Settlement P.		x	x	x													
	- Sabo dams in Lesti river & Improvement of Karangkates Plunge pool		x	x	x													
	- Rehab. Of Jatimlerek RD		x															
	- Rehab. Of Menturus RD, Watudakon Syphon, Cepi-ples GS & Bangiltak Syphon			x	x	x												
	- Constr. Of Ground Sill (13)			x	x	x	x											
	- Rehab. Of Revetment & levee			x	x	x												

No.	Programs	Budget Source	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
3	Non Permanent Working Unit Brantas Water Supply																	
	- Pelayaran Cannal	LB	x	x	x	x												
	- Small Ponds (raw water)	LB	x	x	x	x	x	x	x	x								
4	Non Permanent Working Unit Brantas Flood Controll																	
	- River Normalization Works	LB	x	x	x	x	x	x										
	- Drainage System Works	Loan/LB	x	x	x	x	x	x	x	x								
5	Non Permanent Working Unit Brantas Hydropower																	
	- Ampel Gading Hydropower	LB	x	x	x	x												
	- Kesamben Hydropower	LB			x	x	x	x										

THANK YOU

On sediment yield and transport in the Lesti River Basin

- Experiences from field observations and remotely sensed data-

Hajime NAKAGAWA, Yoshifumi SATOFUKA,
Yasunori MUTO, Satoru OISHI,
Takahiro SAYAMA, and Kaoru TAKARA

Background

- Sediment yield and transport are important issues for the river basin management, specially in the volcanic region like the Brantas River basin.

- Human activity such as deforestation or large scale cultivation may activate sediment yield from a basin.

- It is inevitable to understand the mechanism of sediment yield and transport in a catchment scale and the impact of human activity on sediment yield.

Purposes of the study

- Understanding on the mechanism of sediment yield from the Lesti River basin by taking into account human impact

- Development of a rainfall-sediment-runoff model in a catchment scale

- Integrate water-sediment management

Contents

1. Discharge and sediment conductivity observation results at the downstream and some internal river sections in the Lesti River basin.

2. Relationship between splash erosion and rainfall property.

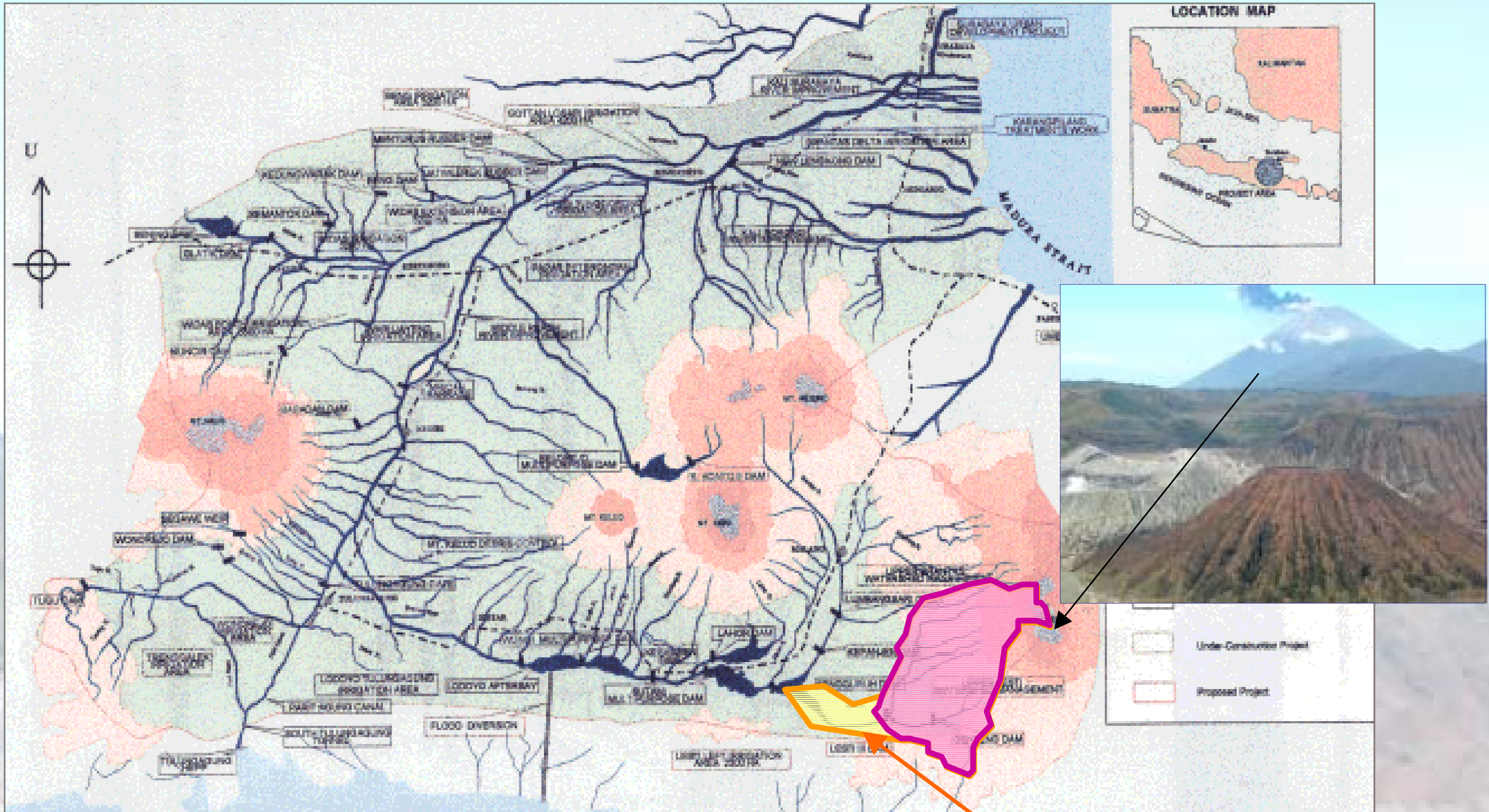
   – Observation of raindrops in the Brantas River basin with MRR.

3. Seasonal land cover change detection with remotely sensed data.

4. Erosion measurement with staves installed at different land use regions.

Brantas River Basin

Brantas River Basin (12500 km^2), Indonesia



Lesti River Basin (625 km^2)

Properties of sediment in Mt. Kelud and Mt. Semeru

Mt. Kelud

Mt. Semeru

Sediment issues in Mt. Kelud catchment and Mt. Semeru catchment

Mt. Kelud

Mt. Semeru

Good quality sand -> sand mining -> riverbed degradation

Fine sediment -> sedimentation problem in dam reservoirs

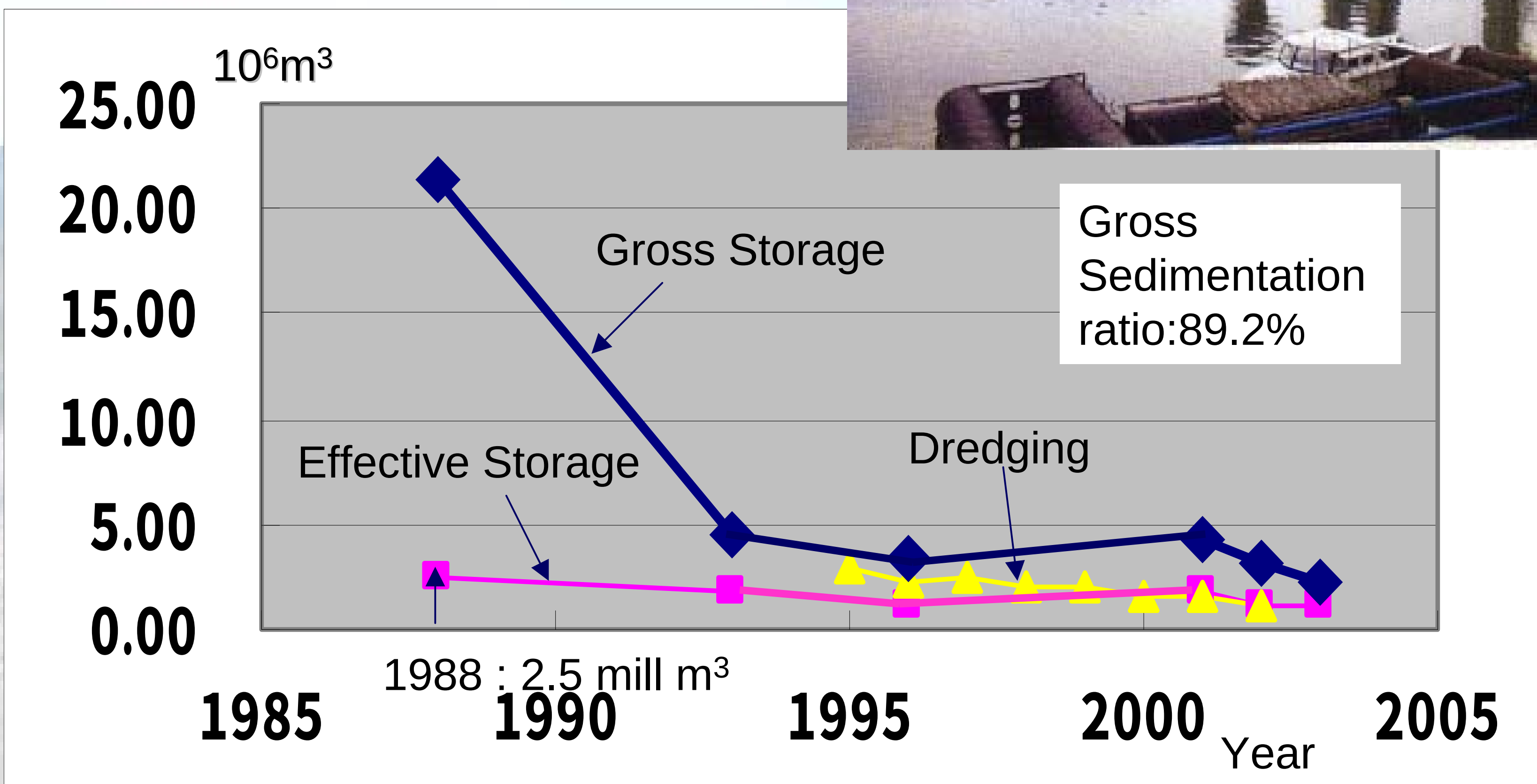
Reservoir Sedimentation

Sengguruh Reservoir

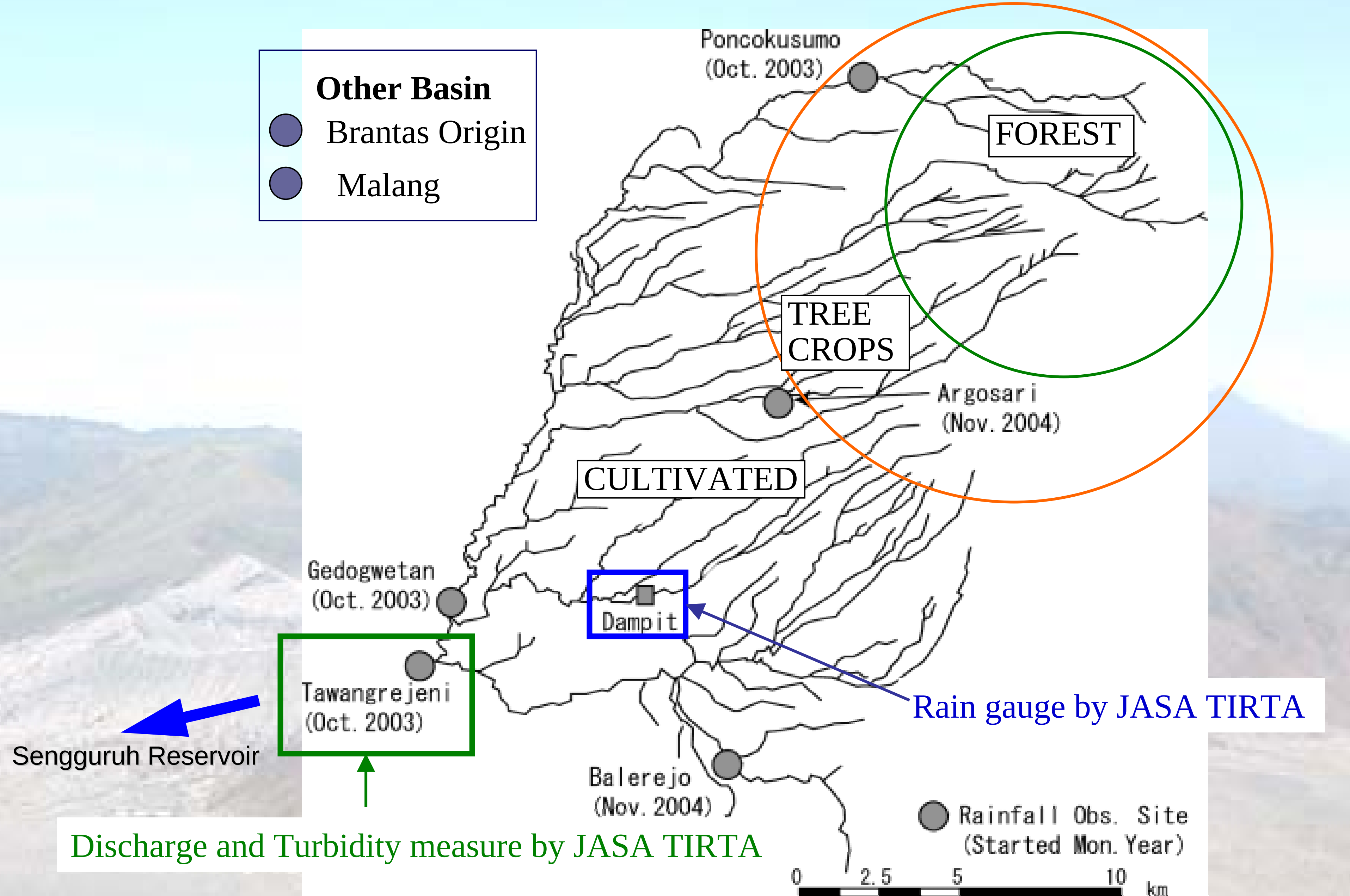
(Hydropower, Water Supply)

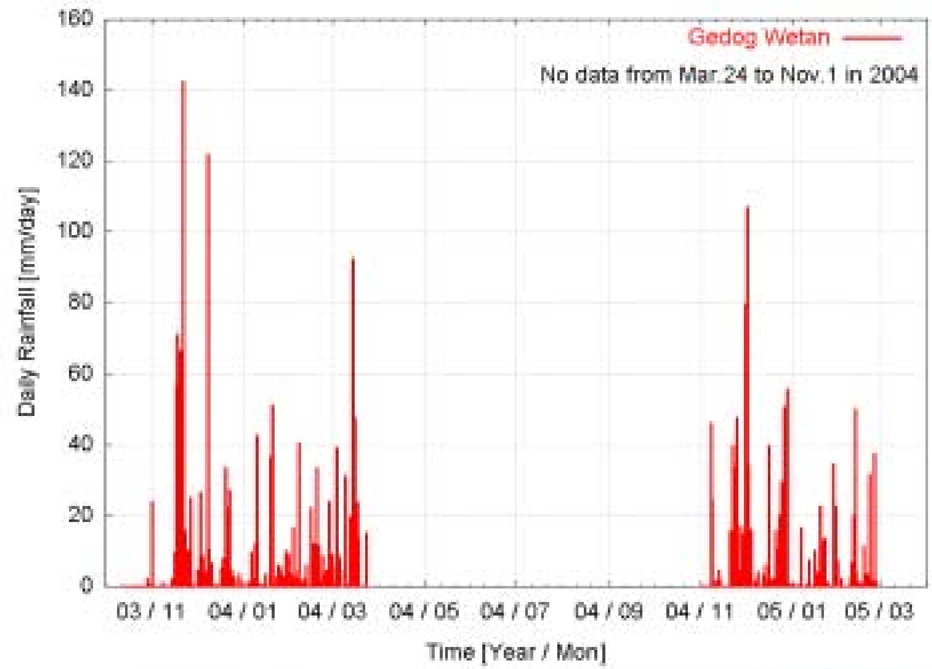
Annual Sediment Yield

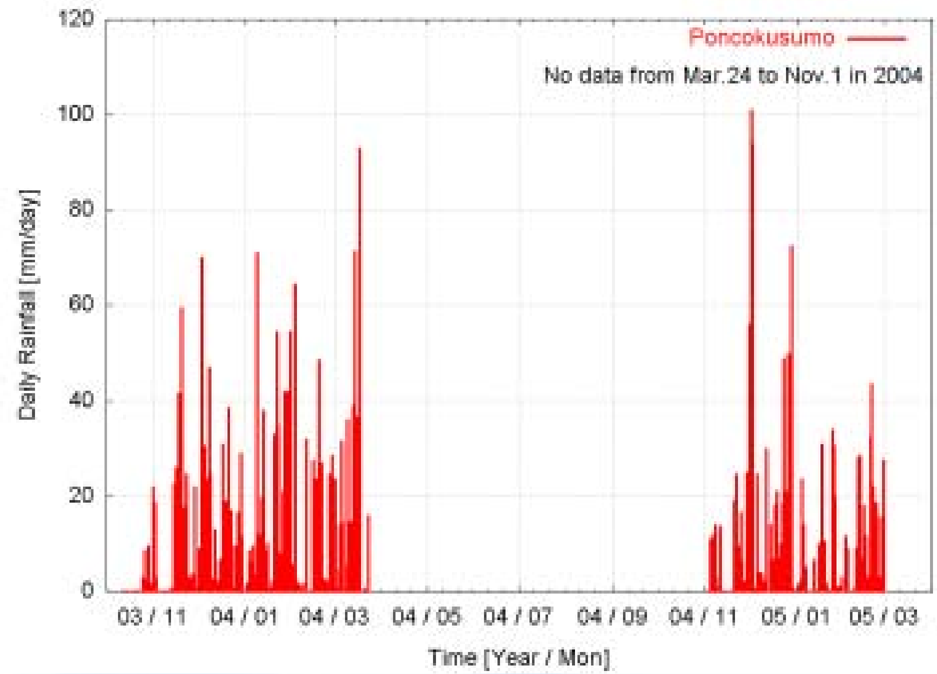
$2.26 \times 10^6 m^3/year$

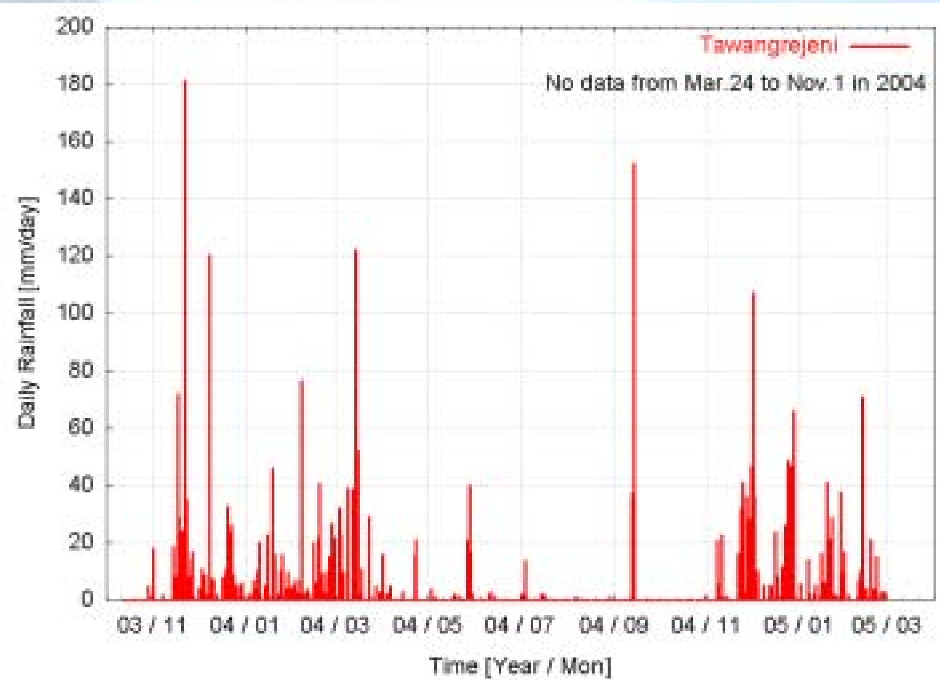


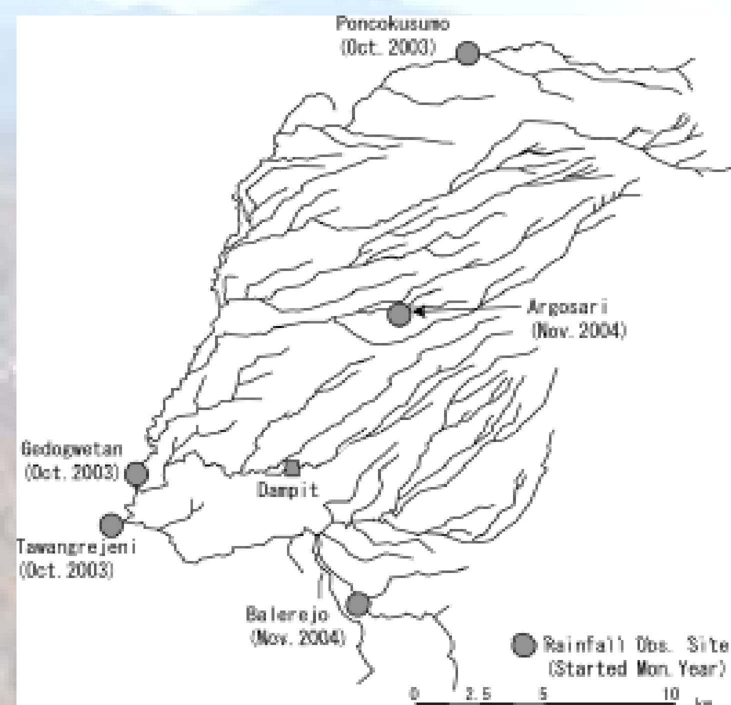
Rainfall observations in the Lesti River basin



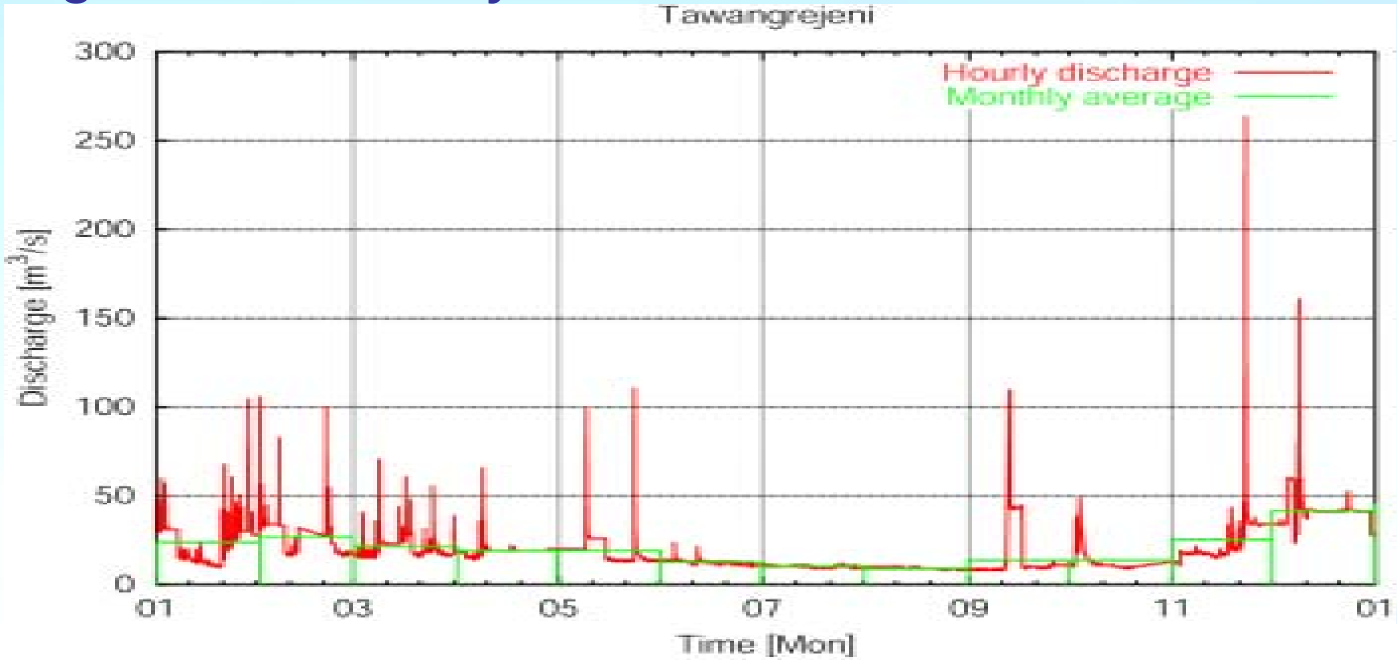

Gedog Wetan
No data from Mar.24 to Nov.1 in 2004
Daily Rainfall [mm/day]
Time [Year / Mon]
03 / 11
04 / 01
04 / 03
04 / 05
04 / 07
04 / 09
04 / 11
05 / 01
05 / 03

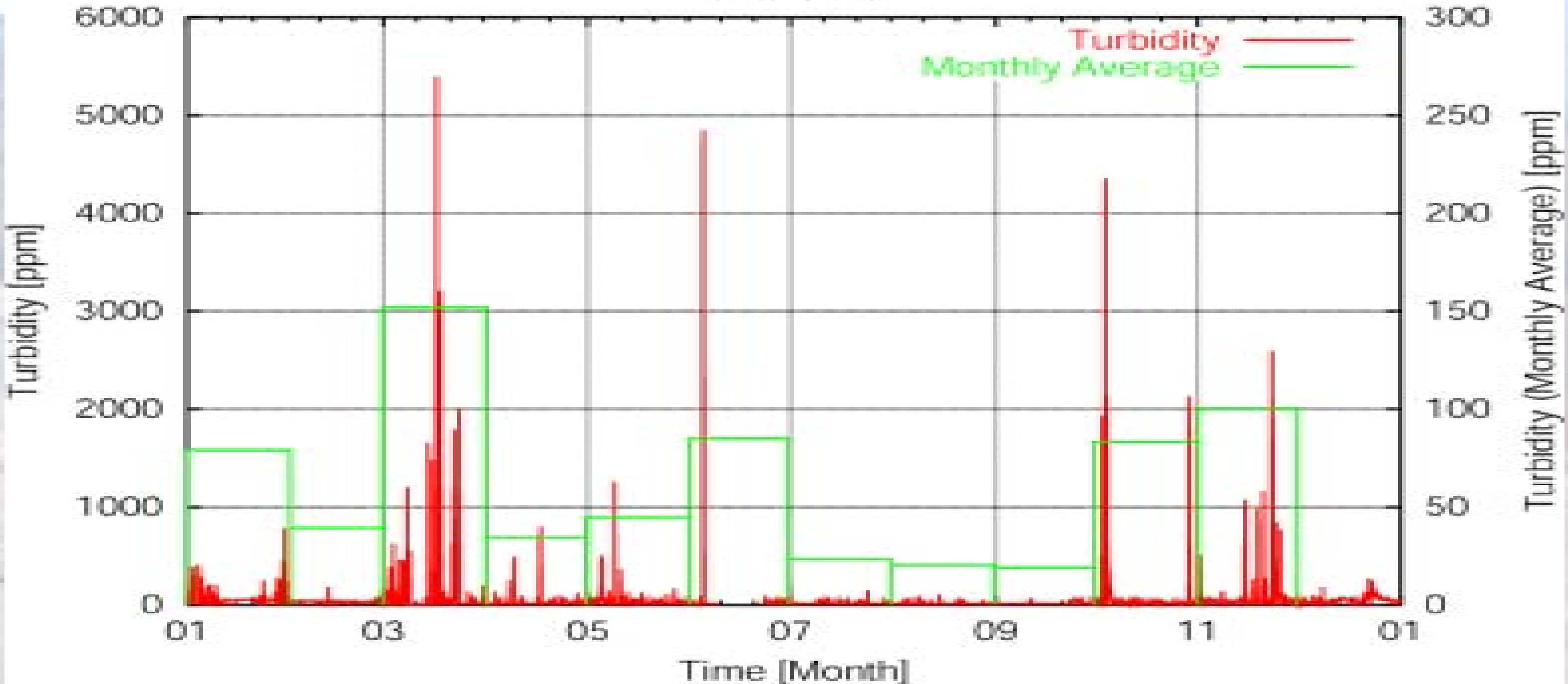

Poncokusumo
No data from Mar.24 to Nov.1 in 2004
Daily Rainfall [mm/day]
Time [Year / Mon]
03 / 11
04 / 01
04 / 03
04 / 05
04 / 07
04 / 09
04 / 11
05 / 01
05 / 03


Tawangrejeni
No data from Mar.24 to Nov.1 in 2004
Daily Rainfall [mm/day]
Time [Year / Mon]
03 / 11
04 / 01
04 / 03
04 / 05
04 / 07
04 / 09
04 / 11
05 / 01
05 / 03

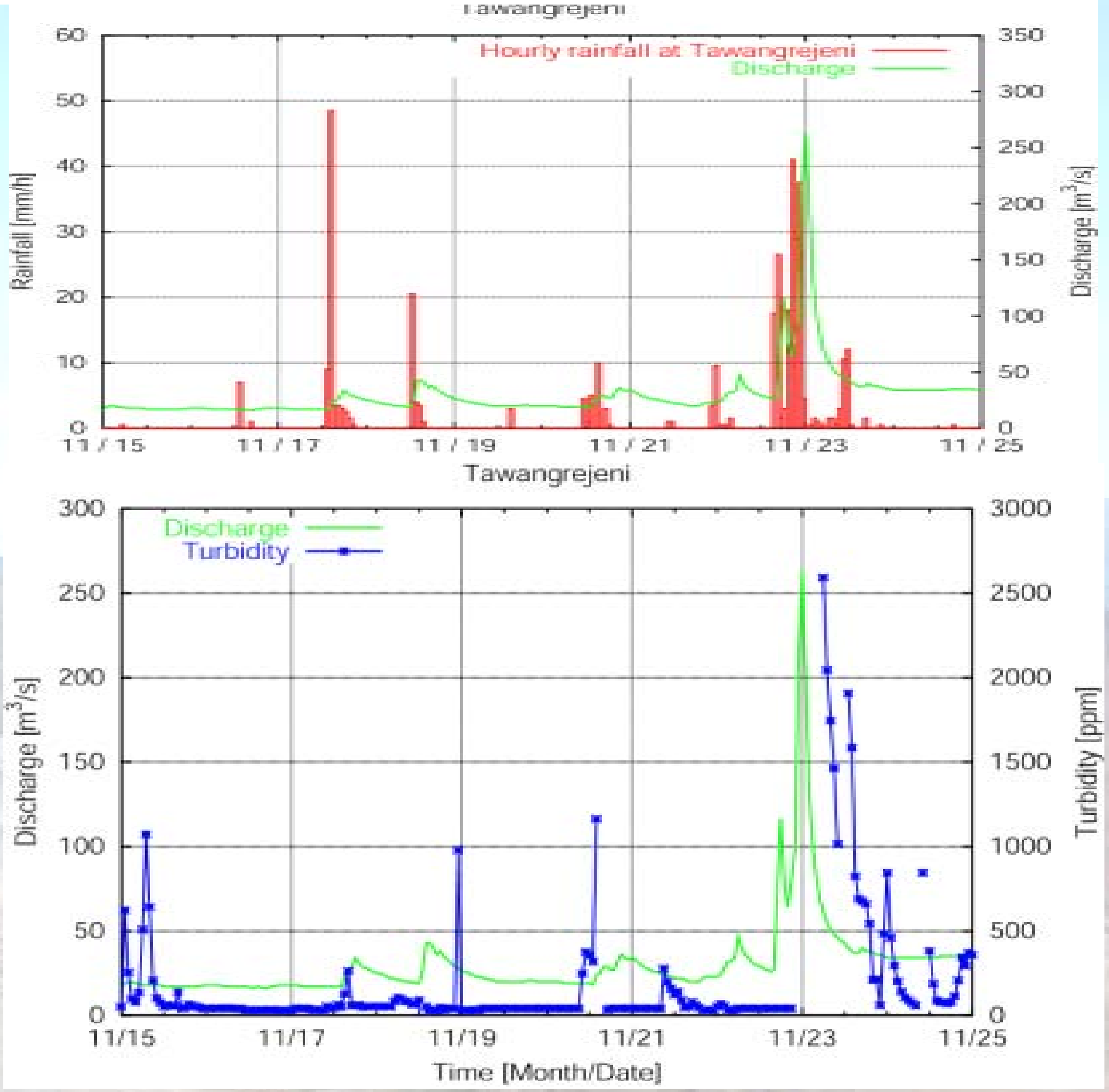

Poncokusumo
(Oct. 2003)
Argosari
(Nov. 2004)
Gedogwetan
(Oct. 2003)
Dampit
Tawangrejeni
(Oct. 2003)
Balerejo
(Nov. 2004)
Rainfall Obs. Site
(Started Mon. Year)
0
2.5
5
10
km

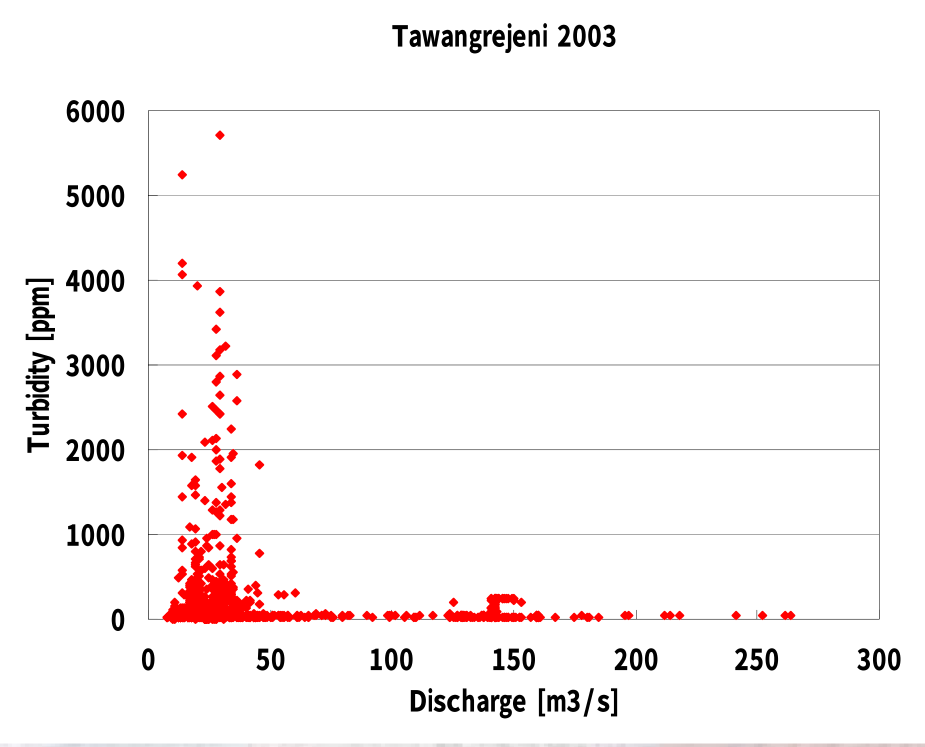
Discharge and Turbidity in 2003



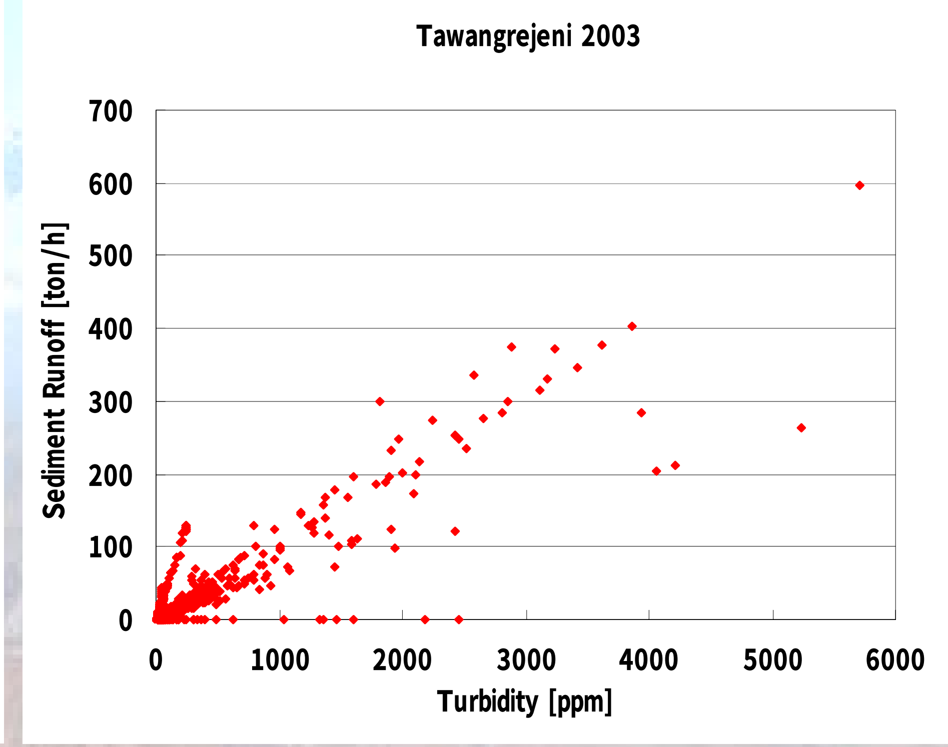


Discharge and Turbidity during flood in Nov. 2003





Tawangrejeni 2003
6000
5000
4000
3000
2000
1000
0
Turbidity [ppm]
0
50
100
150
200
250
300
Discharge [m3/s]



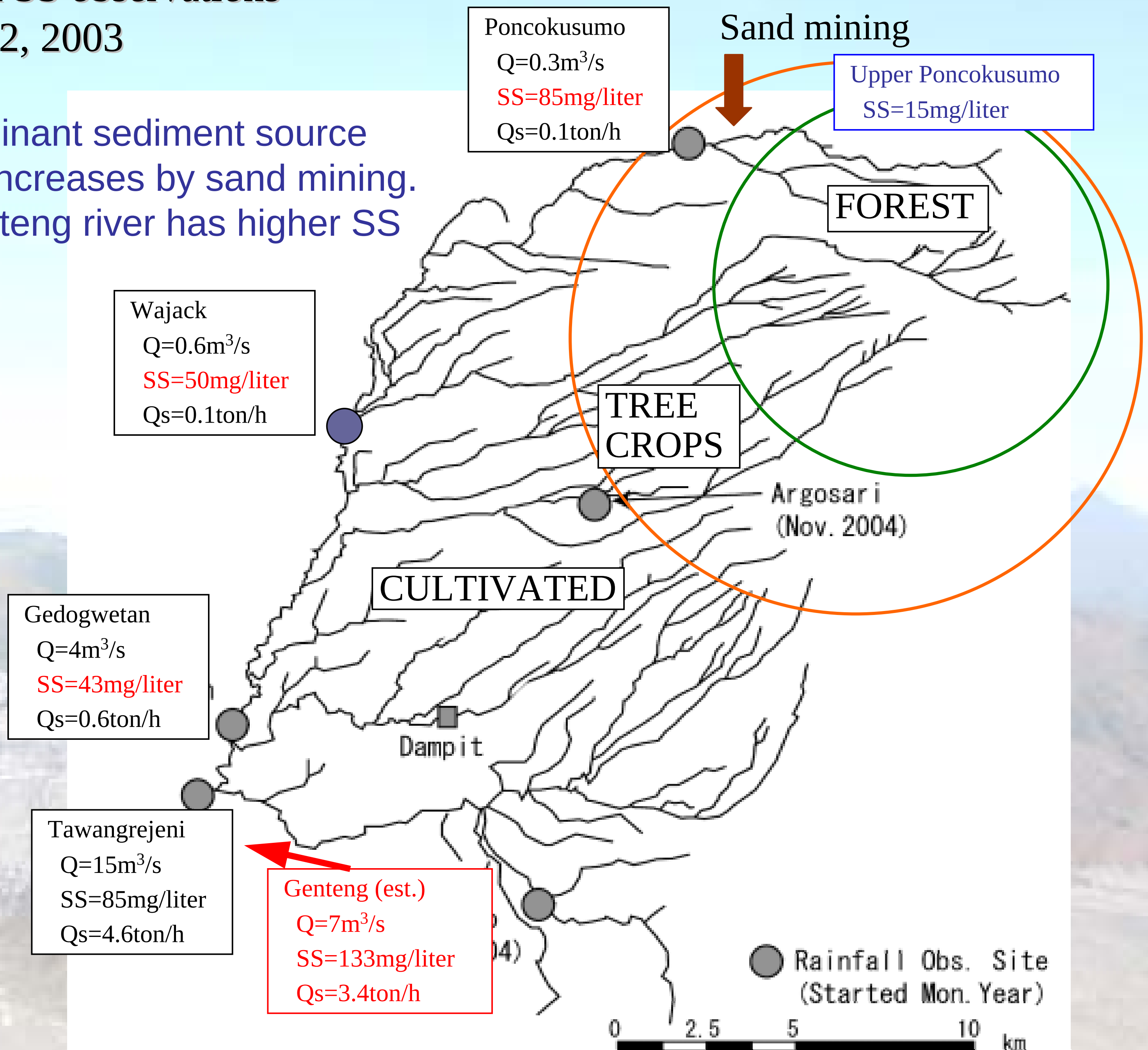
Tawangrejeni 2003
700
600
500
400
300
200
100
0
Sediment Runoff [ton/h]
0
1000
2000
3000
4000
5000
6000
Turbidity [ppm]

Discharge and SS observations in Dec. 20 – 22, 2003

Purpose : Dominant sediment source

Findings : SS increases by sand mining.

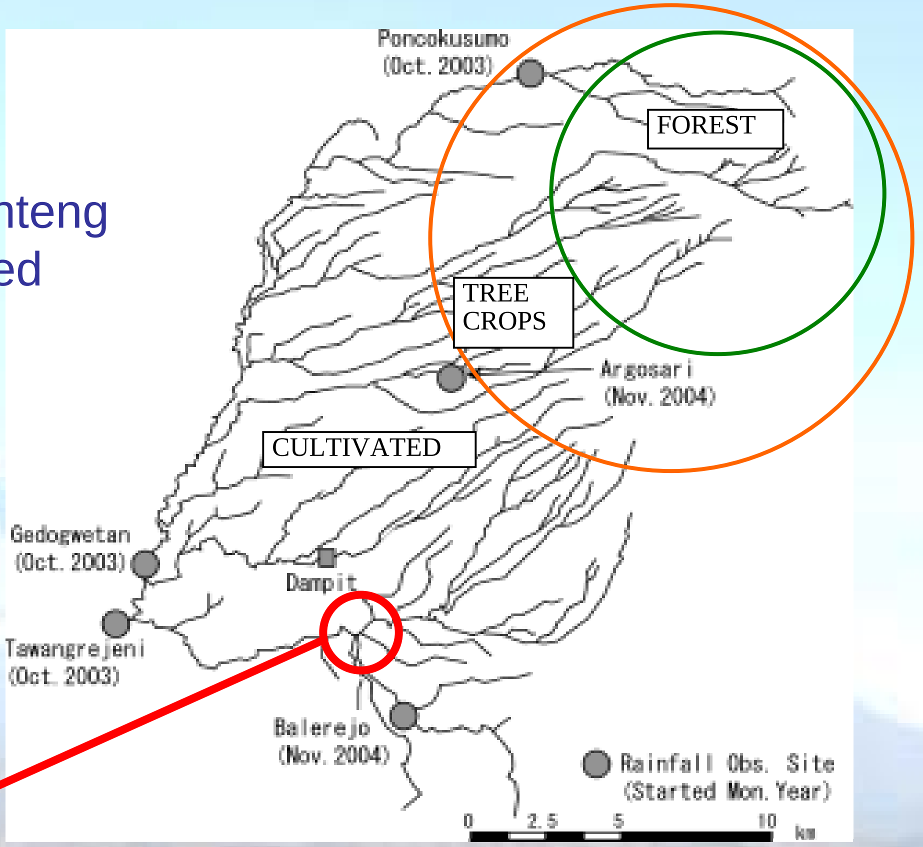
: Genteng river has higher SS



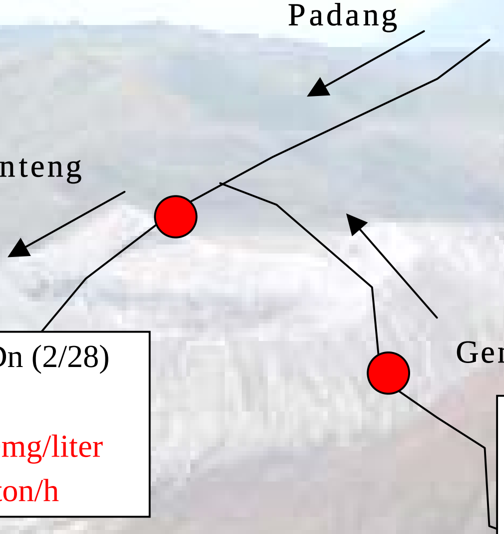
Discharge and SS observations in Feb. 28 - Mar. 2, 2005

Purpose : Dominant sediment source in Genteng

Findings : One order higher SS was observed compared observations in 2003.



Padang (est.) (2/28)
Q=2.2m^3/s
SS=1750mg/liter
Qs=13.9ton/h

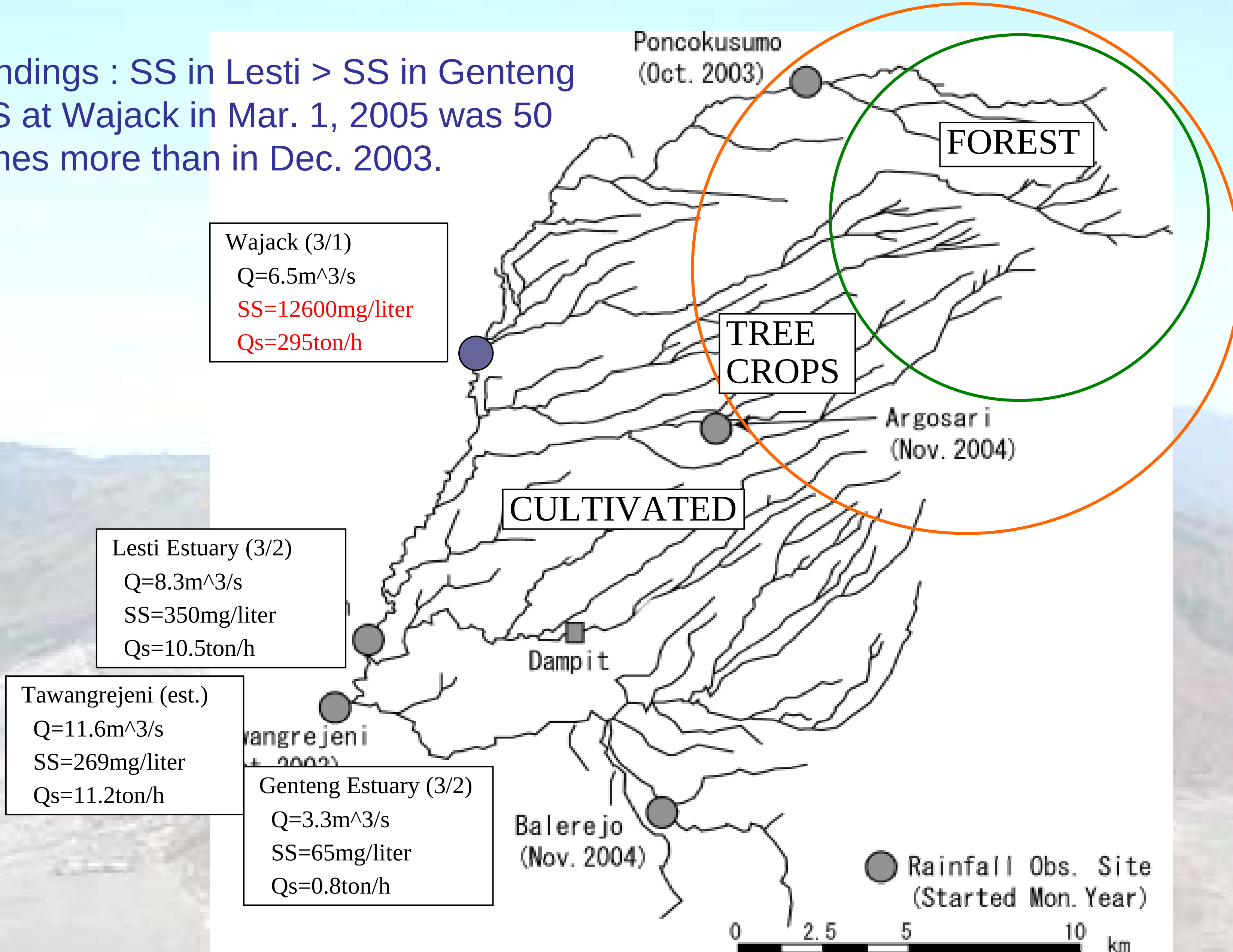


Genteng Dn (2/28)
Q=3m^3/s
SS=1300mg/liter
Qs=14.0ton/h

Genteng Up (2/28)
Q=0.8m^3/s
SS=40mg/liter
Qs=0.1ton/h

Discharge and SS observations in Feb. 28 - Mar. 2, 2005

Findings : SS in Lesti > SS in Genteng
SS at Wajack in Mar. 1, 2005 was 50 times more than in Dec. 2003.



Summary of discharge & sediment concentration observation results

- The spatial distribution of rainfall is very heterogeneous.
- Sediment yield does not have strong correlation with Q
  - Ex. Discharge Nov. 2003 > Mar. 2003
    Conductivity Mar. 2003 > Nov. 2003
- Small conductivity was observed at the upstream of Poncokusumo, whose catchment is covered by forest.
- Conductivity changes drastically in time and space.

Three components to understand sediment yield

Sediment erosion

↓

What is the possible volume of sediment yield in bare land ?

↓

Possible sediment splash erosion rate is subject to raindrop impact energy.

↓

Micro Rain Radar

Interrelation

↓

How can the sediment yield be affected by the land cover change ?

↓

Different land cover results in different sediment yield.

↓

Sediment yield measurement stuffs

Human activity

↓

How does the land cover change in the specific site, Lesti River Basin ?

↓

Land cover changes spatially and temporally.

↓

Remote sensing

Micro Rain Radar

MRR

- Vertical one dimensional Doppler radar.
- Raindrop size distribution (0.21 mm – 4.08 mm)
- Raindrop setting velocity

- Standard meteorological rain radar can observe spatially distributed rainfall pattern, but it requires tuning parameter, B-beta, to convert from radar gain to rainfall, while

- MRR can estimate rainfall intensity theoretically based raindrop size distribution *N(D)* and raindrop setting velocity *v(D)*.

$$RR = \frac{\pi}{6} \int_0^{\infty} N(D) D^3 v(D) dD$$

Sediment erosion and raindrop energy work by MRR

Sediment splash erosion rate in bare land is the function of

- raindrop energy work,

which is the function of

- Raindrop Size
- Raindrop Setting Velocity.

If we can observe raindrop size and raindrop setting velocity, we can estimate sediment splash erosion rate.

Splash erosion rate

Vs+ : Sediment detachment volume by a raindrop

$$V_{s+}(\sigma - \rho)g = 2K_+ \left[0.572 \times \rho g^{1/2} \left(\frac{2E_0}{\rho g \pi} \right)^{7/8} \right]$$

Fukada et al. 1989, 1990, 1992

Integration of this function in time and raindrop size distribution indicate sediment splash erosion rate is the function of $E_{7/8}$, which can be estimated by MRR.

$$E_{7/8} = \int_0^t \int_0^\infty N(D) \left(\frac{E_0}{\rho} \right)^{7/8} v(D)\, dD\, dt$$

$$E_0 = \rho_w \frac{\pi}{6} D^3 \frac{v^2(D)}{2}$$

MRR can measure *N(D), v(D)*

Investigate the property of $E_{7/8}$ estimated by MRR.

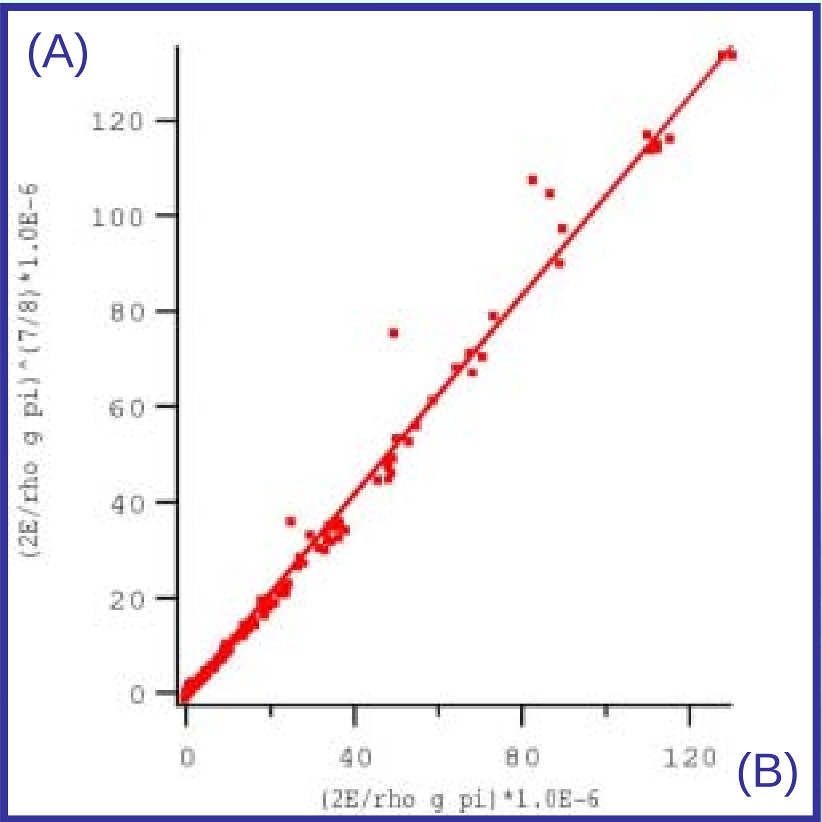
Relationship between $E_{7/8}$ and E_1

(A)

$$E_{7/8} = \int_0^t \int_0^\infty N(D)\left(\frac{E_0}{\rho}\right)^{7/8} v(D)\,dD\,dt$$

(B)

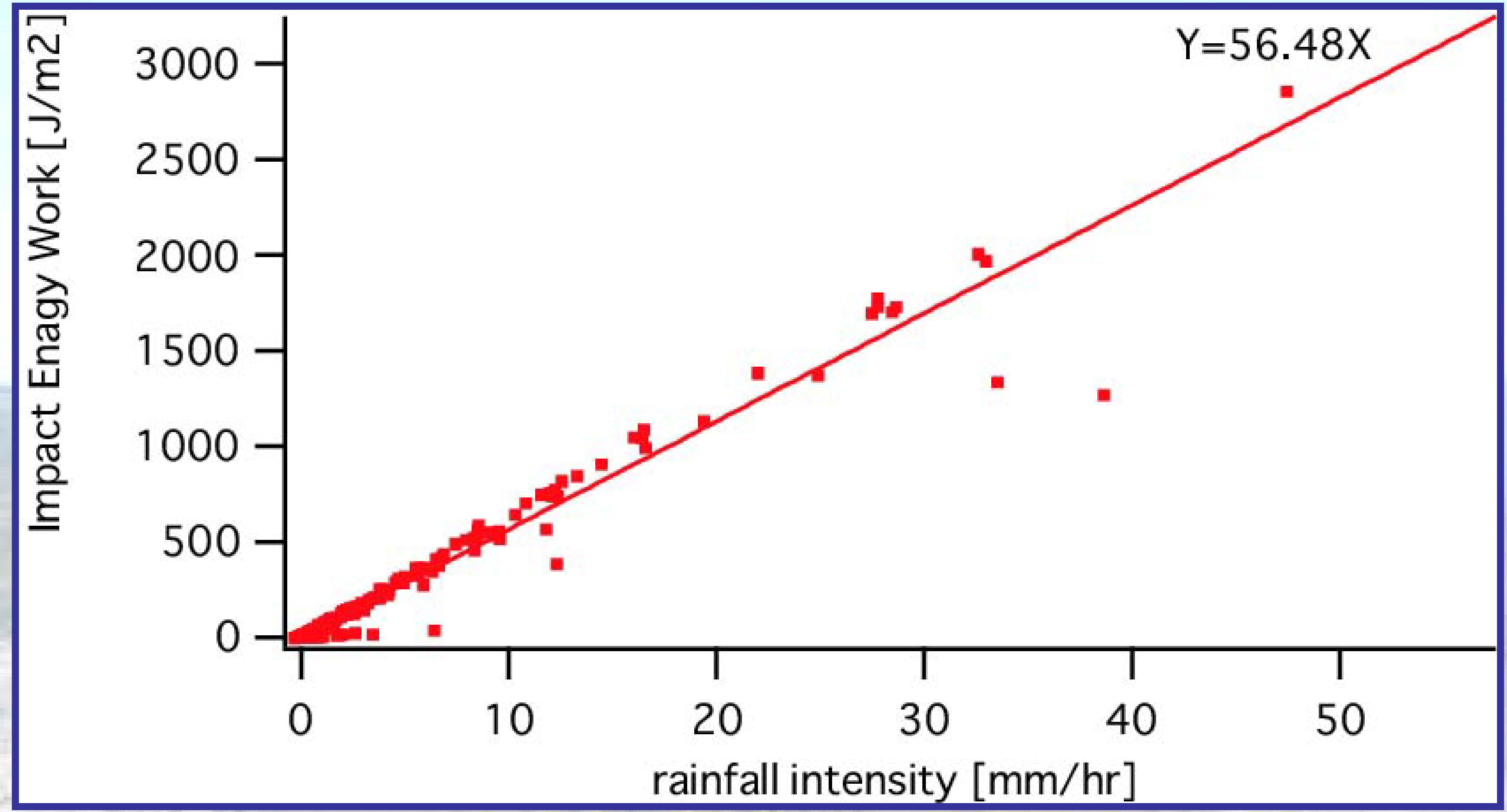
$$E_1 = \int_0^t \int_0^\infty N(D)\left(\frac{E_0}{\rho}\right) v(D)\,dD\,dt$$



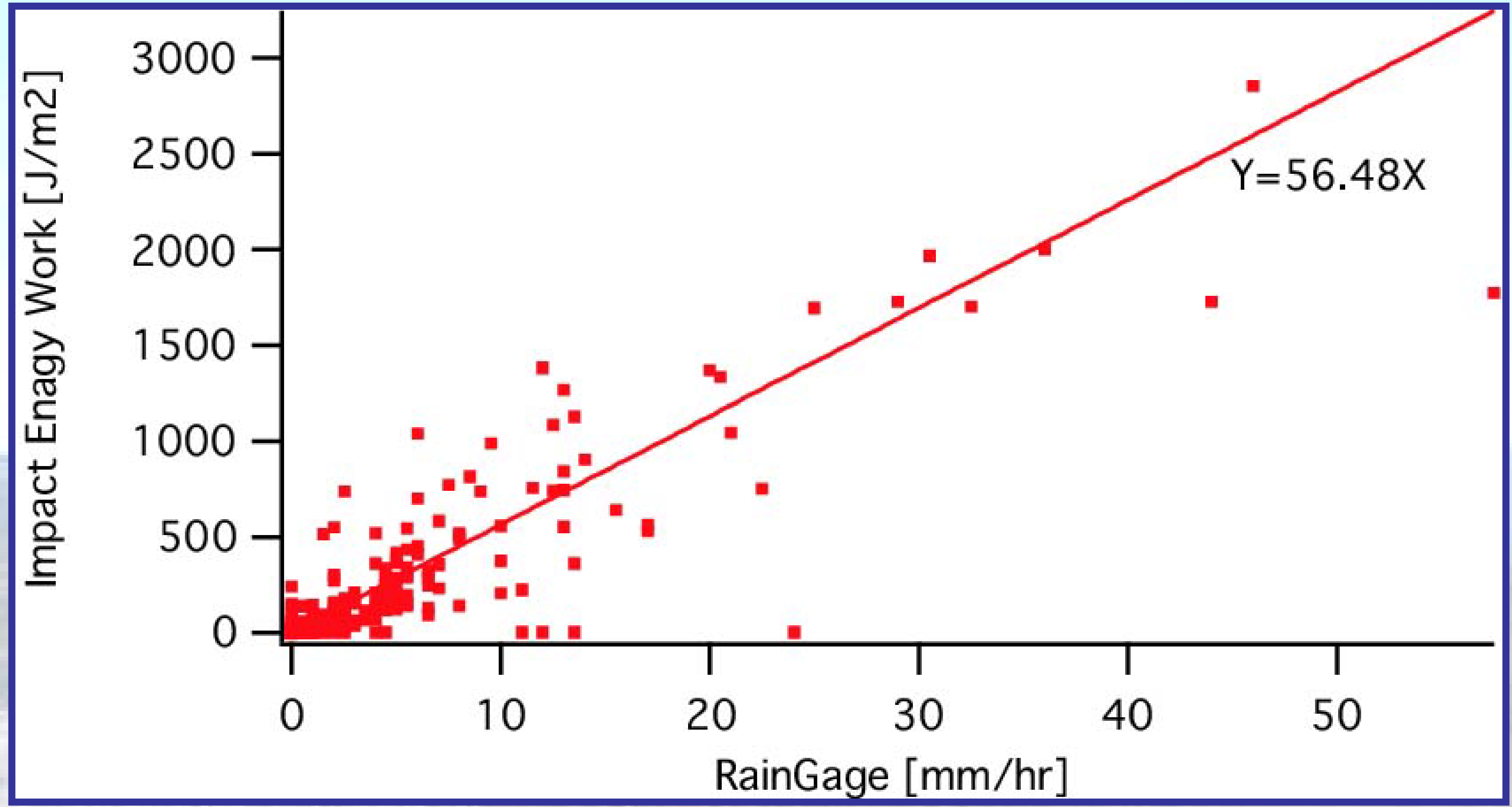
Sediment detachment in bare land has linear relationship with *E_1* : raindrop energy work

Investigate the relationship between *E_1* and rainfall intensity.

Relationship between rainfall intensity and impact energy work



Relationship between rainfall intensity observed by rain gauge and impact energy work



$$E_d = a \times R_d$$

E_d : Daily impact energy work [J/m^2/day]
R_d : Daily rainfall [mm/day]
a : coefficient (= 49.5 [J/m2/mm])

Summary for MRR observation

Sediment detachment in bare land

♦

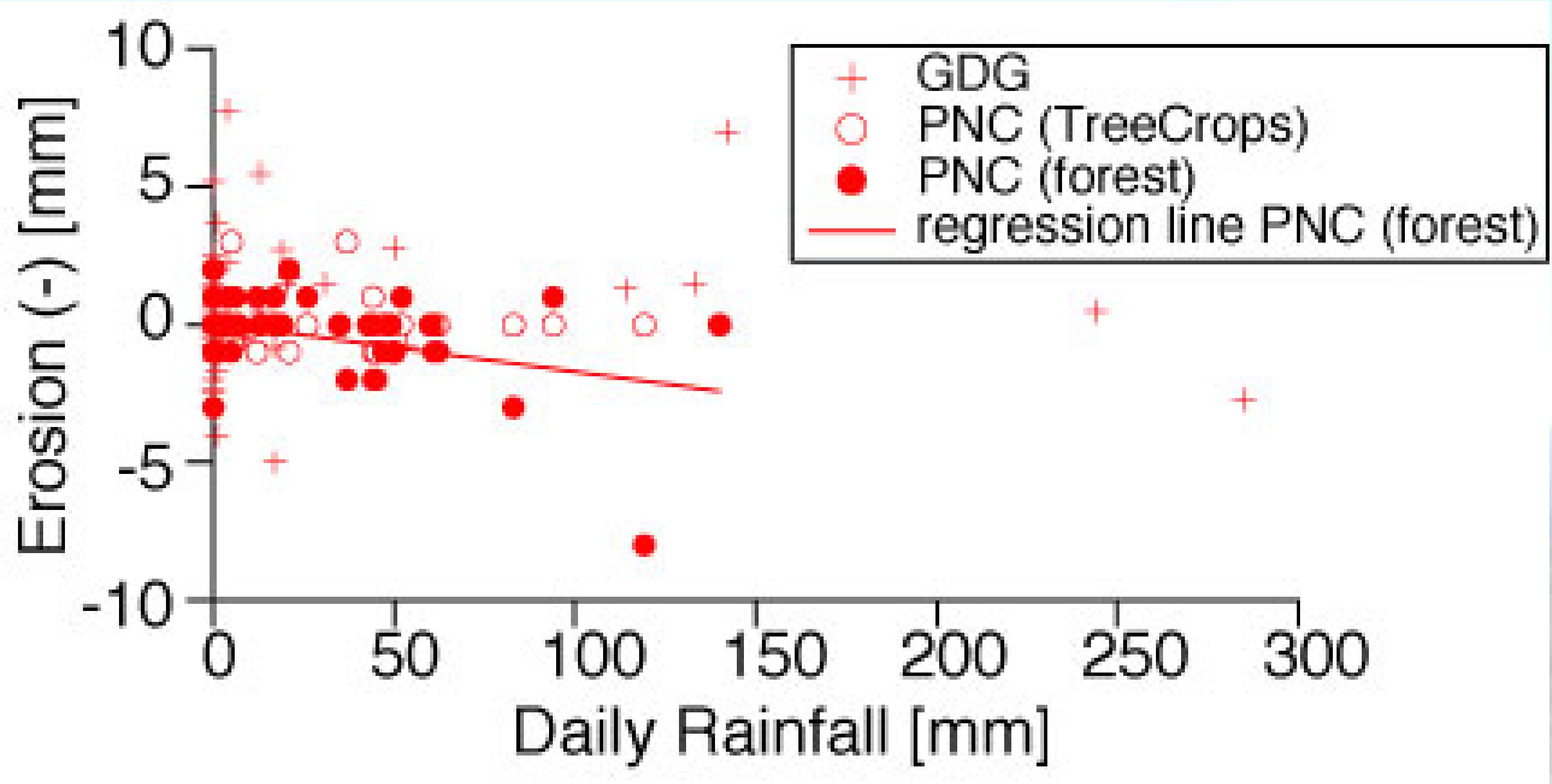
Raindrop impact energy work $E_{7/8}$

♦

Raindrop impact energy work E_1

♦

Rainfall intensity observed by Rain gauge



GDG
PNC (TreeCrops)
PNC (forest)
regression line PNC (forest)
Erosion (-) [mm]
10
5
0
-5
-10
0
50
100
150
200
250
300
Daily Rainfall [mm]

Seasonal land cover change

Oct 2002

Feb 2003

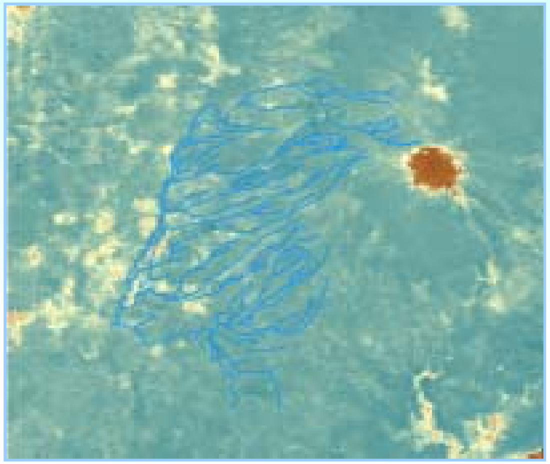
Oct 2003

Seasonal variability of vegetation index

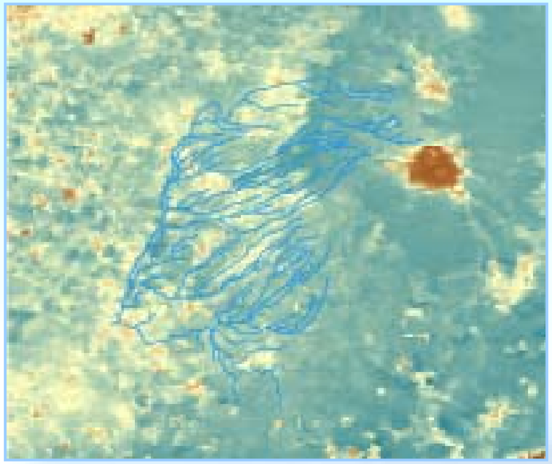
MODIS is a optical sensor installed in the satellite “TERRA”

NDVI=(IR-R)/(IR+R)

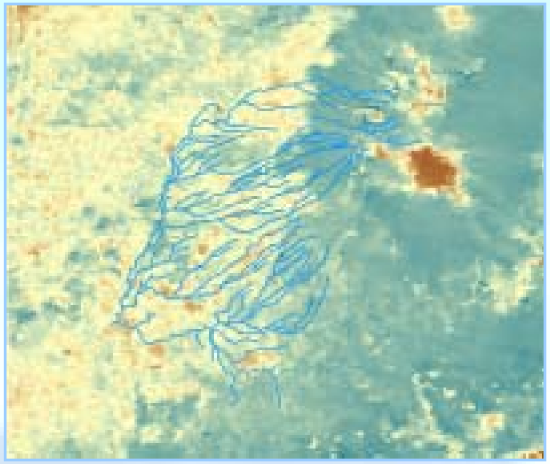
Dry season : May.- Aug.
Rainy season: Oct. – Mar.



May, 2002

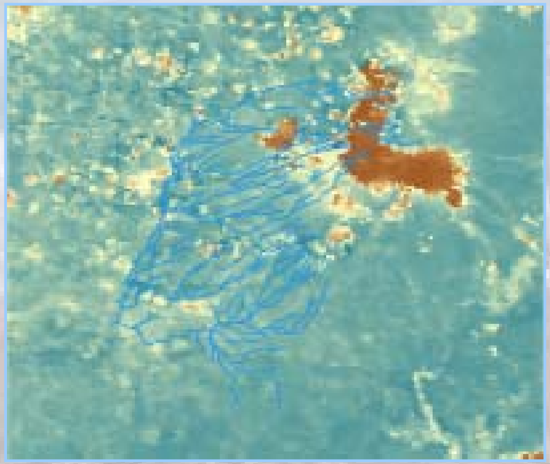


July, 2002

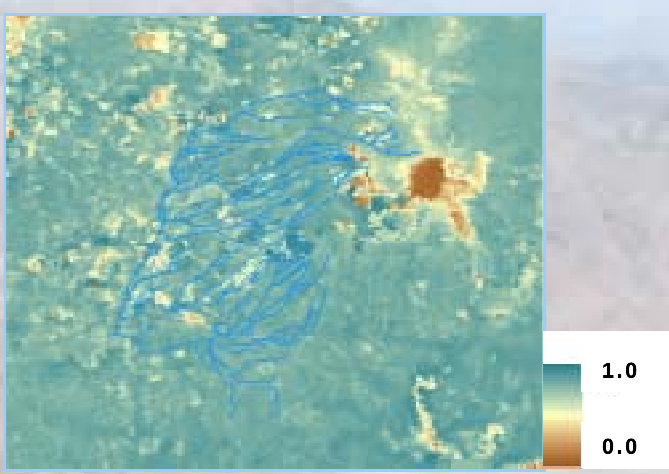


August, 2002

October, 2002

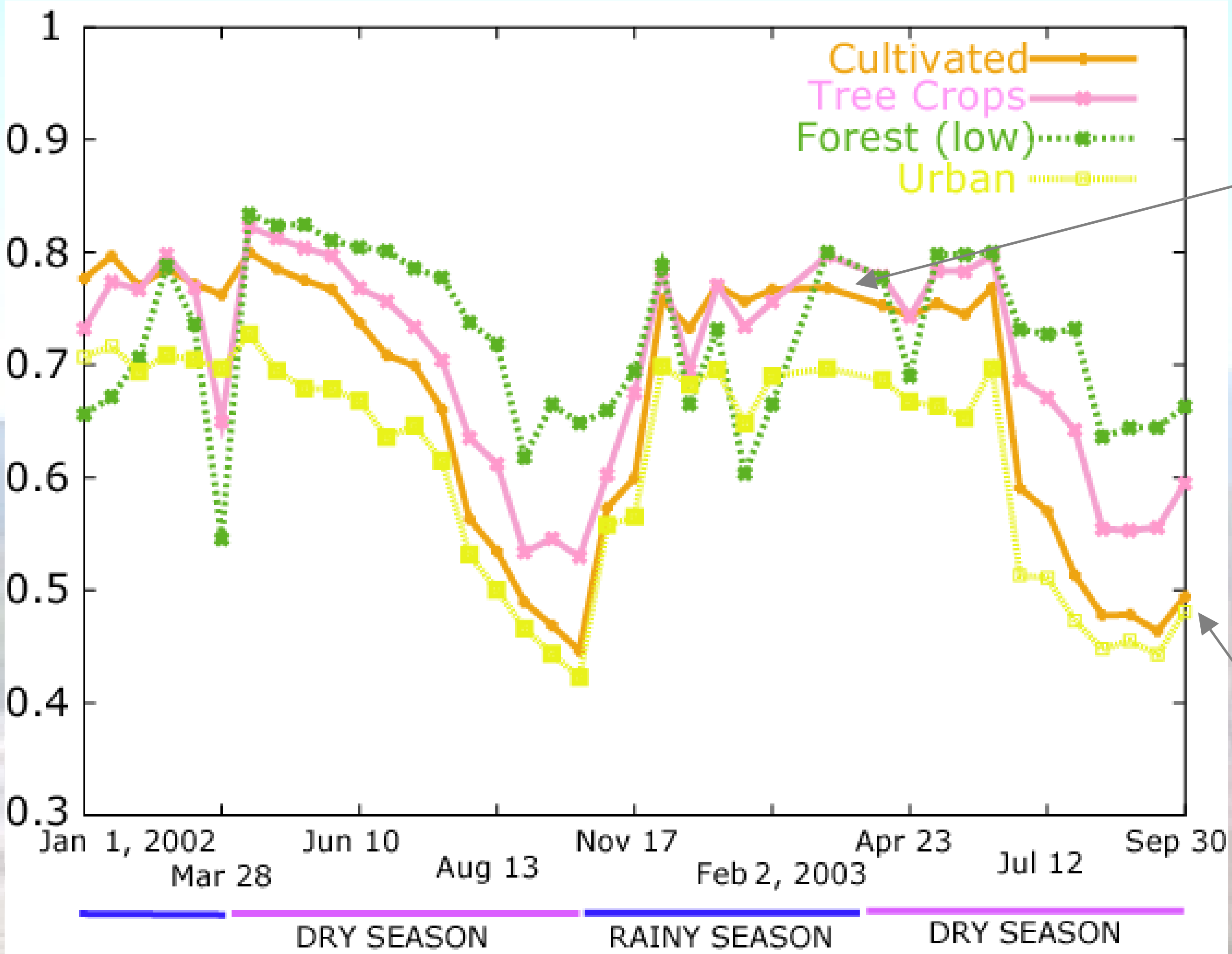


December, 2002

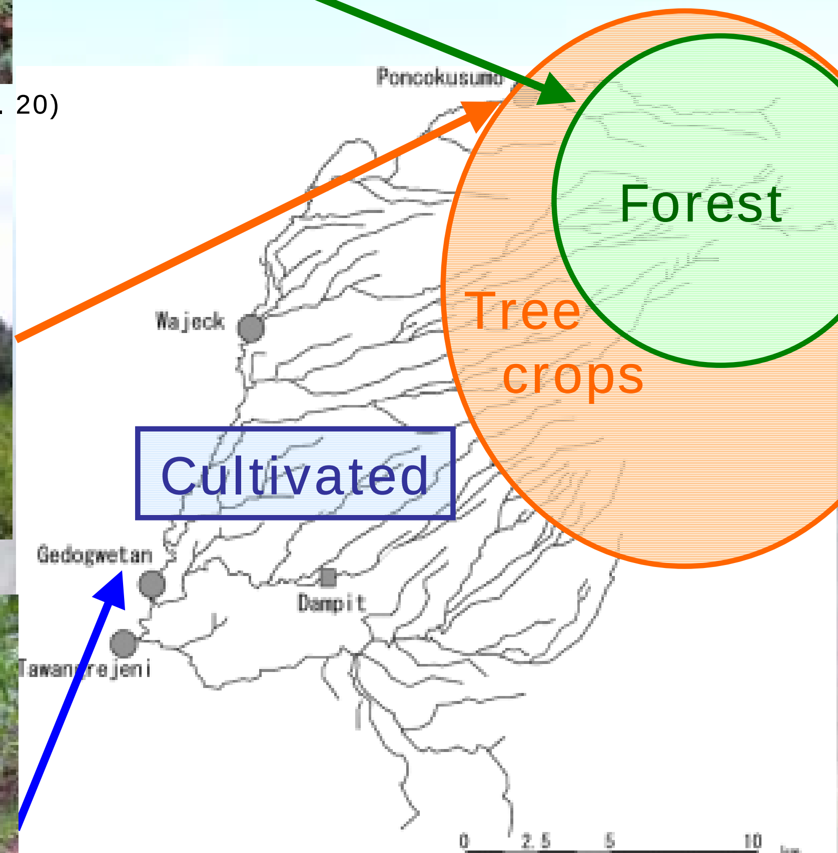


March, 2003

NDVI time series in different landuse



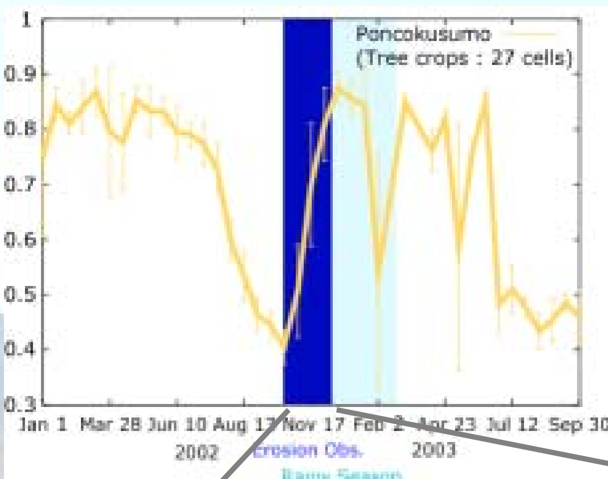
Sediment yield in different land cover



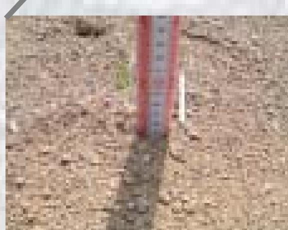
Gauge for erosion measurement

MODIS / NDVI to monitor land cover change

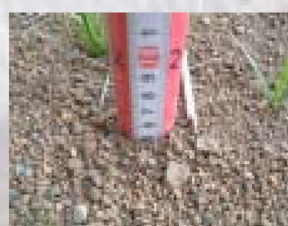
NDVI by MODIS



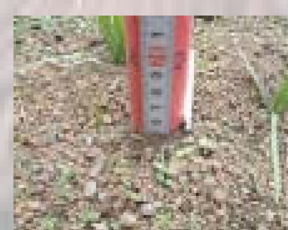
Dec 19, 2003



Oct 12

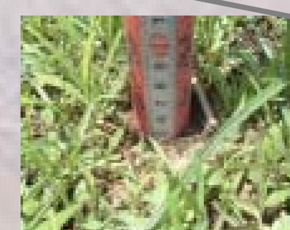


Nov 1



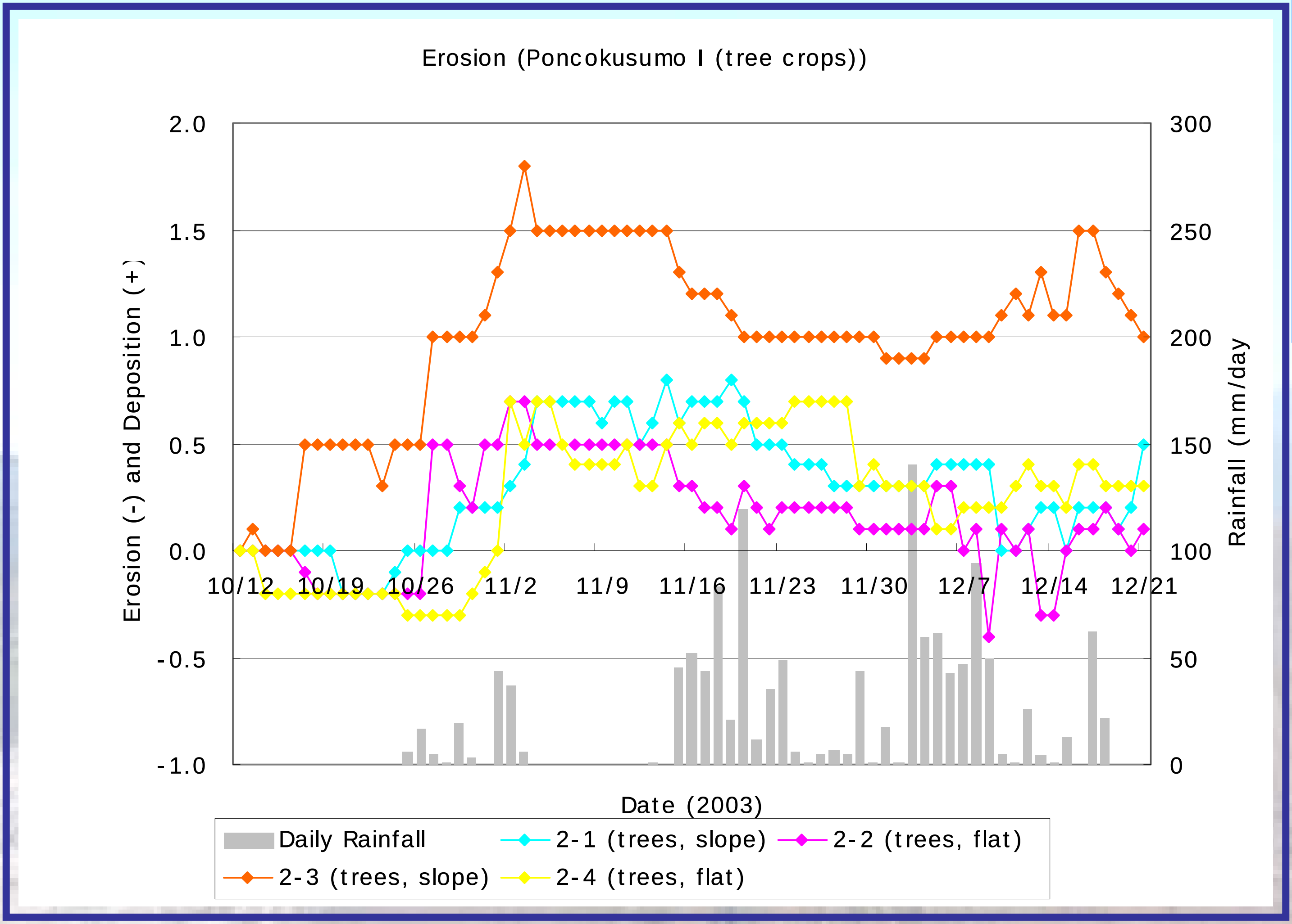
Nov 6

Nov 17



Nov 29

Tree crops (Apple tree)

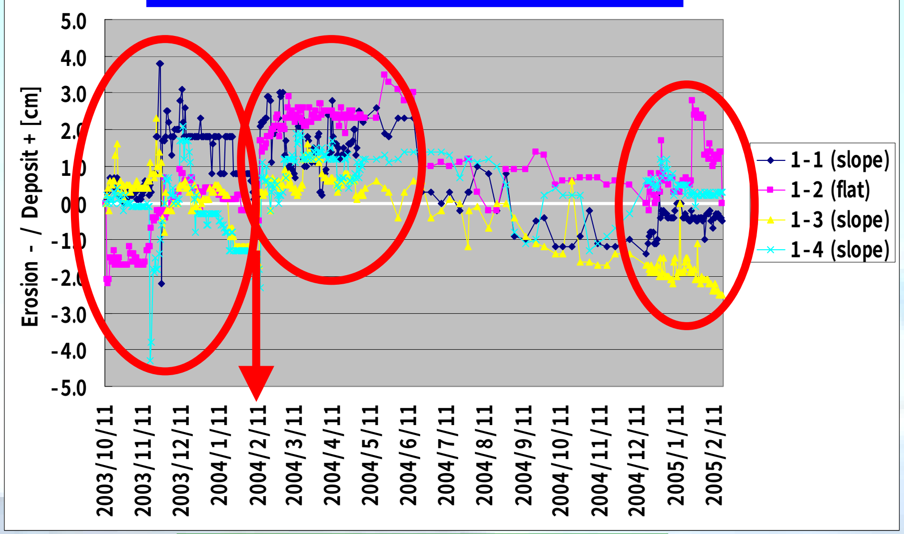


Deposit – Erosion – Stable

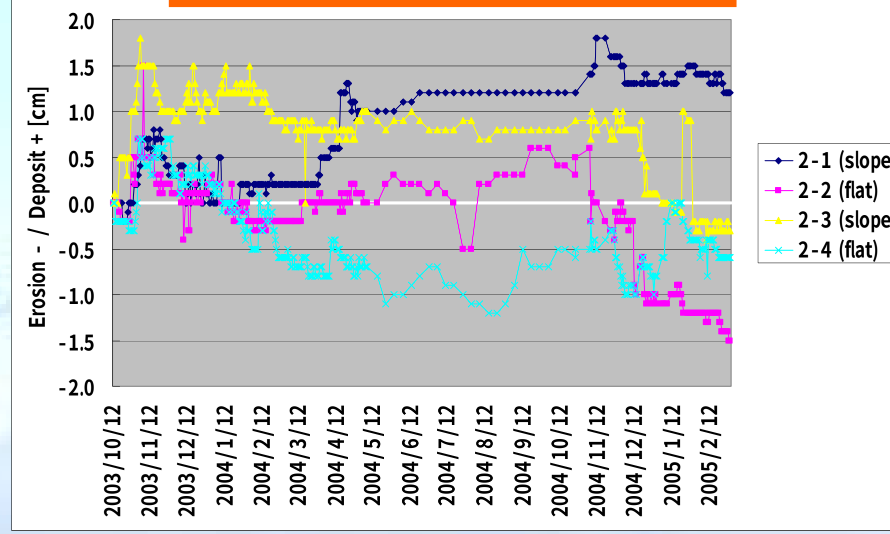
Sediment yield in different land use

Deposit – Erosion – Stable

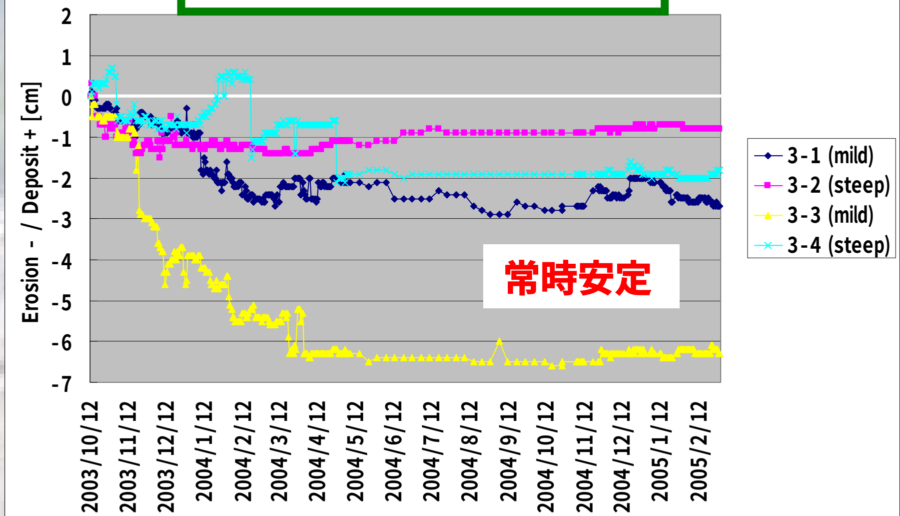
Gedogwetan (cultivated)



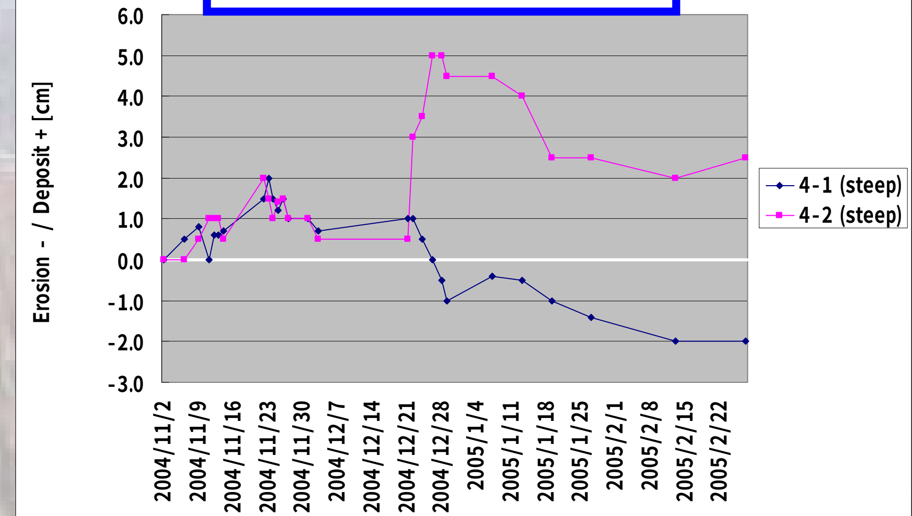
Poncokusumo (tree crops)



Poncokusumo (forest)

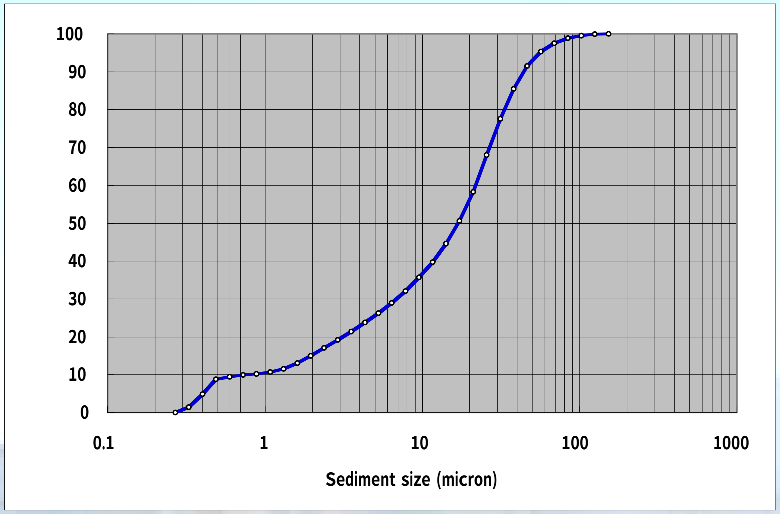


Srimulyo (cultivated)



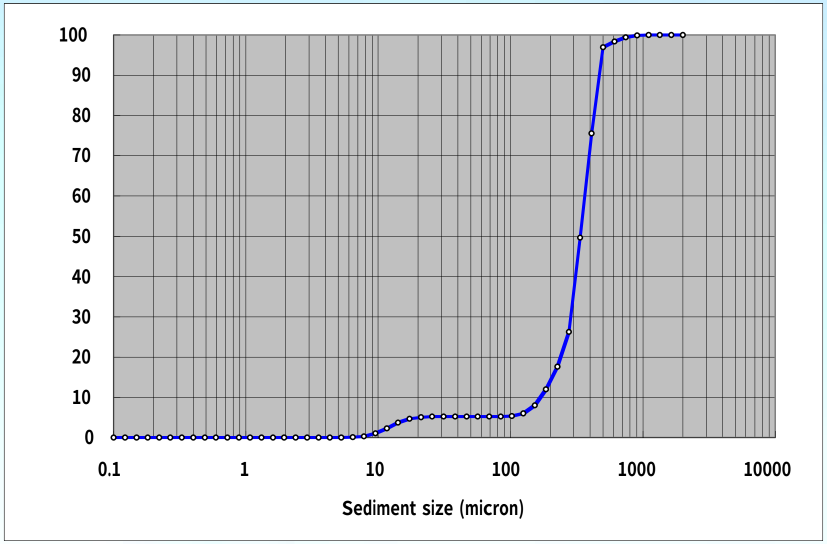
Summary

- Measurement of raindrop impact energy work with MRR indicates linear relationship between rainfall volume and splash erosion rate in bare land, so possible sediment erosion volume can be estimated by rainfall amount.
- Actual sediment yield volume is complex phenomenon; different landuse and different land cover conditions result in different sediment yield. Typical erosion and deposit pattern, deposit – erosion – stable, was found.
- The pattern may correlate with land cover seasonal variability, which can be viewed with remotely sensed data. NDVI drops the beginning of rainy season and it increases within one month in cultivated areas.



Bare land

Average grain size：20 μ
Maximum grain size：100 μ
Wash load if this is transported

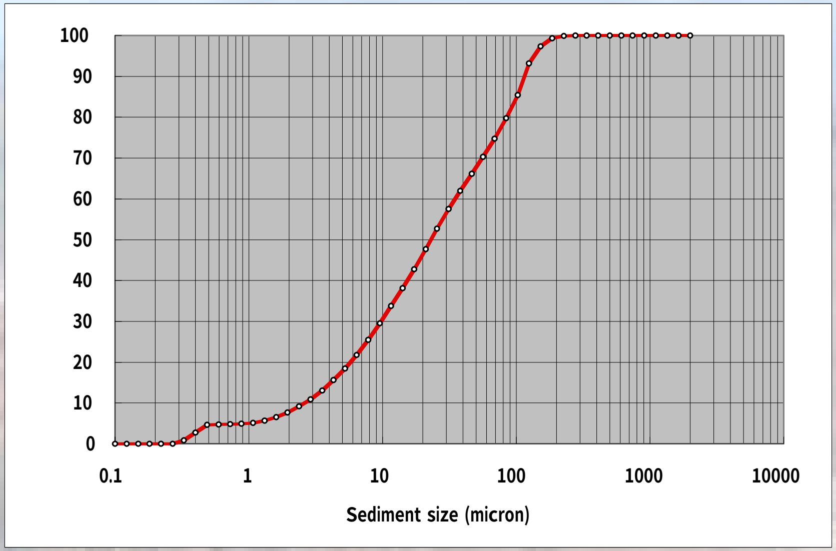


SS (before heating)

Average grain size ：340 μ

Maximum grain size ：500 μ

with litter



SS (after heating)

Average grain size ：30 μ
Maximum grain size ：200 μ

Wash load

EFFECT OF LAND-USE CHANGE ON SEDIMENTATION RATE AT UPPER CITARUM RIVER BASIN, WEST JAVA PROVINCE

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Background

The more increasing population rate and economic growth in Indonesia results in the more changing land-use of urban area.

Unfortunately, it is often found that the land-use management practice does not comprise water balance aspect. The practice can effect in many disasters such as floods, drought and high-rate sedimentation.

Those disasters have all been found to occur in main watersheds of West Java Province, which are also including Citarum watershed. High-rate sedimentation is one of the major problems, which decreases the capacity of most hydraulic structures.

Citarum River is a major river in West Java Province with 269 km in length and 6080 km^2 in area of catchment.

There are three large reservoirs built in the midstream of Citarum River. The upper reservoir is named Saguling, the middle one is Cirata and the lower one is Jatiluhur.

The intentions of their construction are to be a main source of hydropower in Java Island, also of water supply to freshwater fisheries and agriculture.

Saguling Reservoir retains most of sediment brought by Citarum stream. If the sedimentation keeps happening without any prevention and controlling actions, it will become a serious danger to the majority of Java Island's people because with the energy output of 700 MW, Saguling Reservoir supports the people's need of electricity significantly.

Purpose and Objective

The purpose of this study is to describe the effect of land-use change on sedimentation rate. The objective is to give representation of the land-use change effect to the lifetime of Saguling Reservoir, located at upper Citarum river basin.

Scope of Study

The scope of this study can be summarized as follow:

- Land-use change of an upper catchment area
- The relationship of land-use change and sedimentation rate
- Effect of sedimentation rate on the capacity of water resources infrastructure

Citarum

Map of River

Table of Basic Data

Name: Citarum River		**Serial No.:** Indonesia-1
Location: Java Island, Indonesia	S 05° 55′ 00″ ~ 07° 10′ 00″	E 107° 02′ 00″ ~ 107° 39′ 00″
Area: 6 080 km^2	**Length of main stream:** 269 km	
Origin: Mt. Wayang (1 700 m)	**Highest point:** Mt. Pangrango (3 019 m)	
Outlet: Java Sea	**Lowest point:** River mouth (0 m)	
Main geological features: Old Quaternary Volcanic, Miocene Sedimentary, Granite, Alluvium, Pleistocene Limestone		
Main tributaries: Citarik River (265 km^2), Cisangkuy River (286 km^2), Cisokan River (964 km^2), Cipamingkis River (1 887 km^2)		
Main lakes: Situ Lembang, Situ Patenggang		
Main reservoirs: Saguling Dam (982 x 10^6 m^3, 1986), Cirata Dam (2 165 x 10^6 m^3, 1988), Jatiluhur Dam (3 000 x 10^6 m^3, 1963)		
Mean annual precipitation: 2 300 mm (basin average)		
Mean annual runoff: 97.8 m^3/s at Nanjung (1 675 km^2) (1992)		
Population: 8 200 000 (1992)	**Main cities:** Bandung, Cianjur, Purwakarta, Karawang, Bekasi.	
Land use: Forest (20%), Paddy field (30%), Urban (32%), Other agriculture (18%) (1983)		

Major Reservoirs

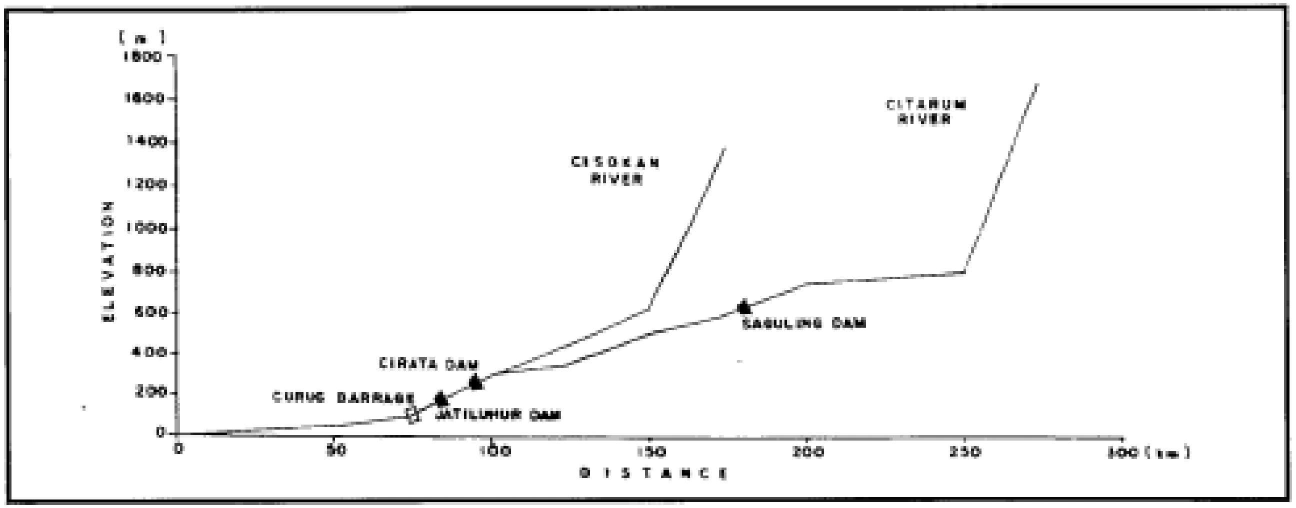
Name of river	Name of dam	Catchment area [km^2]	Gross capacity [10^6 m^3]	Effective capacity [10^6 m^3]	Purpose [1)]	Year of completion
Citarum	Saguling	2 283	982	609	P	1986
	Cirata	4 119	2 165	709	P	1988
	Jatiluhur	4 500	3 000	1 825	A, F, I, N, P, W	1963

2.3 Characteristics of River and Main Tributaries

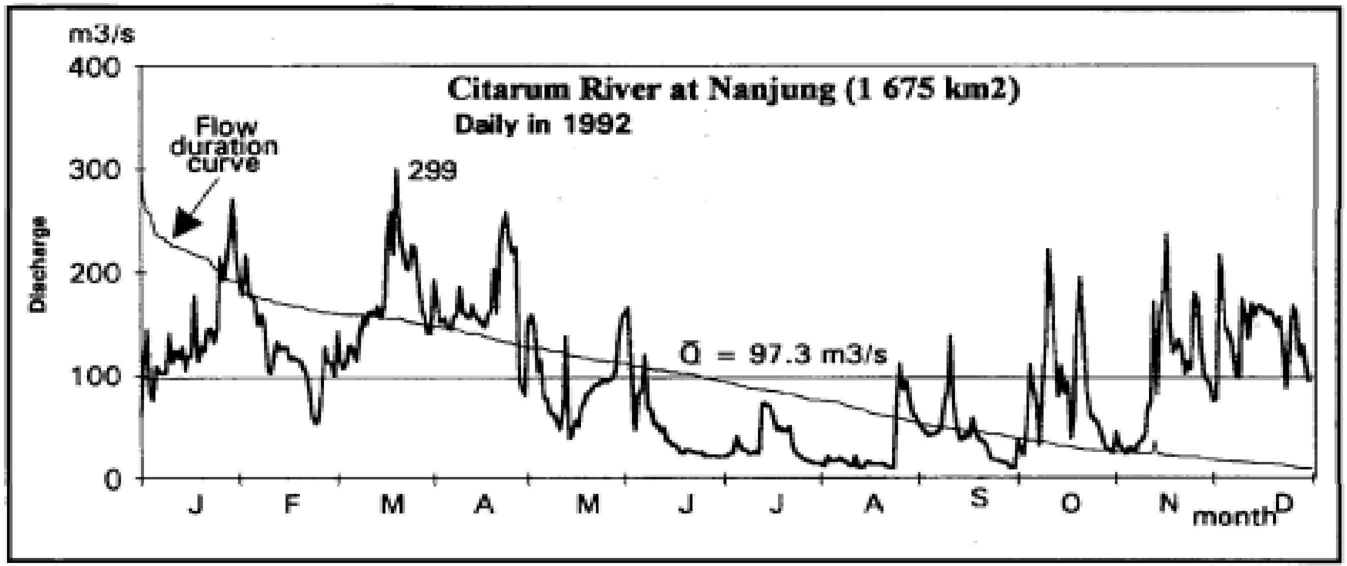
No.	Name of river	Length [km] Catchment area [km²]	Highest peak [m] Lowest point [m]	Cities Population (1992)	Land use [%]				
					A	F	L	P	U
1	**Citarum** (Main River)	269 6 080	Mt. Wayang, 1 700 ----------	Bandung 2 513 000	18	20	2.5	30	29.5
2	**Citarik** (Tributary)	31.8 265	Mt. Calangcang, 1 887 ----------	Bandung 2 513 000	20	20	2.5	30	25
3	**Cisangkuy** (Tributary)	32.3 286	Mt. Patuha, 2 385 ----------	Bandung	22	25	3	30	20
4	**Cisokan** (Tributary)	78.6 984	Mt. Kendeng, 694 ----------	Cianjur 320 000	30	20	4	25	21
5	**Cipamingkis** (Tributary)	53.2 1 887	Mt. Pangrango, 3 019 ----------	Bekasi Karawang 1 600 000	27	15	3	20	35

A: Other agricultural field F: Forest L: Lake, River, Marsh P: Paddy field U: Urban

2.4 Longitudinal Profiles



4.4 Annual Pattern of Discharge



Indonesia-1

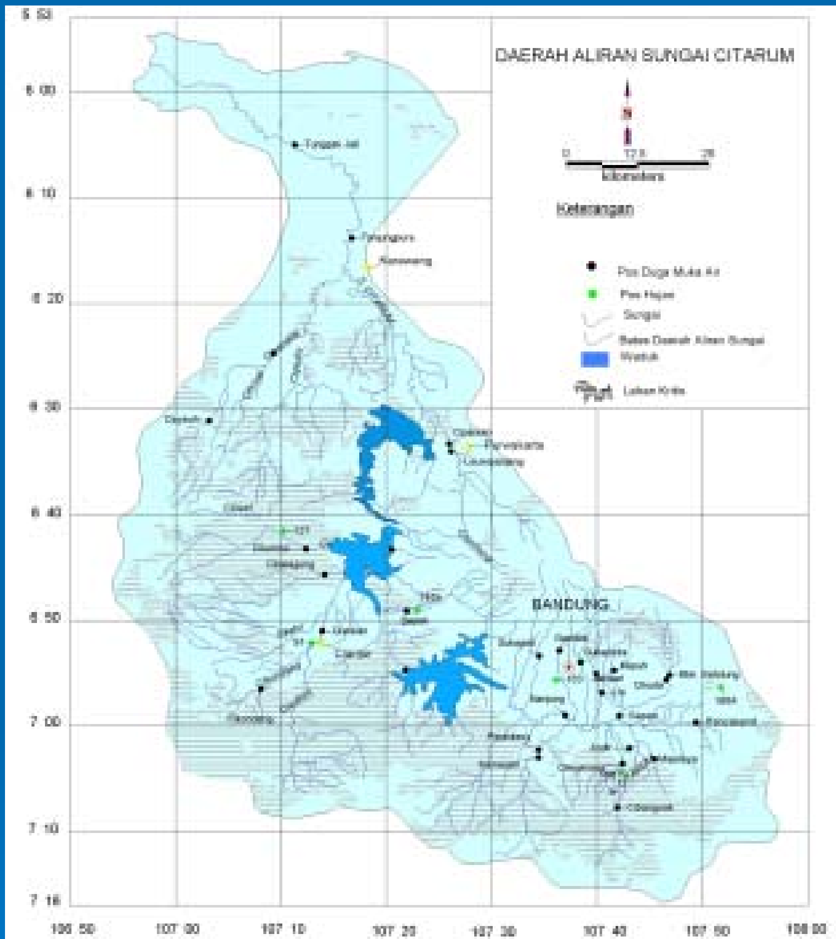
4.6 Annual Maximum and Minimum Discharges

At Citarum Nanjung [1 675 km²]

Year	Maximum 1)		Minimum 2)		Year	Maximum 1)		Minimum 2)	
	Date	[m³/s]	Month	[m³/s]		Date	[m³/s]	Month	[m³/s]
1918	12.14	244	10	3.65	**1977**	10.05	290	10	3.2
1919	12.04	252	8	1.8	**1978**	12.11	302	-	13.3
1920	10.25	224	8	10.5	**1979**	12.07	301	9	5.2
1921	4.05	261	10	2.6	**1980**	12.05	284	8	4.8
1922	4.16	275	9	3.51	**1981**	3.16	276	9	8.0
1923	7.12	252	10	2.71	**1982**	12.26	265	10	3.8
1924	1.23	252	9	2.57	**1984**	2.11	269	8	1.8
1925	12.29	204	11	2.10	**1986**	3.16	332	9	11.2
1974	5.12	323	6	12.5	**1987**	4.15	264	11	3.7
1975	4.17	364	6	12.5	**1988**	-	288	-	3.5
1976	12.17	247	8	2.6	**1991**	3.24	379	10	3.5

1), 2) Instantaneous observation by recording chart

CONDITION OF UPPER CITARUM RIVER BASIN



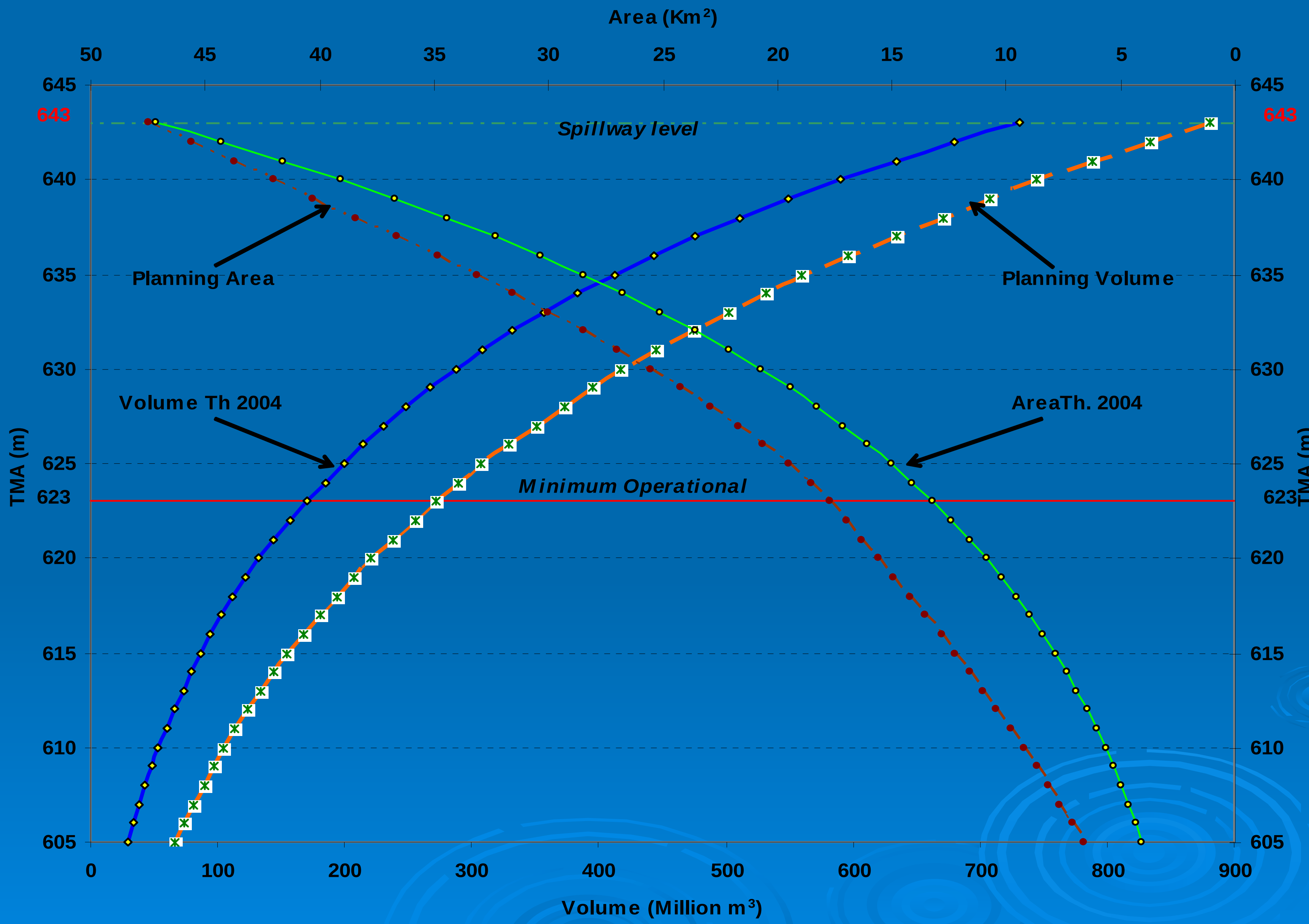
GN-RHL PLANNING AREA: 46.678 Ha

FORESTRY AREA:

1993 → **27 %**

2003 → **14 %**

EFFECT

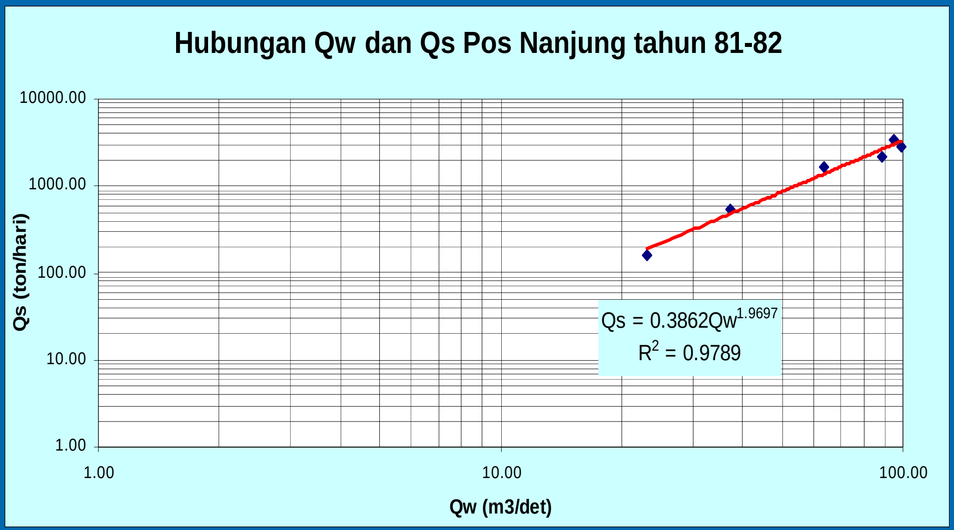


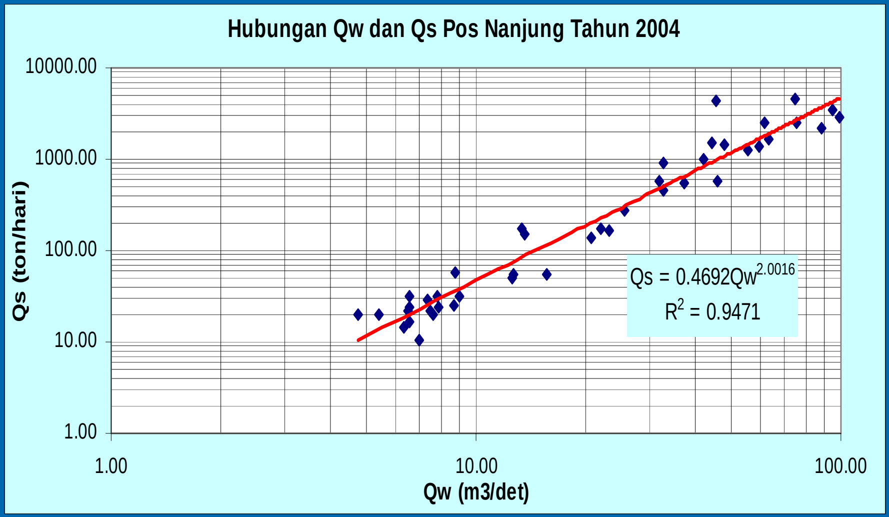
Area (Km²)
50 45 40 35 30 25 20 15 10 5 0
645 643 640 635 630 625 623 620 615 610 605
Spillway level
Planning Area
Planning Volume
Volume Th 2004
AreaTh. 2004
Minimum Operational
TMA (m)
0 100 200 300 400 500 600 700 800 900
Volume (Million m³)

The Differences of Reservoir Capacity at Planning Stage and Measurement at 2004

Elevation	Volume at Planning Stage	Volume Measurement 2004	Reduce of Reservoir Capcity
(m)	(Juta m^3)	(Juta m^3)	(Juta m^3)
643	**881,00**	**730,5**	**150,5**
642	833,50	680,4	153,1
641	788,97	633,6	155,3
640	744,44	590,0	154,4
639	707,52	549,4	158,2
638	670,60	511,4	159,2
637	633,68	476,1	157,6
636	596,76	443,1	153,6
635	559,84	412,4	147,4
634	531,24	383,8	147,5
633	502,64	357,1	145,6
632	474,05	332,2	141,9
631	445,45	309,0	136,4
630	416,85	287,4	129,4
629	394,71	267,3	127,4
628	372,56	248,6	124,0
627	350,42	231,1	119,3
626	328,27	214,9	113,4
625	306,13	199,8	106,4
624	289,04	185,1	104,0
623	**271,95**	**170,2**	**101,8**
622	255,12	156,4	98,7
621	237,84	143,8	94,1
620	220,55	132,1	88,4
619	207,23	121,4	85,8
618	193,91	111,6	82,4
617	180,60	102,5	78,1
616	**167,28**	**94,1**	**73,1**
615	153,96	86,4	67,5
614	143,91	79,4	64,5
613	133,85	73,6	60,2
612	123,80	66,2	57,6
611	113,75	59,6	54,2
610	103,70	53,6	50,1
609	96,26	48,1	48,1
608	88,83	43,3	45,6
607	81,39	37,9	43,5
606	73,95	33,1	40,9
605	66,52	28,8	37,7

SEDIMENTATION RATE AT CITARUM





→ Sediment Flowrate (1981-1982)

1,05 million ton/year

Mean flow at Nanjung Station:

92,3 m^3/s

→ Sediment Flowrate (2004)

1,47 million ton/year

Increasing ± 40 %

SEDIMENTATION RATE AT CITARUM

SEDIMENTATION AT
CIKAPUNDUNG KOLOT RIVER

SEDIMENTATION AT CISANGKUY RIVER

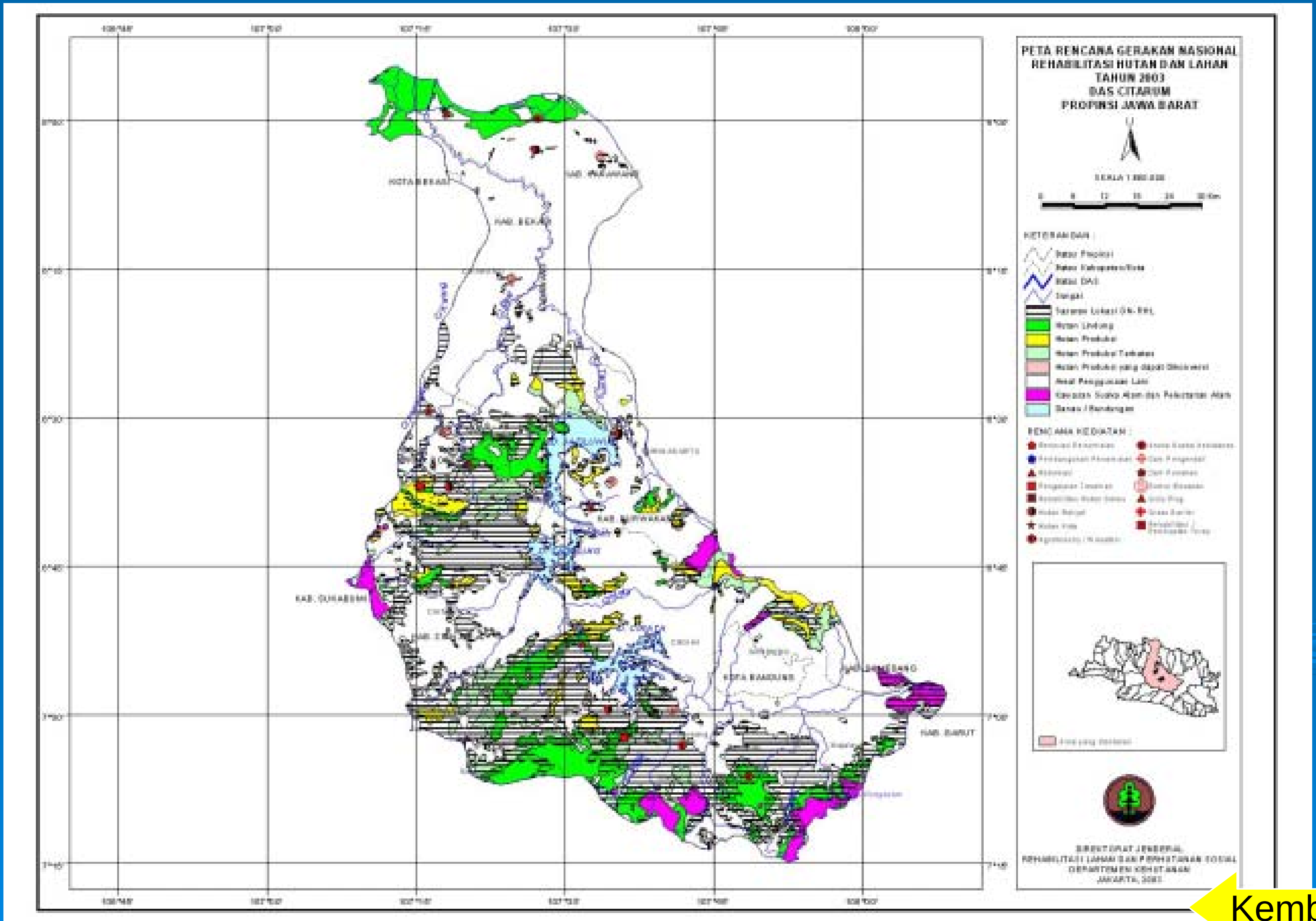
LIFETIME OF SAGULING RESERVOIR

	Planning in Year 1986	Year 2004
Volume at +643 m Elevation →	881 million m^3	730,5 million m^3

Sedimentation → 8,36 million m^3 /year

Lifetime of Saguling Reservoir
(dead-storage elevation of +616 m) → 6 25 years

GN-RHL PLANNING MAP



Kembali

CONCLUSION AND RECOMMENDATION

CONCLUSION

Land-use change in the upper Citarum river basin has caused the increasing sedimentation rate along the river and the reducing lifetime of Saguling Reservoir

RECOMMENDATION

- It is important to rearrange the land-use of upper Citarum river basin through water and land conservation
- As an input to land-use planning, it is recommended to monitor the river flow and sedimentation rate as well as sediment characteristics at Saguling Reservoir

Thank You

THE QUANTITATIVE AND QUALITATIVE ANALYSIS OF EROSION AND SEDIMENTATION IN UPPER BRANTAS BASIN

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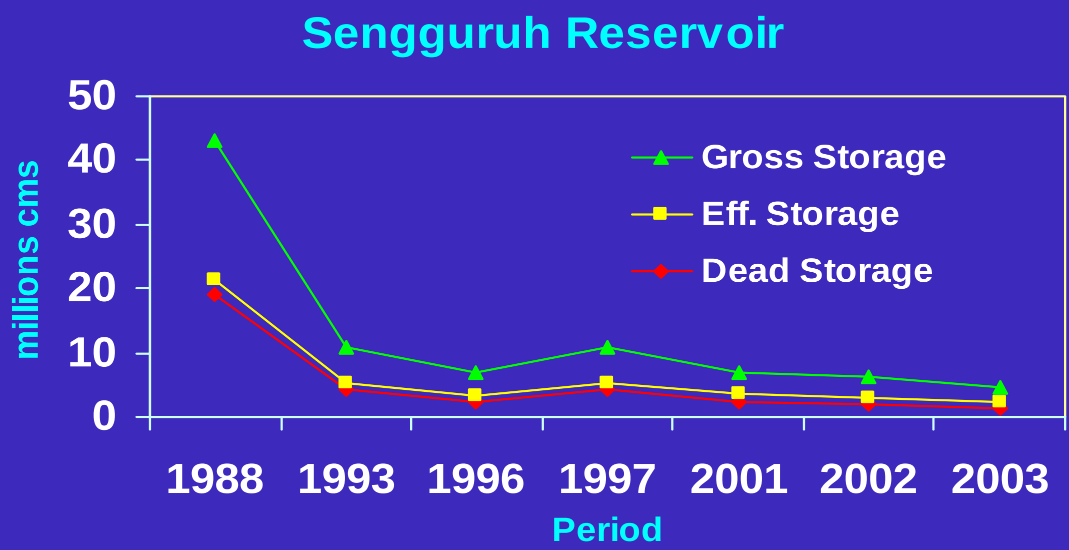
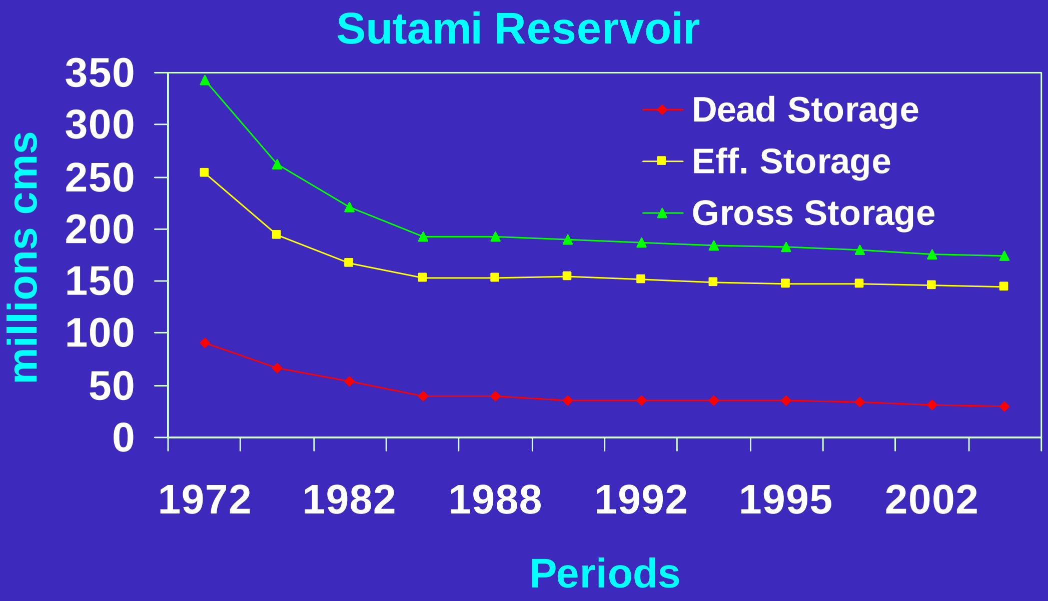
[2]Dr. of Eng., Professor, Dept. of Civil and Environmental Engineering, University of Yamanashi (4-3-11, Takeda, Kofu, Yamanashi 400-8511, Japan)
[3]Dr. of Eng., Associate Professor, Dept. of Civil and Environmental Engineering, University of Yamanashi (4-3-11, Takeda, Kofu, Yamanashi 400-8511, Japan)

Why is erosion-sedimentation a big problem in reservoir management ?

1. Erosion is the detachment of soil particles caused by wind, water, and glacial ice.
2. Eroded sediment acts as both a physical and chemical pollutant.
3. Physically: decrease turbidity, limit sunlight penetration, change water temperature, change fish habitat and spawning patterns
4. Chemically: transport nutrients such as phosphorus and nitrogen, heavy metals, degrade water quality.

WHAT HAPPENED ?





WHAT HAPPENED ?

RESERVOIR LIFE (Murhty, 1977) :

- Design Life : period used

- Project Life : reliably serve the purposes for which its originally constructed

- Economic Life : benefits exceeds costs

- Usable Life : either its original or modified purposes

THE STARTING POINTS FOR ALL ANALYSIS IS AN ASSESMENT OF THE NATURE AND SEVERITY OF THE SEDIMENTATION PROBLEM

WHAT HAPPENED ?

EROSION : rock or earth material is loosed or dissolved and removed

SEDIMENT YIELD : amount of eroded sediment discharged by stream

Anthropogenic

THE STARTING POINTS FOR ALL ANALYSIS IS *AN ASSESMENT OF THE NATURE AND SEVERITY OF THE SEDIMENTATION PROBLEM*

MAIN OBJECTIVE OF THE STUDY

QUANTITATIVE

USLE

QUALITATIVE

MINERALOGY

IDENTIFY THE DOMINANT SOURCES, VURNERABLE YIELDS

Walter Wischmeier
"Soil Conservation Pioneer"

WHY USLE ?

1. The USLE is widely used as an empirical equation derived from more than 10,000 plot-years of data collected on natural runoff plots and an estimated equivalent of 2,000 plot-years of data from rainfall simulators.

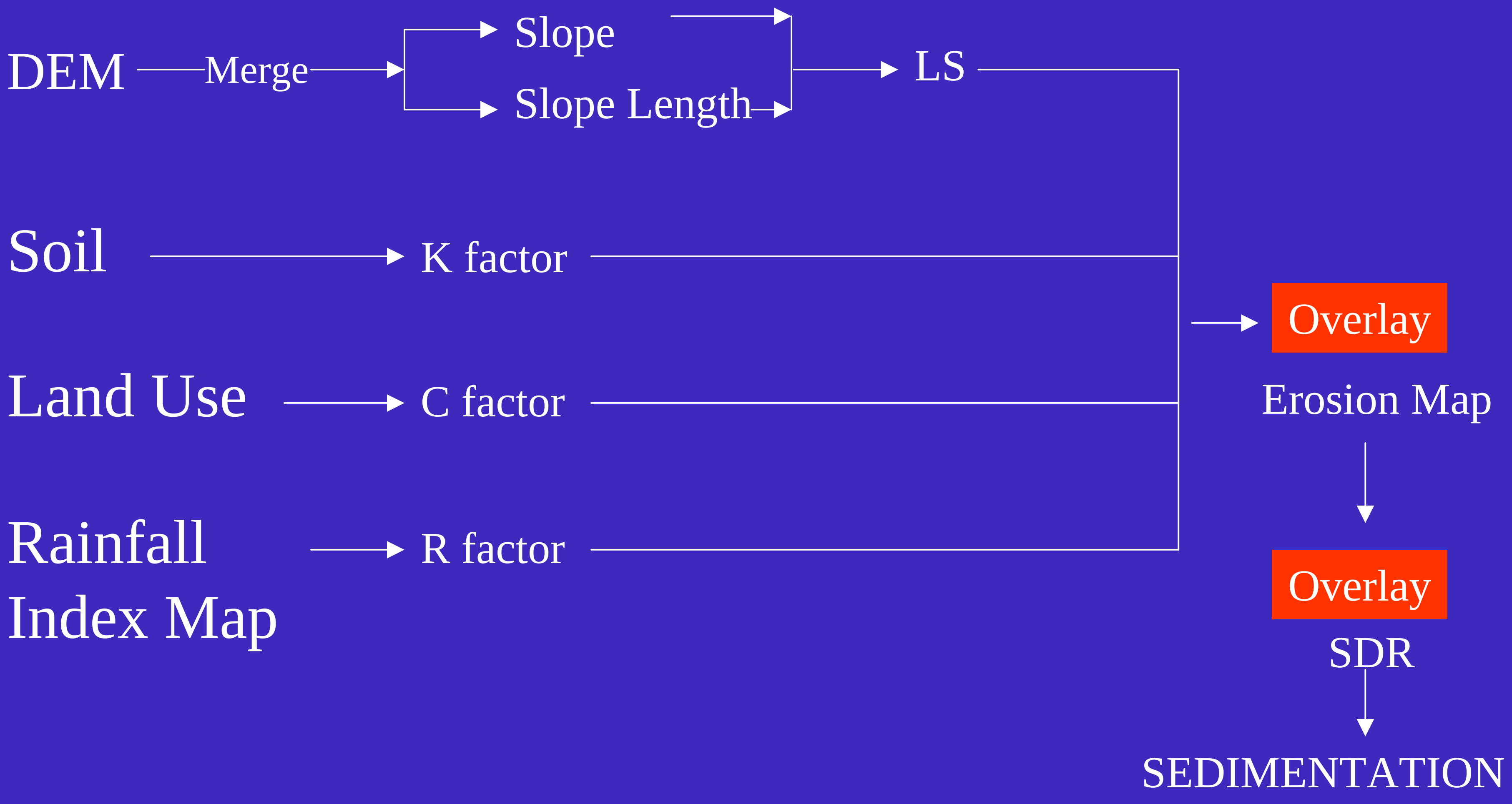
2. Model should not be more complex than necessary and its parameters should be derived from the data

QUANTITATIVE

USLE

$$A = R\ K\ L\ S\ C\ P$$

SEDIMENT YIELDS



RESERVOIR SEDIMENTATION & DEPOSITION PATTERNS

USLE

USLE in observed point

ECHO SOUNDING

Annual Sediment Inflow → Storage Evaluation

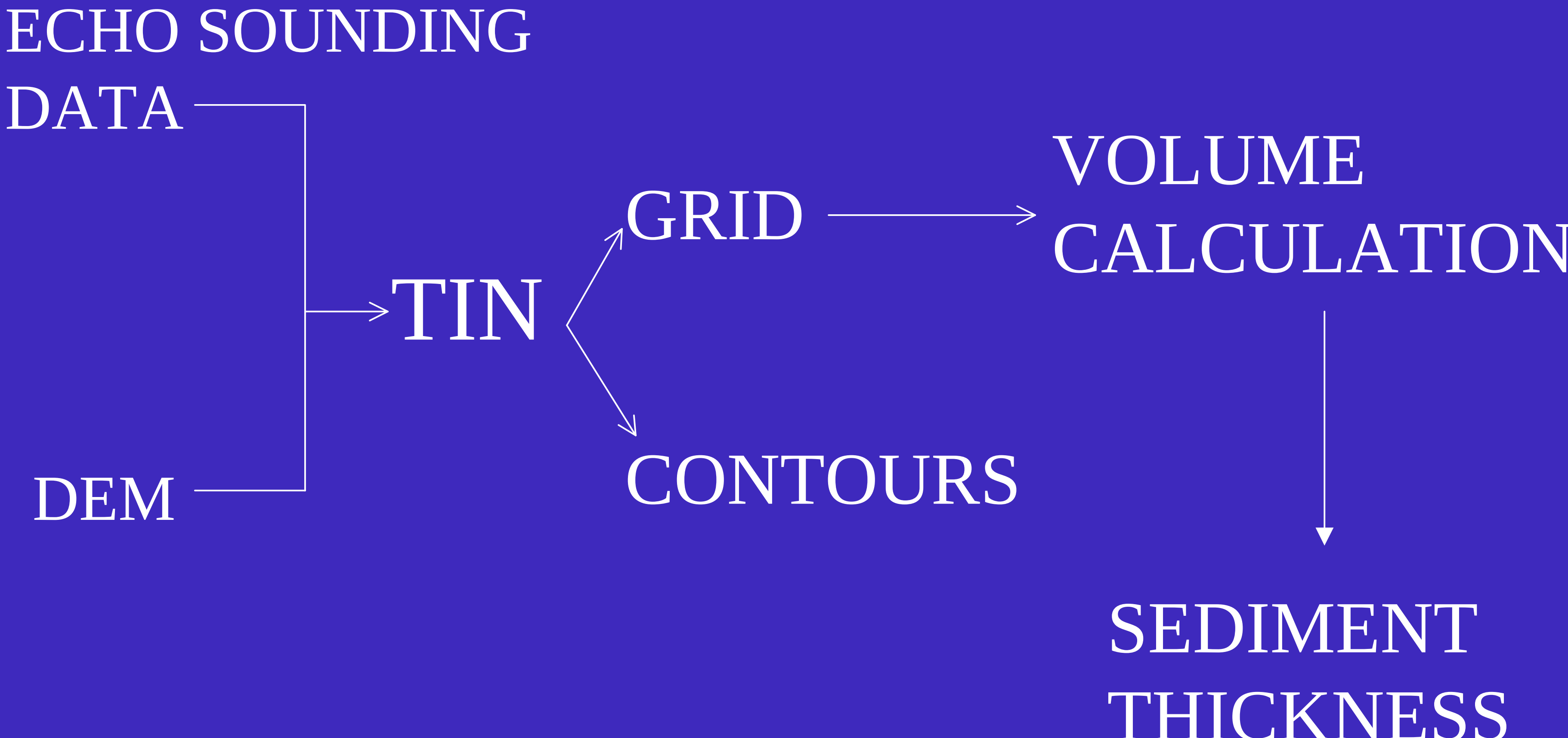
Area –Increment and Empirical Area

Reduction Methods

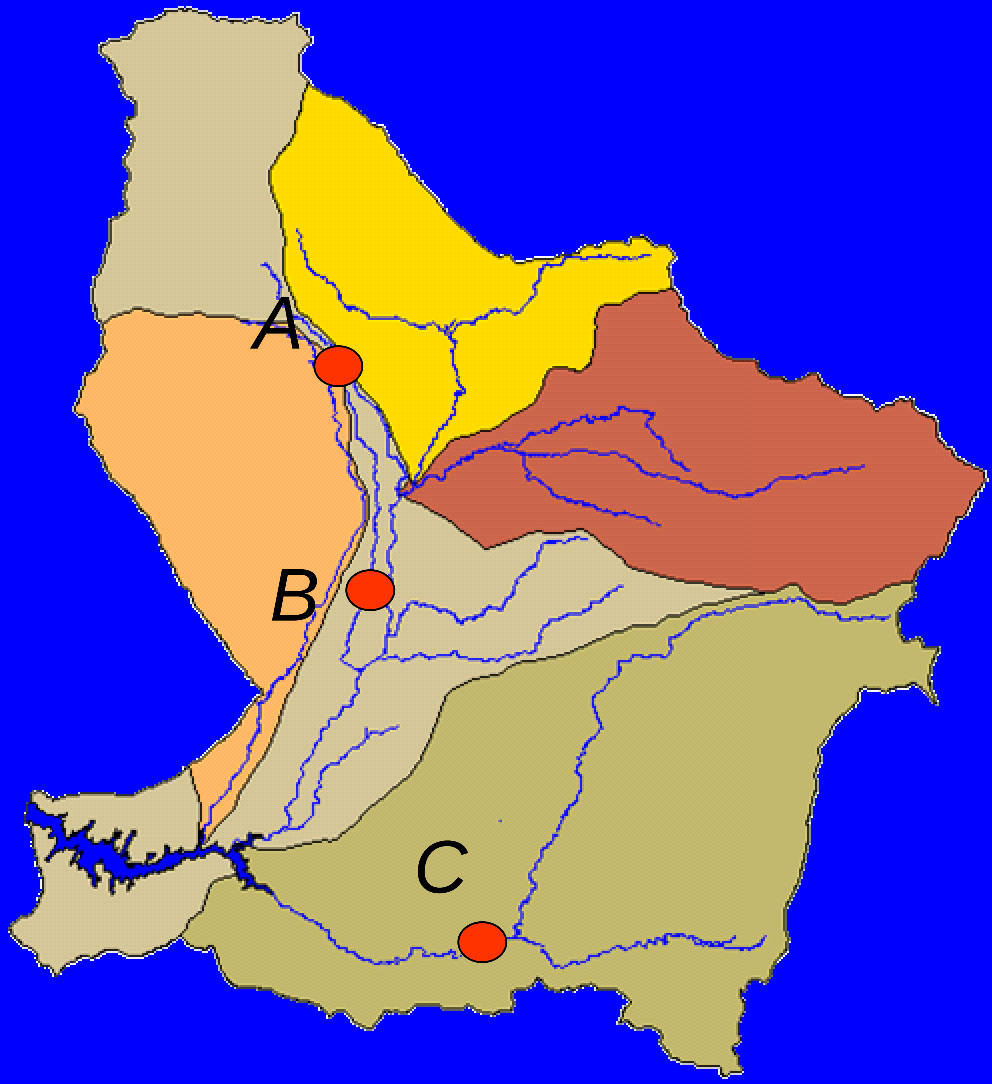
POINT OBSERVATION

EMPIRICAL APPROACHES

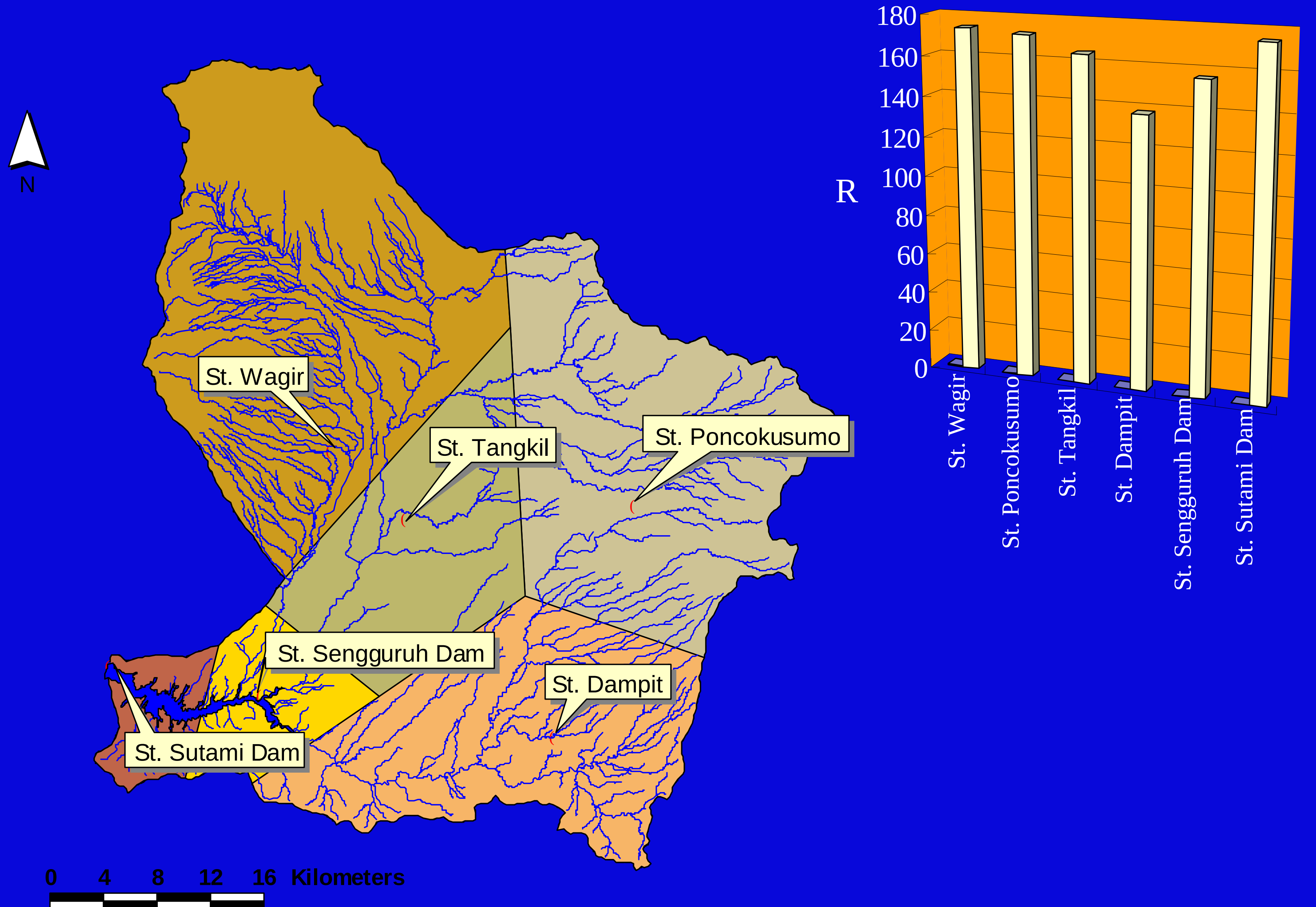
RESERVOIR BATHYMETRY

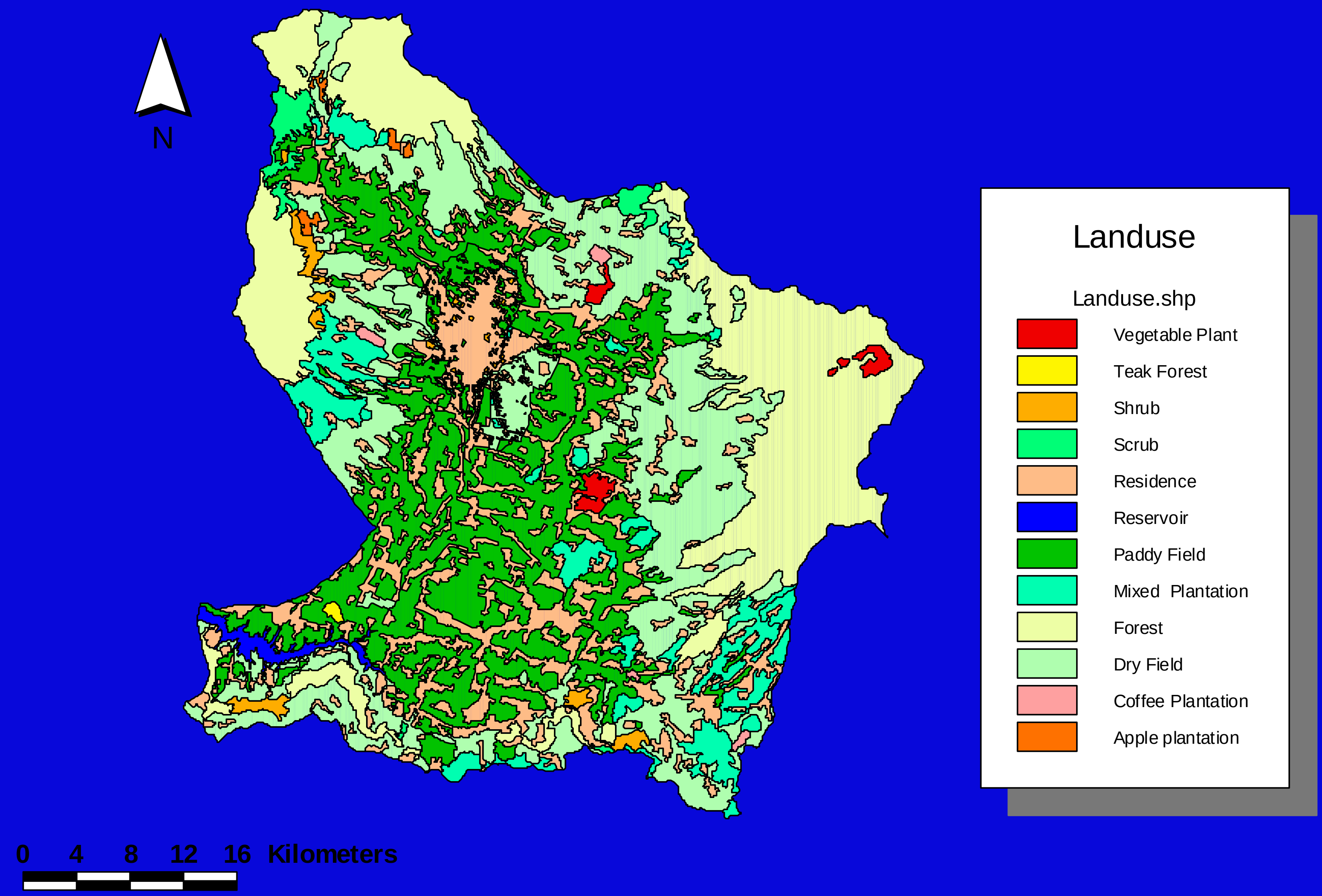


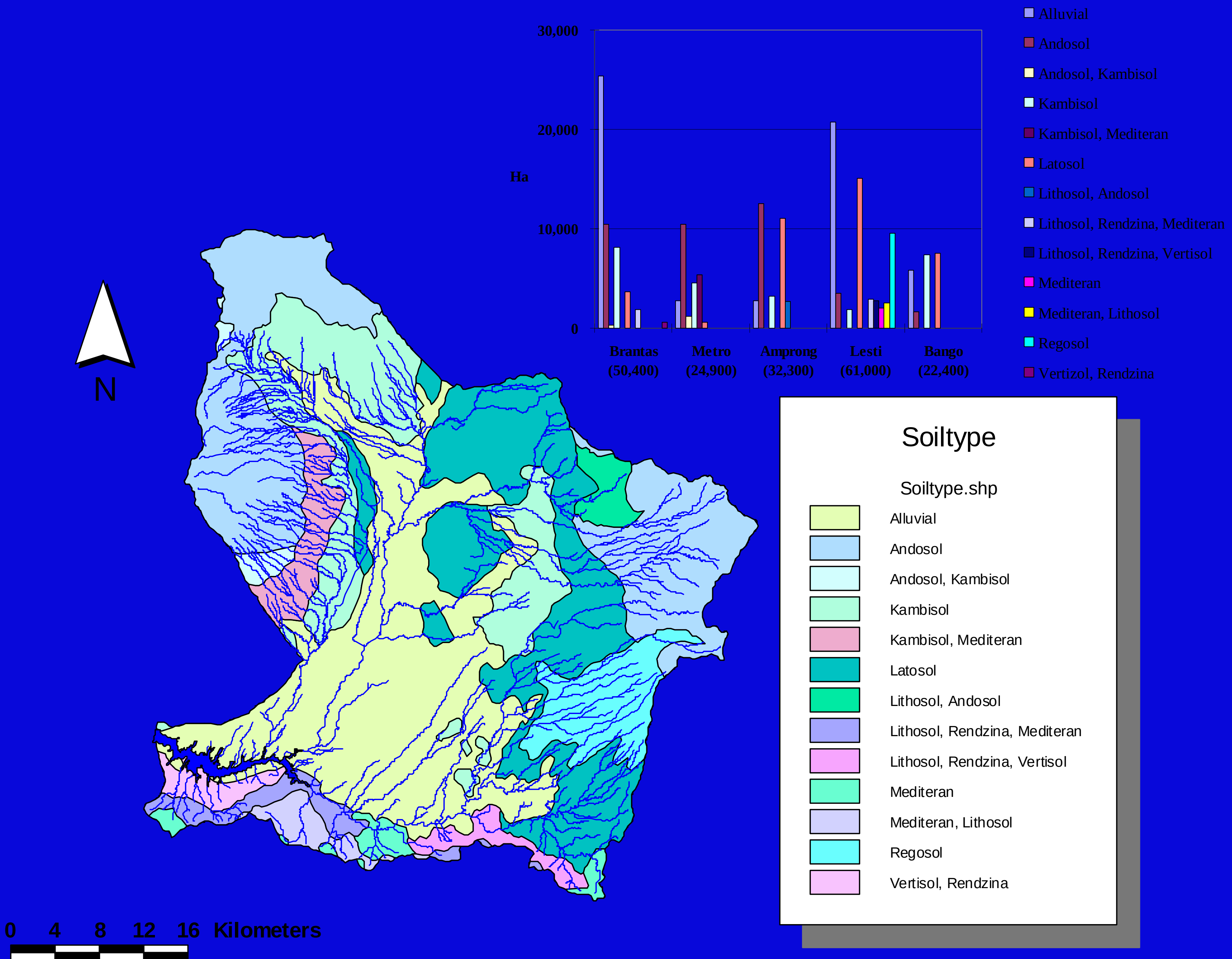
1. *Rainfall Data*
2. *Topography, Soil and Landuse Maps*
3. *Echo sounding data at reservoirs*
4. *Observation of sediment discharge in the river*

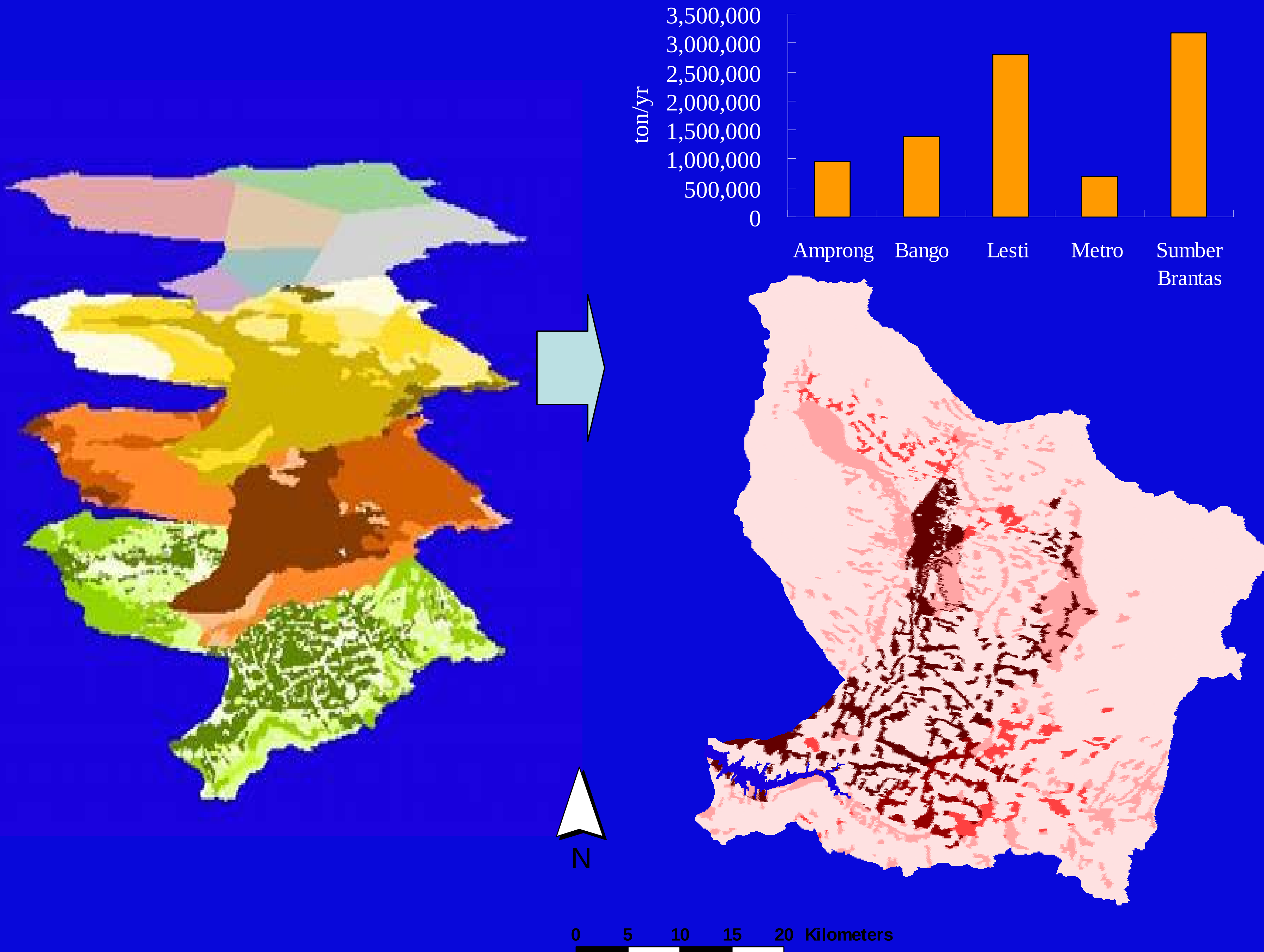


A,B,C = observation points

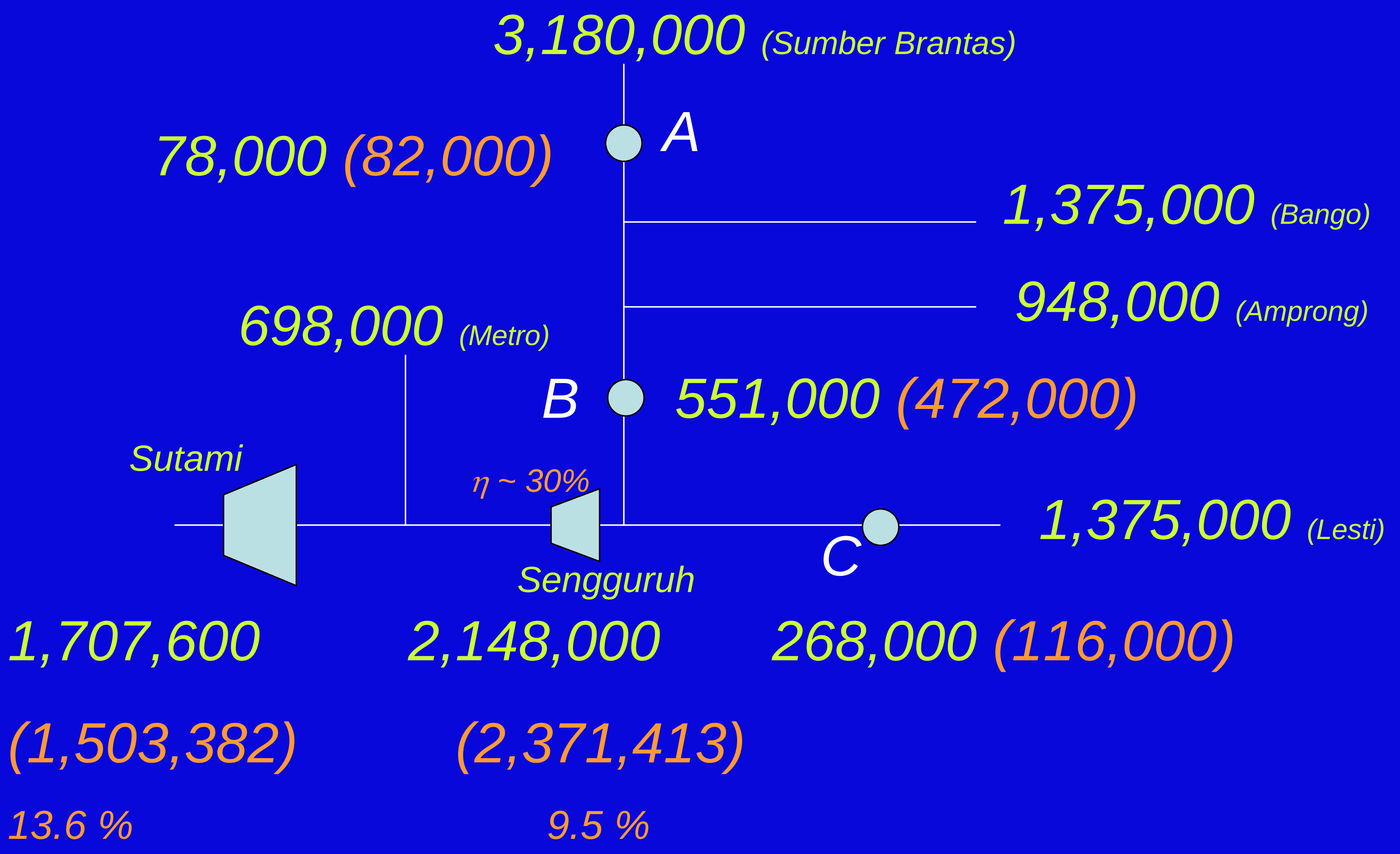

N
St. Wagir
St. Tangkil
St. Poncokusumo
St. Sengguruh Dam
St. Dampit
St. Sutami Dam
0 4 8 12 16 Kilometers
R
180
160
140
120
100
80
60
40
20
0
St. Wagir
St. Poncokusumo
St. Tangkil
St. Dampit
St. Sengguruh Dam
St. Sutami Dam


N
Landuse
Landuse.shp
Vegetable Plant
Teak Forest
Shrub
Scrub
Residence
Reservoir
Paddy Field
Mixed Plantation
Forest
Dry Field
Coffee Plantation
Apple plantation
0 4 8 12 16 Kilometers


30,000
20,000
10,000
0
Ha
Brantas (50,400)
Metro (24,900)
Amprong (32,300)
Lesti (61,000)
Bango (22,400)
Alluvial
Andosol
Andosol, Kambisol
Kambisol
Kambisol, Mediteran
Latosol
Lithosol, Andosol
Lithosol, Rendzina, Mediteran
Lithosol, Rendzina, Vertisol
Mediteran
Mediteran, Lithosol
Regosol
Vertizol, Rendzina
N
Soiltype
Soiltype.shp
Alluvial
Andosol
Andosol, Kambisol
Kambisol
Kambisol, Mediteran
Latosol
Lithosol, Andosol
Lithosol, Rendzina, Mediteran
Lithosol, Rendzina, Vertisol
Mediteran
Mediteran, Lithosol
Regosol
Vertisol, Rendzina
0 4 8 12 16 Kilometers


3,500,000
3,000,000
2,500,000
2,000,000
1,500,000
1,000,000
500,000
0
ton/yr
Amprong
Bango
Lesti
Metro
Sumber Brantas
N
0
5
10
15
20
Kilometers

SEDIMENT BALANCE (ton/year)



POINT	LOCATION	USLE	MPM-USBR	VAN RIJN	EINSTEIN-USBR
A	Pendem	78,400	82,800	688,600	287,200
B	Gadang	551,700	472,000	153,000	471,900
C	Tawangrejeni	268,500	116,500	1,405,200	107,900

AREA –INCREMENT AND EMPIRICAL AREA REDUCTION METHODS

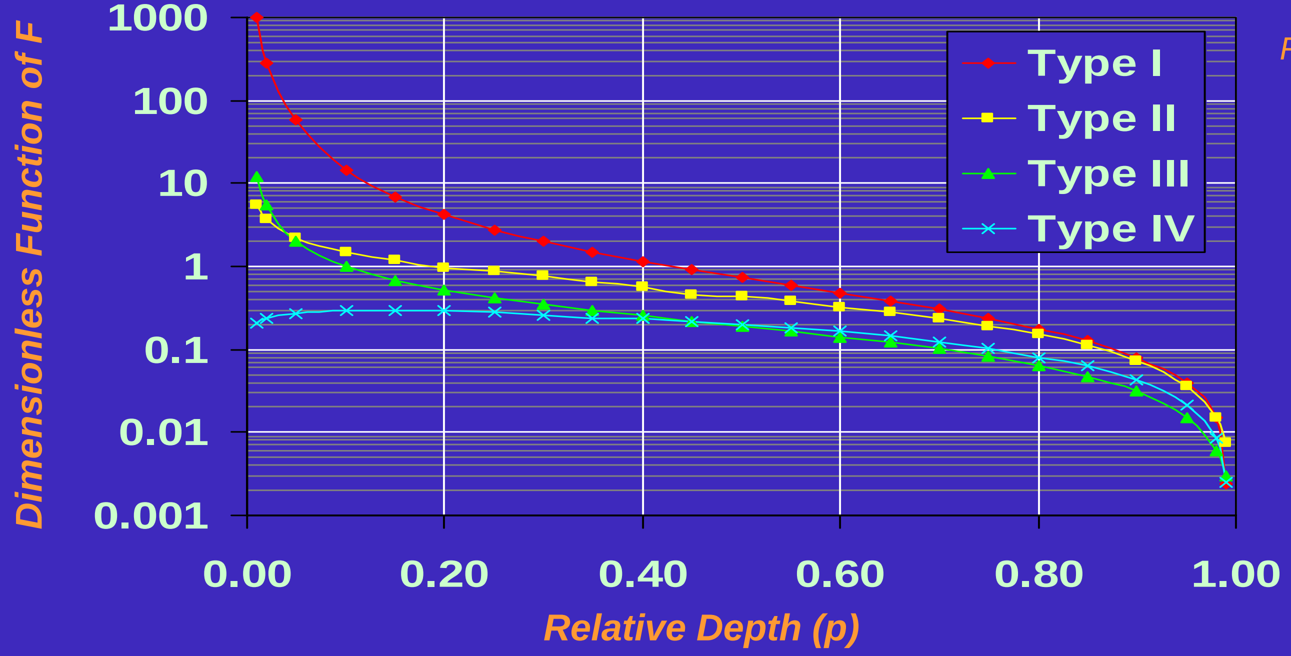
Sediments are deposited in reservoirs at all elevations, causing the-stage capacity curve to shift. This methods are much quicker and easier to use than mathematical modeling to evaluate Stage-Area and Stage-Capacity curves, when the sediment survey data available.

AREA–INCREMENT AND EMPIRICAL AREA REDUCTION METHODS

Based on the assumption that an equal volume of sediment will be deposited within each depth increment in the reservoir

1. **Determine amount of sediment to be distributed (USLE)**
2. **Select the appropriate sediment distribution curves based on site characteristics**
3. **Determine the height of sediment accumulation at the dam, *new zero capacity elevation***
4. **Distribute sediment as a function of depth above the zero – capacity elevation.**
5. **Adjust curves**

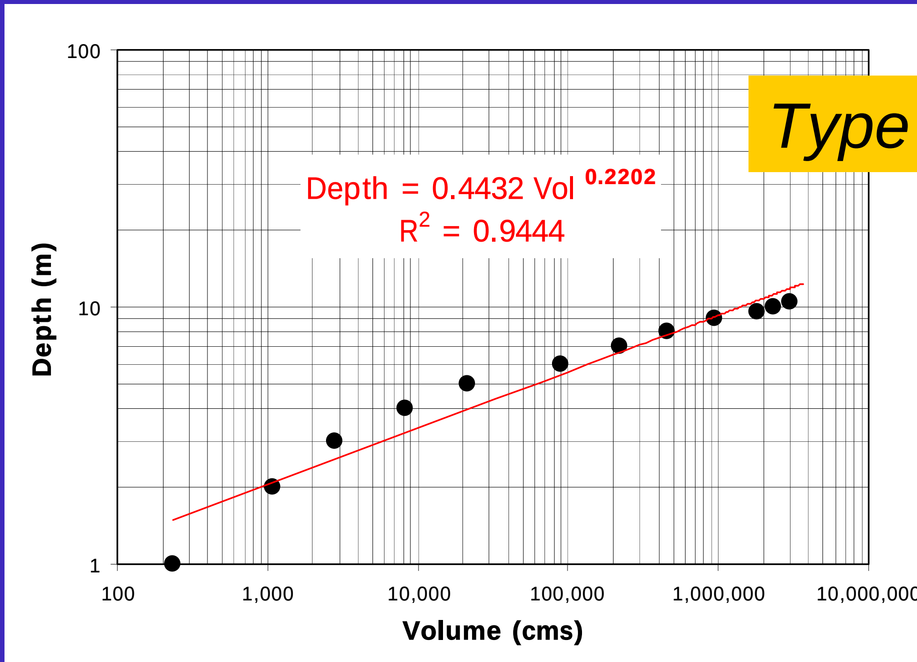
AREA–INCREMENT AND EMPIRICAL AREA REDUCTION METHODS



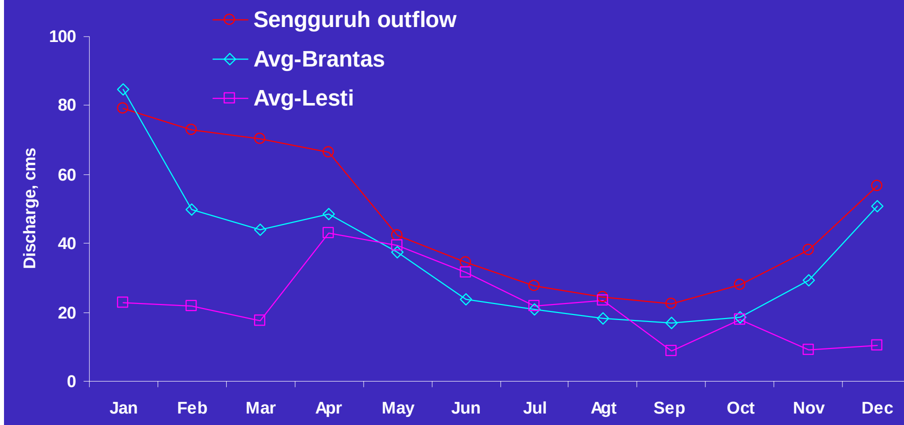
F = Function of total sediment deposition, capacity, depth and area

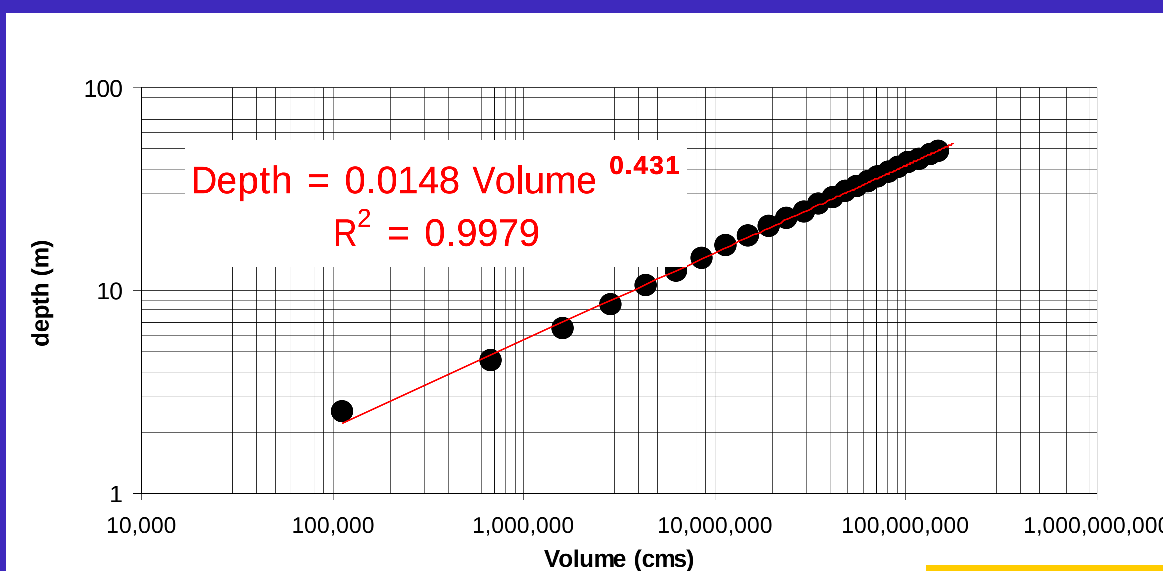
Reservoir Type	Classification	*m*	Predominant size
I	Lake	3.5 -4.5	Sand or Coarse
II	Flood plain-foot hill	2.5-3.5	Silt
III	Hill	1.5-2.5	Clay
IV	Normally empty	1.0-1.5	

m is reciprocal of slope of the Depth–Capacity curves in logarithmic paper

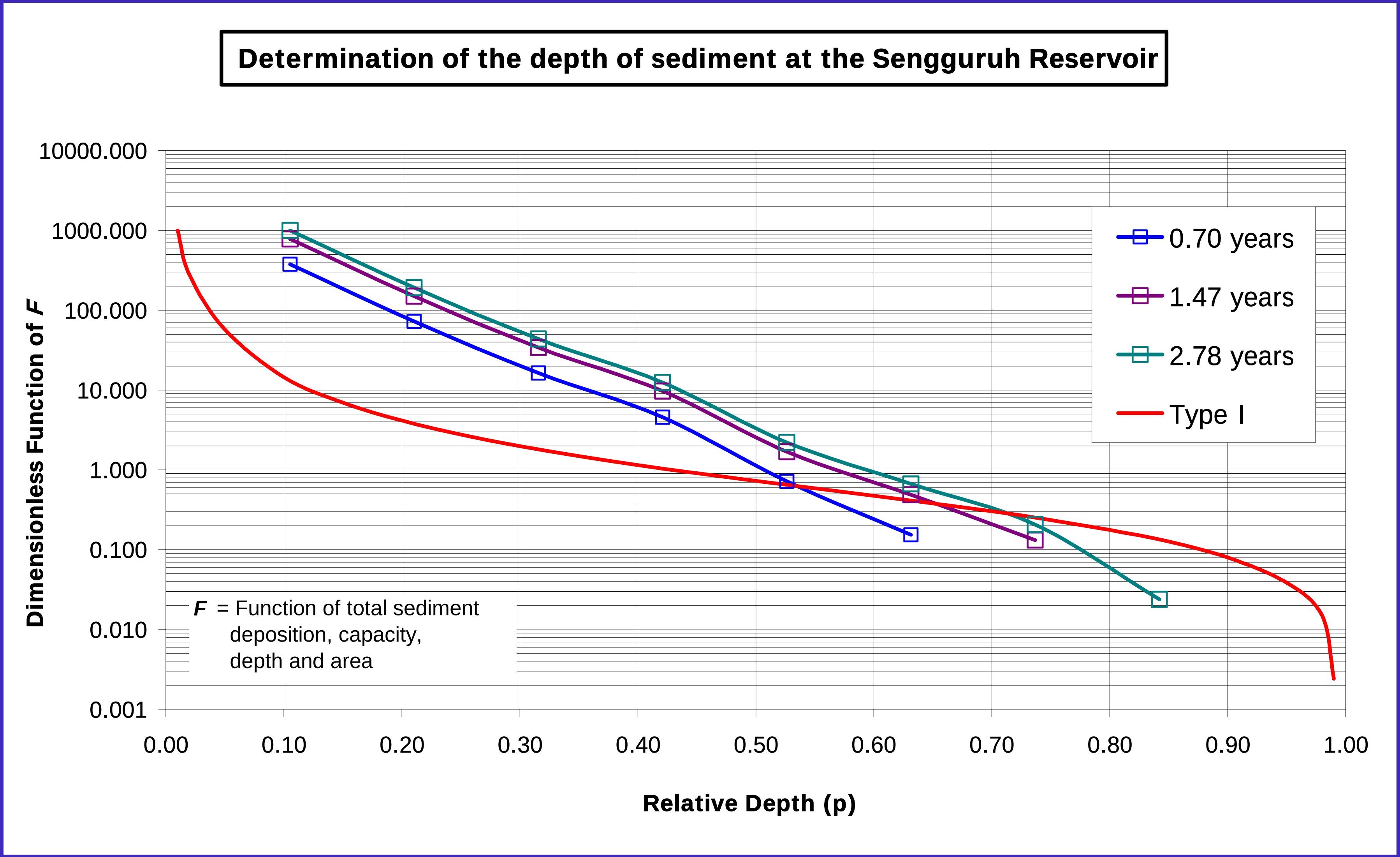


Type I (Lake)



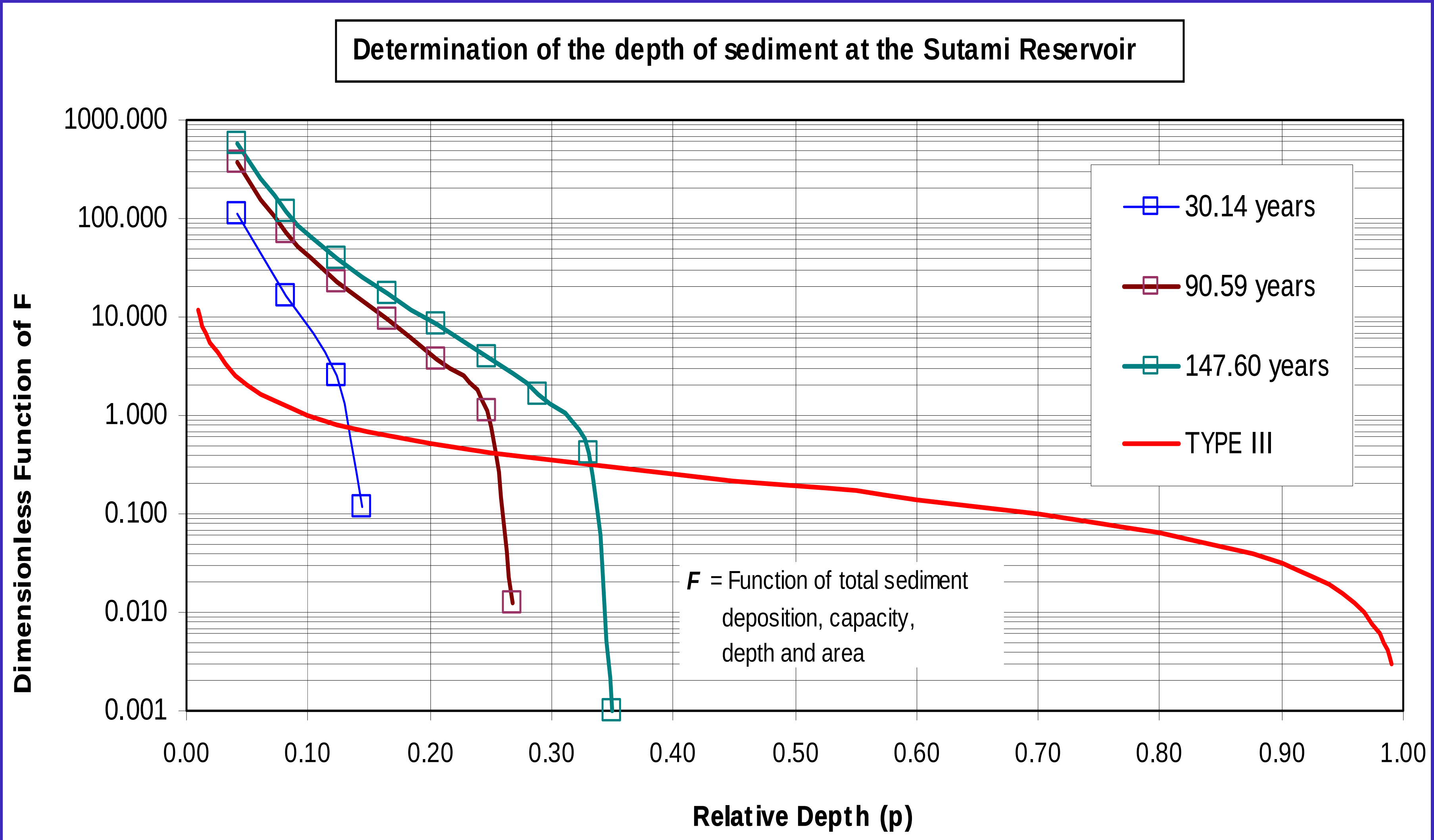


Type III (Hill & Gorge)



Determination of the depth of sediment at the Sengguruh Reservoir
10000.000
1000.000
100.000
10.000
1.000
0.100
0.010
0.001
Dimensionless Function of F
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
0.90
1.00
Relative Depth (p)
0.70 years
1.47 years
2.78 years
Type I
F = Function of total sediment deposition, capacity, depth and area

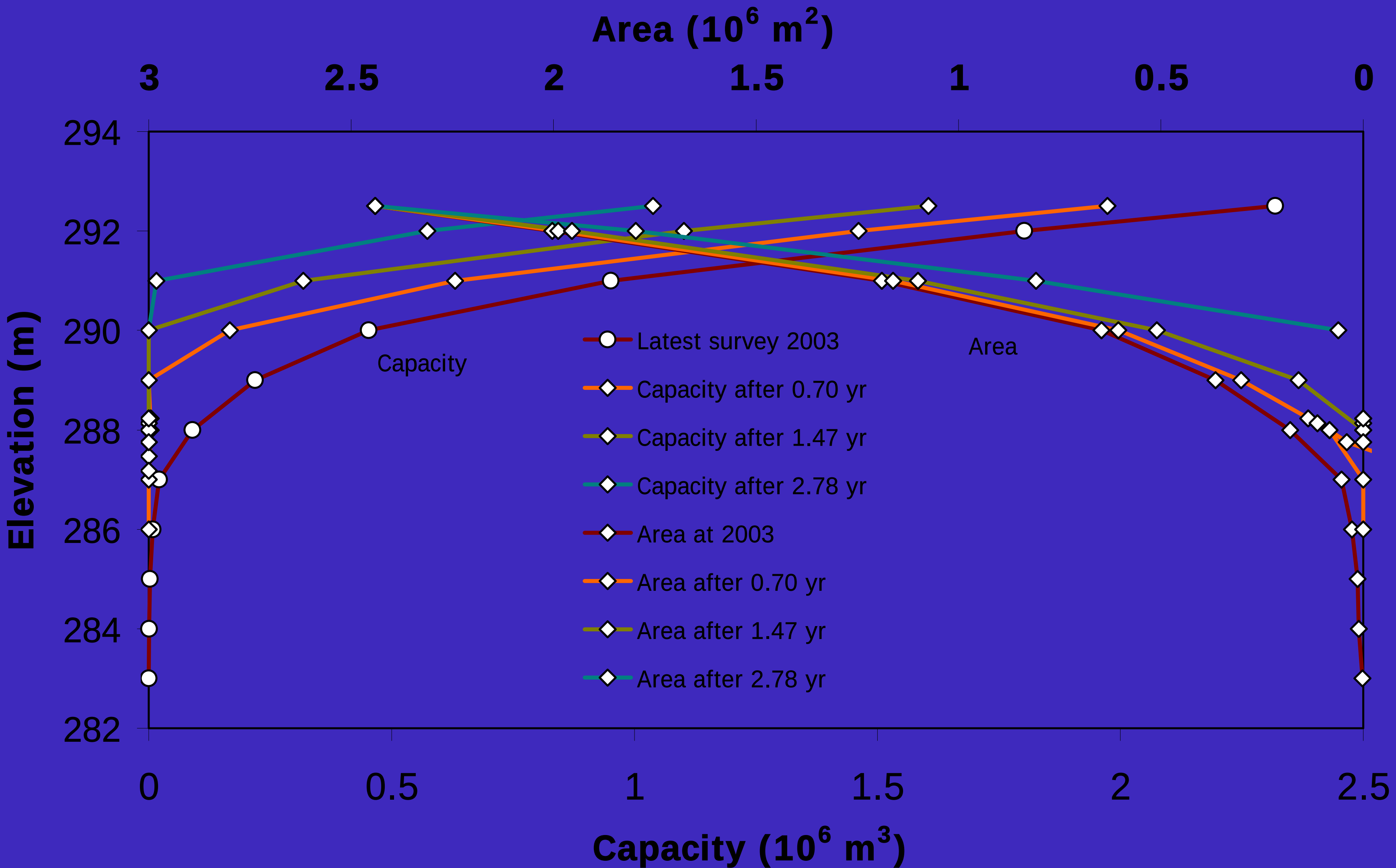
Type I (Lake)



Type III (Hill & Gorge)

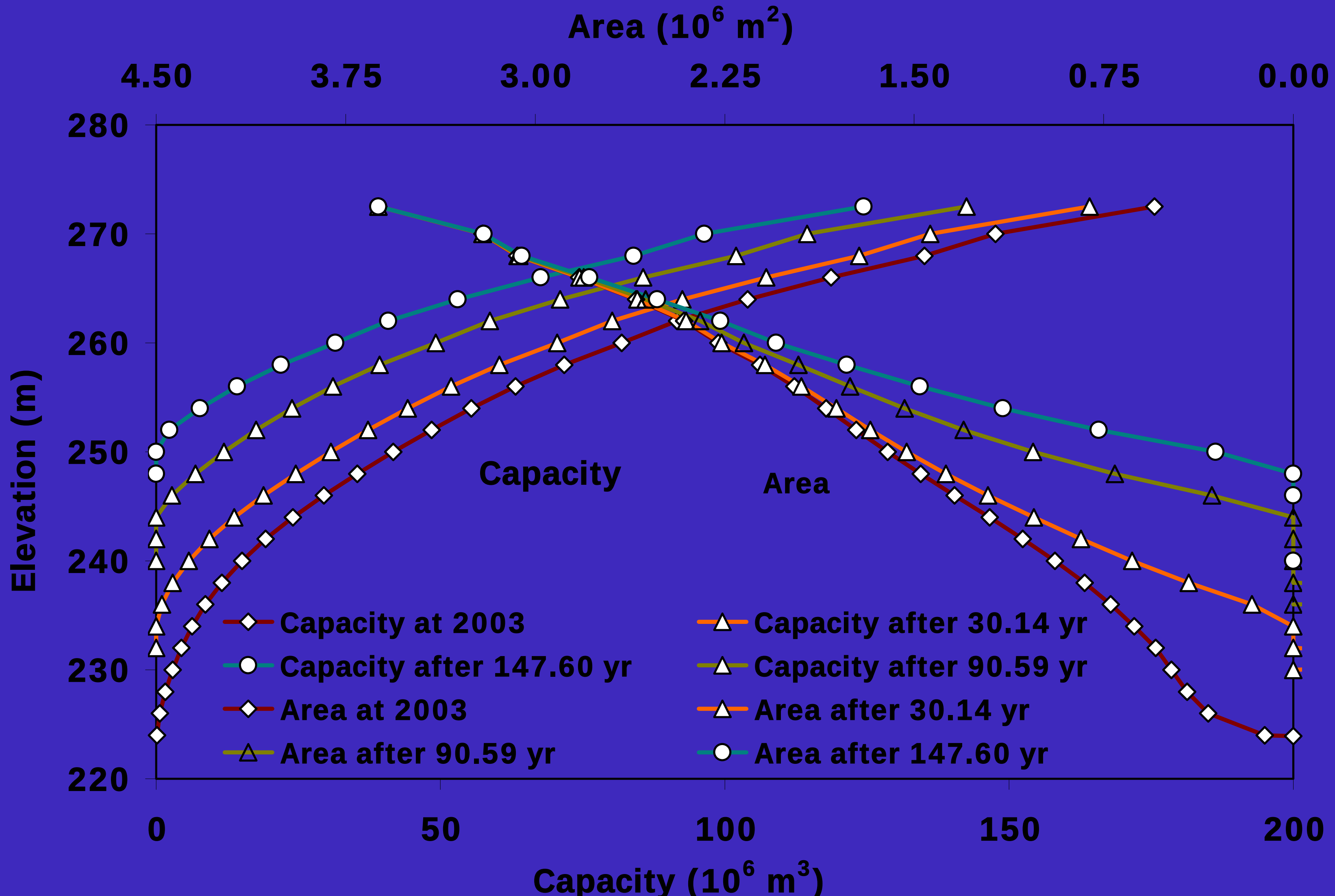
ADJUSTED CURVED

SEDIMENT DISTRIBUTION PATTERNS



ADJUSTED CURVED

SEDIMENT DISTRIBUTION PATTERNS



1. The annual sedimentation in the Sengguruh reservoir is 2,148,000 ton/yr (9.5%, 2.78-yr) and Sutami reservoir is around 1,707,600 ton/yr (13.6%, 147.6-yr)

2. USLE method and MPM-USBR are applicable to this basin.

3. Based on Area–Increment and Empirical Area Reduction Methods, the usable life of storages are 2.78 and 147.6 years for Sengguruh and Sutami reservoirs, respectively.

Note that all results are based on assumptions (i) constant sediment inflow and (ii) no countermeasures.

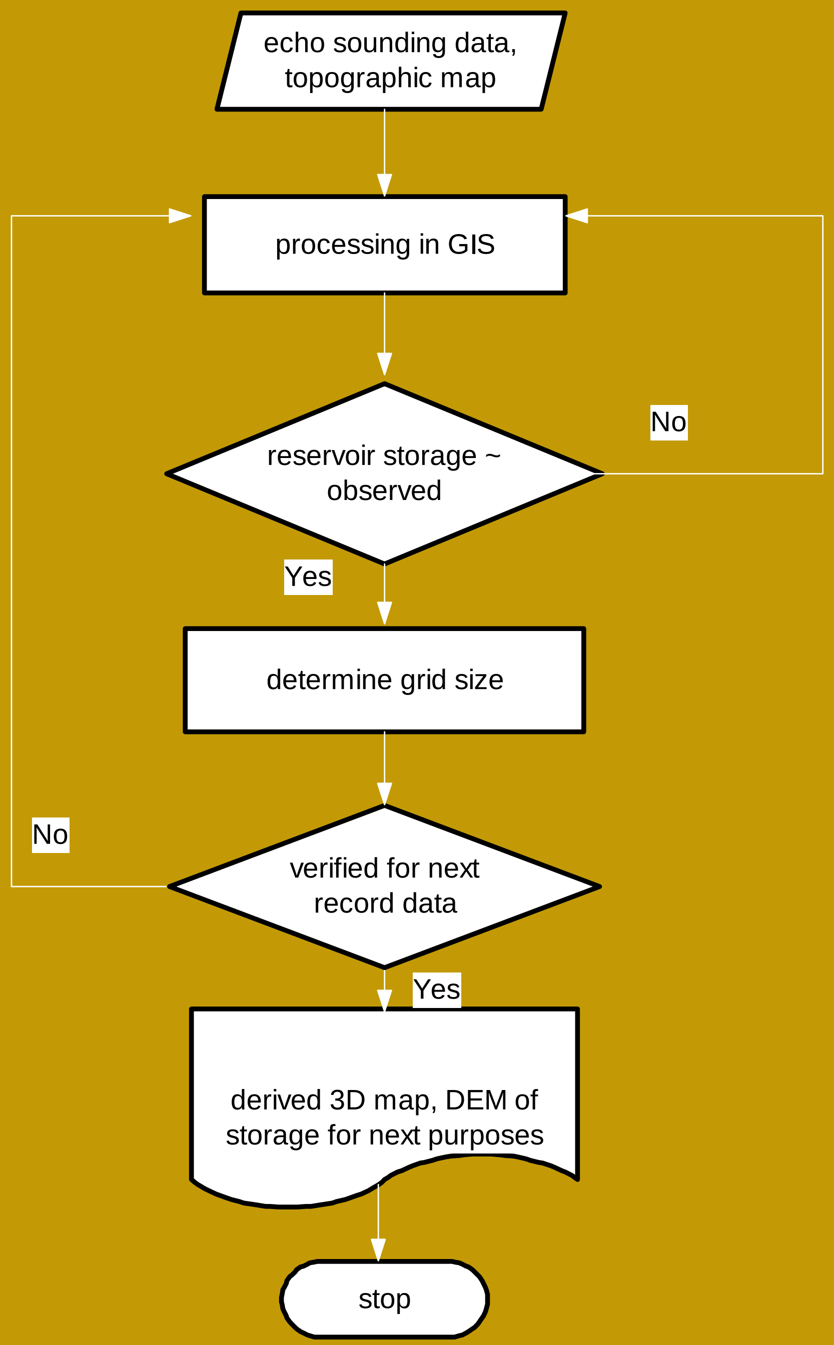
RESERVOIR BATHYMETRY AND SEDIMENT THICKNESS

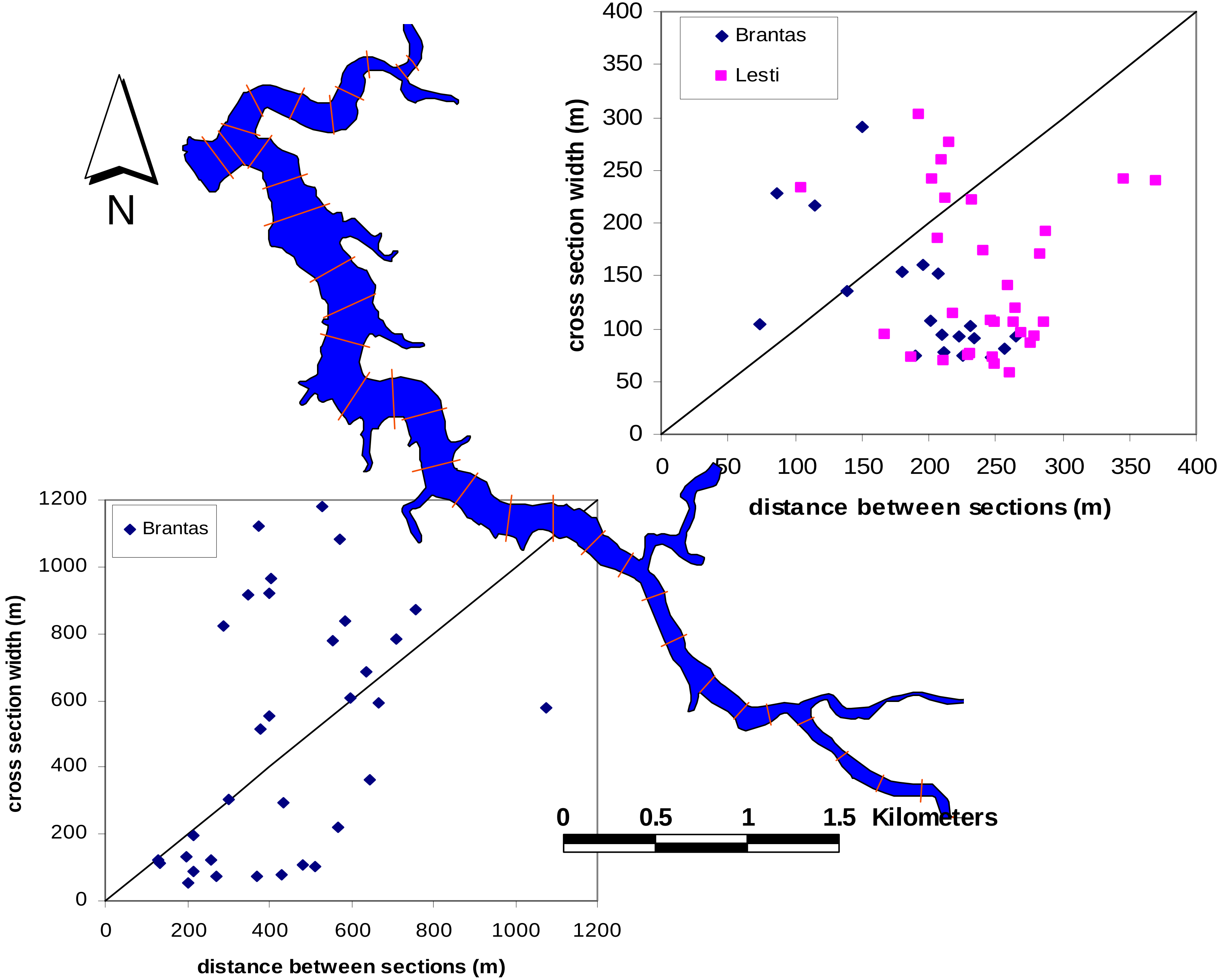
The lost storage capacity of a reservoir can be removed by flushing, dredging, or siphoning. However, the most critical thing to get the better result of the flushing or dredging is how precise or accurate information of deposited material and bottom relief.

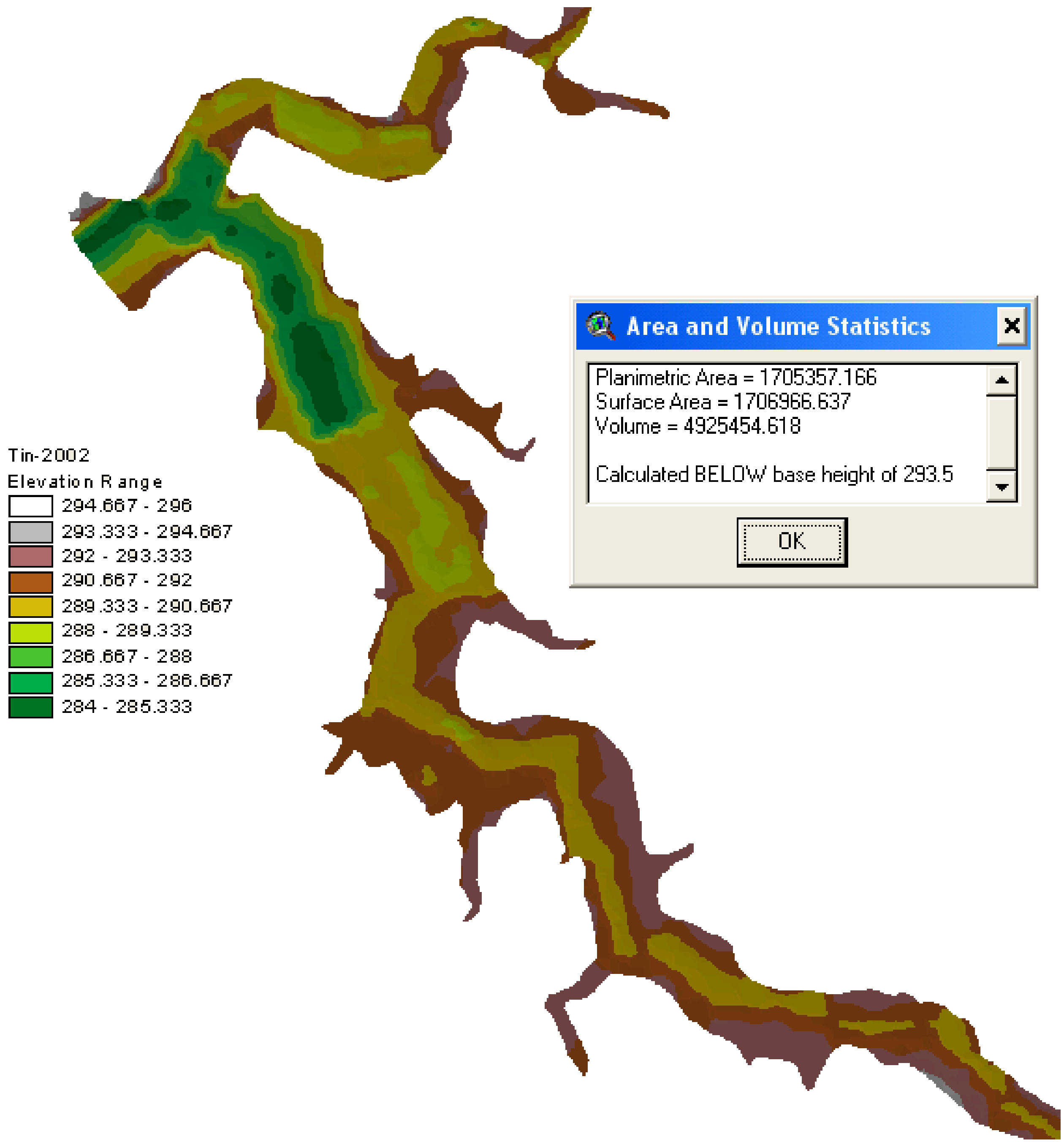
Unfortunately, most of the conventional data from field survey is manually calculated or drawn, so the complex analysis using this data is cumbersome.

In order to integrate the ground survey data with GIS application to identify the sedimentation thickness in reservoir is presented.

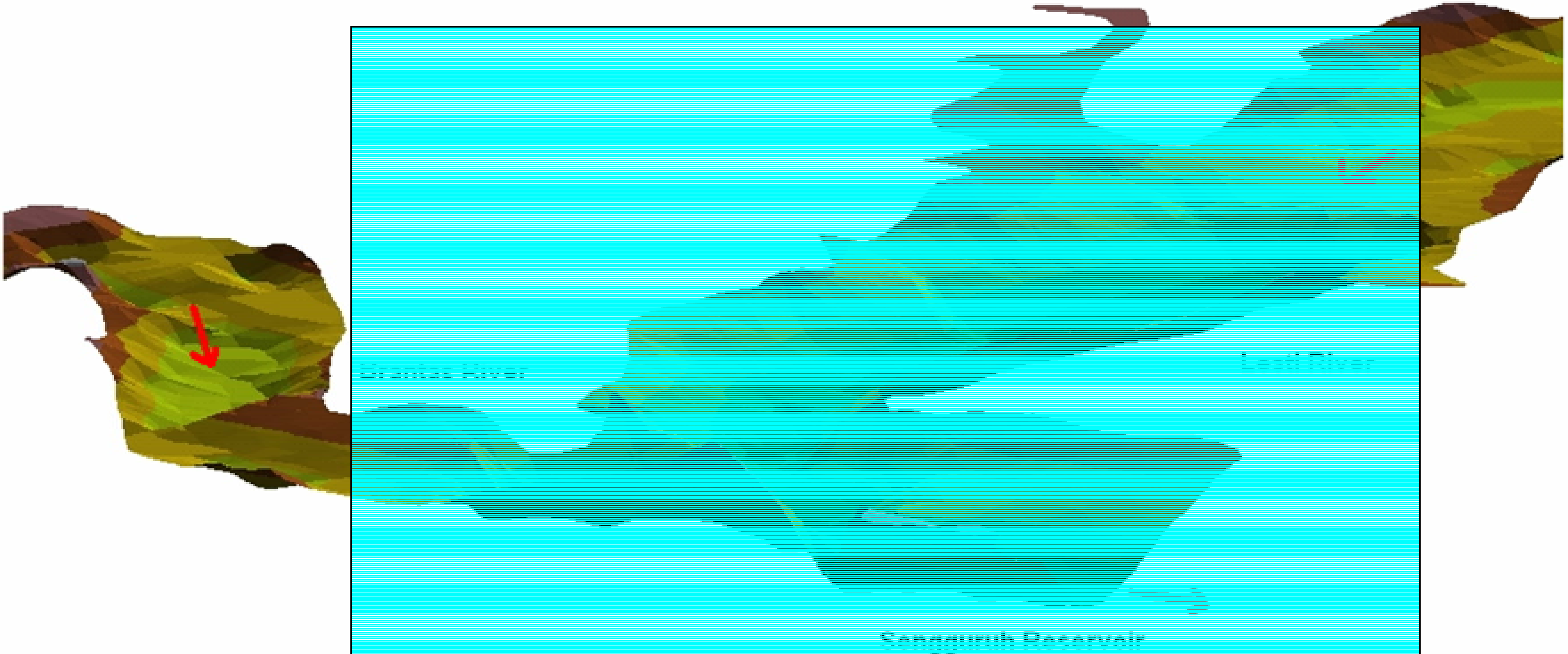
1. Establish Arcview project with appropriate extensions
   - *3D analyst*
   - *Spatial Analyst*
   - *Geoprocessing*
   - *Poly conversion to spaced points*
2. Create theme for GPS points measurement data
3. Convert reservoir boundary to points to overlay with depth
4. Interpolate a continuous surface of reservoir
5. Convert a surface to TIN to calculate volume
6. Using Map Calculator to identify sediment thickness between periods observation



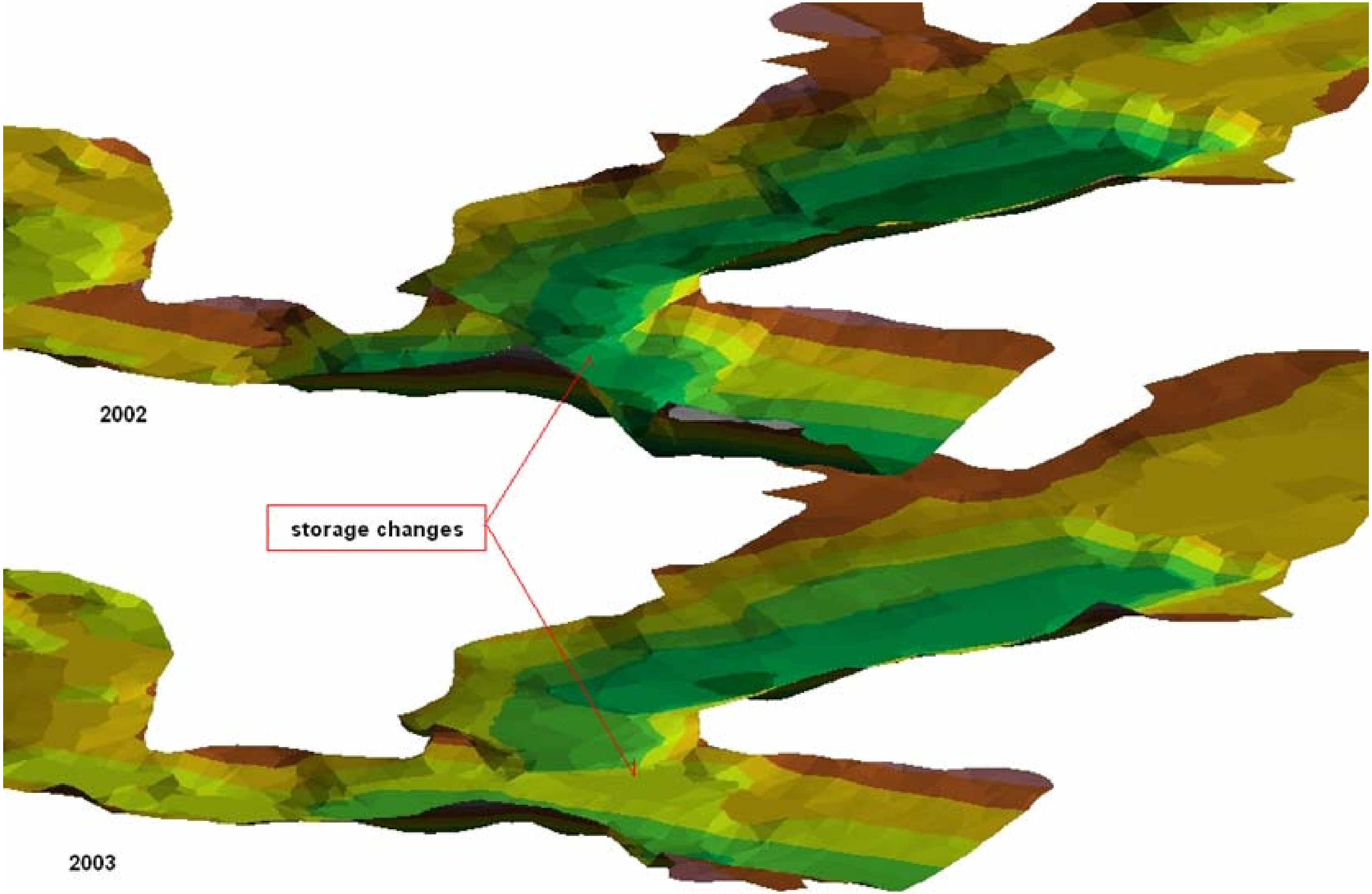

N
Brantas
Lesti
cross section width (m)
distance between sections (m)
0
50
100
150
200
250
300
350
400
Brantas
cross section width (m)
distance between sections (m)
0
200
400
600
800
1000
1200
0 0.5 1 1.5 Kilometers

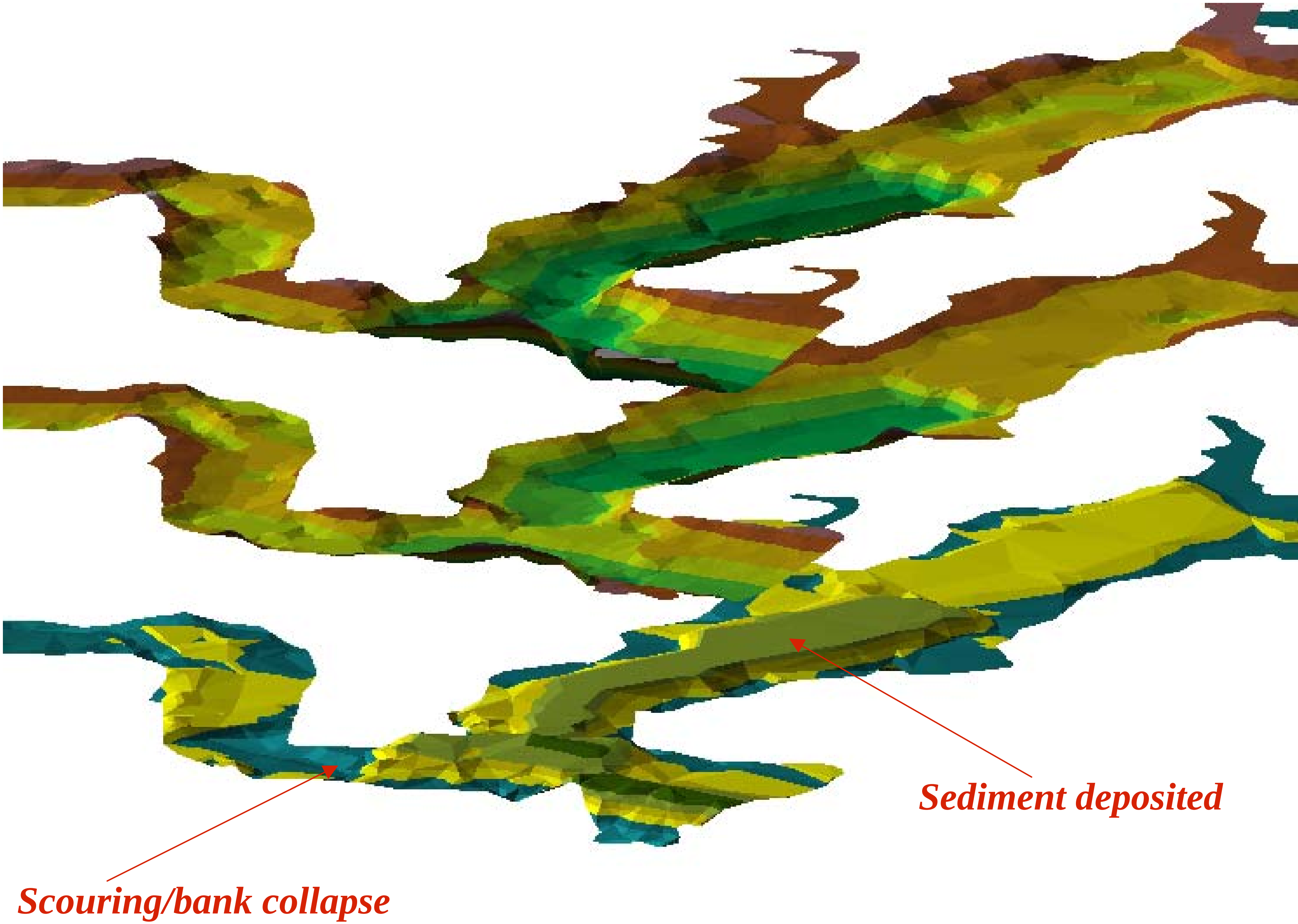


Tin-2002
Elevation Range
294.667 - 296
293.333 - 294.667
292 - 293.333
290.667 - 292
289.333 - 290.667
288 - 289.333
286.667 - 288
285.333 - 286.667
284 - 285.333
Area and Volume Statistics
Planimetric Area = 1705357.166
Surface Area = 1706966.637
Volume = 4925454.618
Calculated BELOW base height of 293.5
OK



The main pool of the Sengguruh reservoir


2002
storage changes
2003


Sediment deposited
Scouring/bank collapse

Conclusions

Apparently, location and the thickness of sediments on the reservoir bottom were easily detected.

The proposed method gives the total volume of reservoir below HWL +193.5m as 4,925,454.62 m^3 and 3,698,383.96 m^3 for 2002 and 2003 respectively.

During 2002-2003, the sediment thickness varies between +2/-2 m.

Compare to the observed data, the error of total volume for this method are:

2002 , error = 4.925.454,618 m^3 – 4.527.583.411 m^3

= 397.871,207m^3 ~ 8.8%

2003, error = 3.698.383,96 m^3 – 3,663,658 m^3

= 34.725,64 m^3 ~ 0,95%


QUALITATIVE
MINEROLOGY ANALYSIS - BASED ON X-RAY DIFFRACTION METHOD

In order to identify the sources and to inventory the characteristics material deposited in those reservoirs, the qualitative analysis of material deposited in the reservoir is needed to do.

This study is being done based on field survey and laboratory evaluation of physical properties of basin,soil-characteristics, hydrological parameters in basin area and the properties of sediment deposited in reservoirs.

The ultimate goal of are to establish relationship among those parameter as a support-evidence of the quantitative model such as USLE, which is black box model characterization and to give appropriate countermeasure for known vulnerable area.

Volcanic ash ??

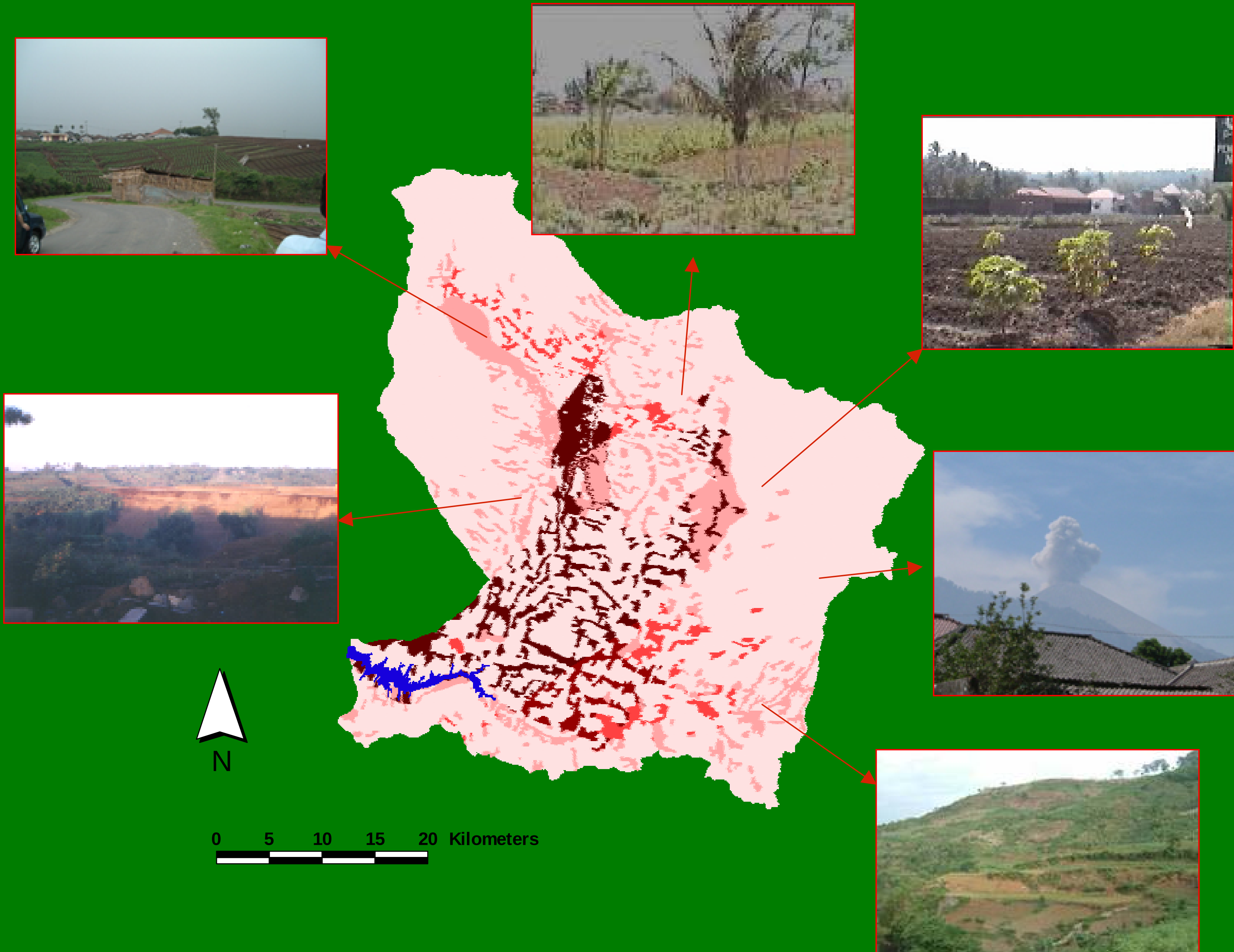
Surface erosion ??

X-RAY DIFFRACTION METHOD

Size and composition are the most fundamental attributes of sediments.

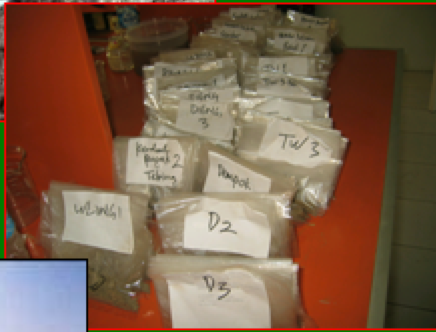
Although optical microscopy, X-ray powder diffraction is the most common technique used.

It is attractive because of its speed and ease of performance, and because it requires only small amounts of material, is nondestructive.


N
0 5 10 15 20 Kilometers

SEDIMENT SOURCES

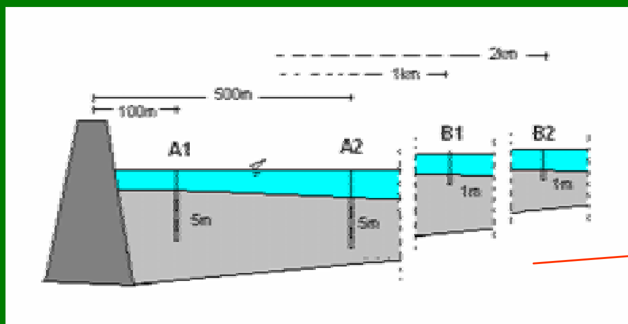
1. Collecting sampling data from the potential sources material
2. Identify the physical of basin properties
3. Identify the properties of deposited sediment

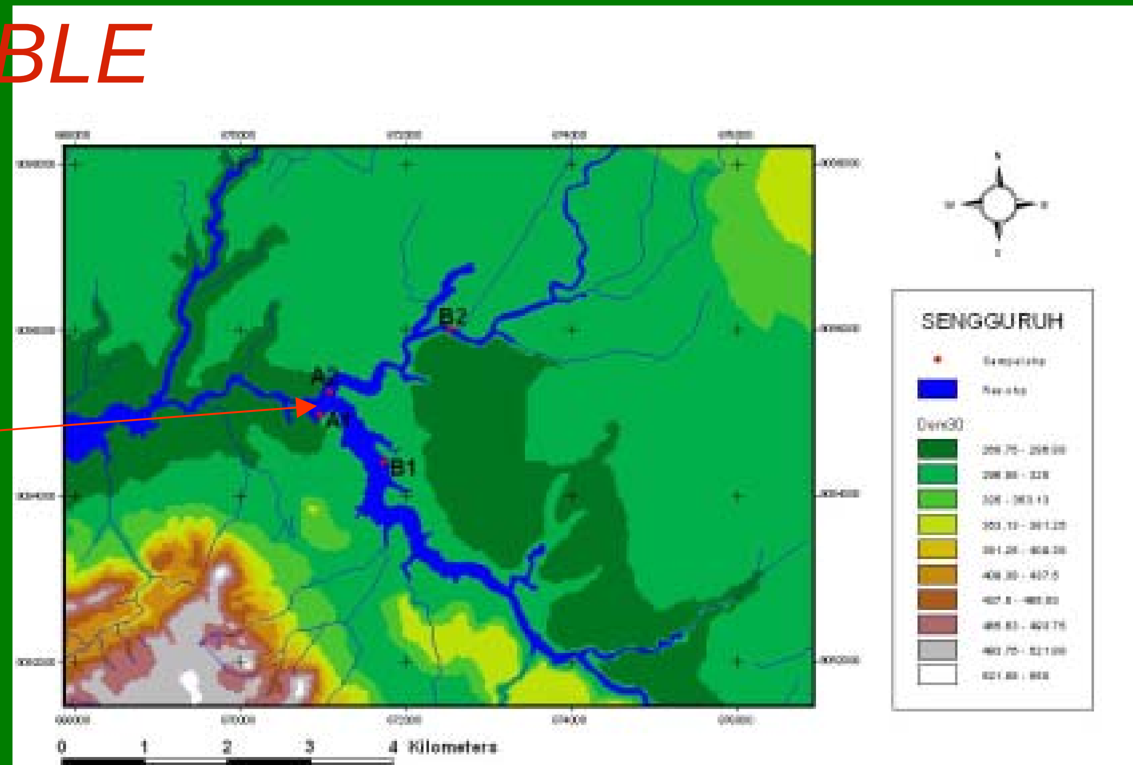


PROCESSES

1. ***Laboratory Analysis – (physical properties analysis, Chemical and Mineralogy decomposition)***
2. ***Identify the dominant sources considering the sources and deposited material properties***
3. ***Multivariate technique***

DATA AVAILABLE



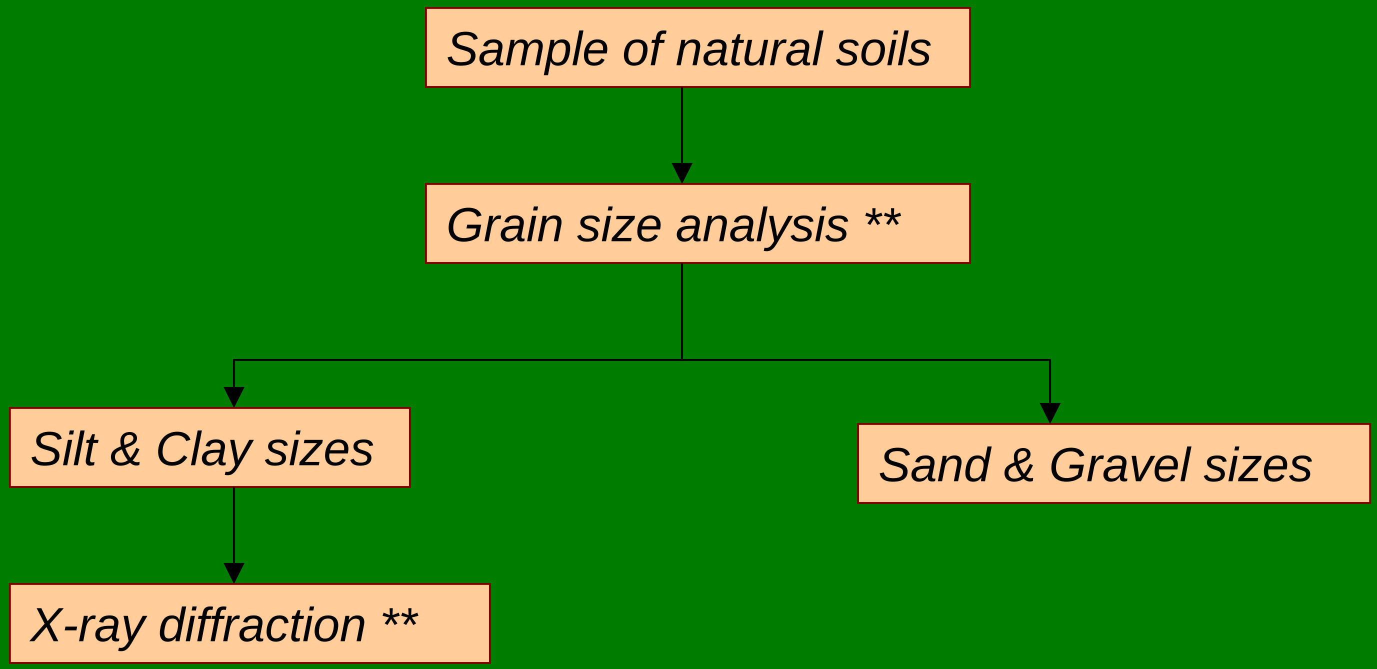


Test item	method	A1	A2	B1	B2	Sources
Sediment Size	Sieving	O	O	O	O	O
Specific gravity	ASTM D854, BS 1377	O	O	O	O	O
Natural water content	ASTM D2216, BS1377	O	O	O	O	
Atterberg limits	ASTM D4318, BS1377	O	O			

Test Item	Method	A1	A2	B1	B2
Organic matter content	AASHTOT194	O	O	O	O
Loss on ignition		O	O		
PH value	BS1377	O	O	O	O
Carbonate content	ASTM C244, BS1377	O	O	O	O
Sulphate content	BS1377	O	O	O	O
Chloride content	ASTM C245	O	O	O	O

Source : Sediment Survey and Laboratory Test for Sediment of Dam Reservoirs and Sabo Facilities, BPP-FTUB, 2004

Mineral composition analysis

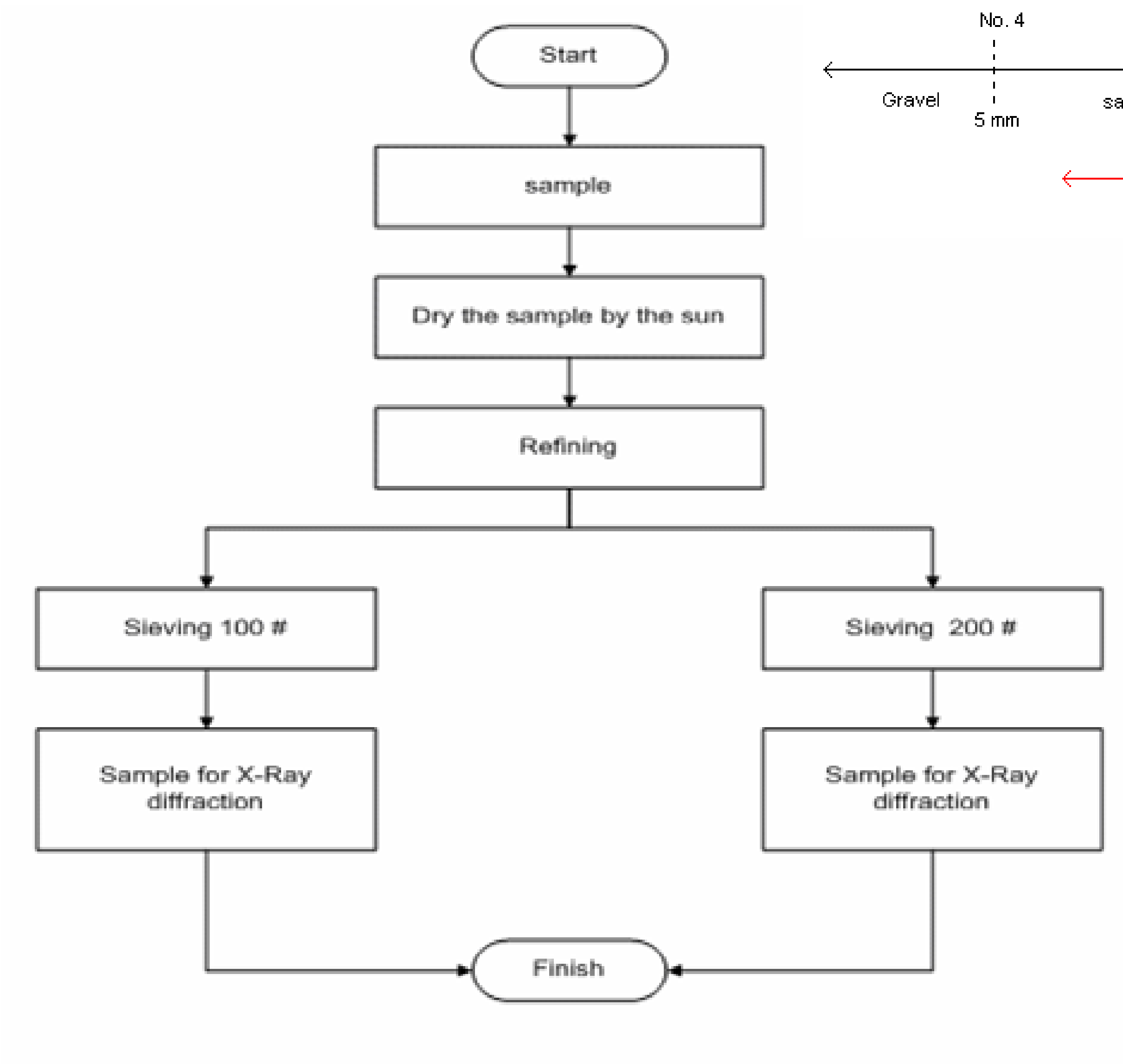


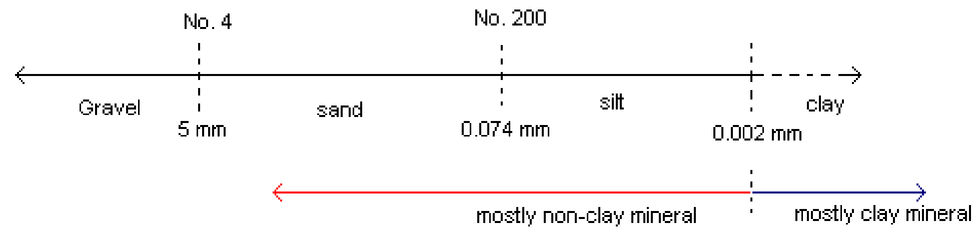
We can determine the size and the shape of the unit cell for any compound most easily using the diffraction of x-rays.

*** most valuable*

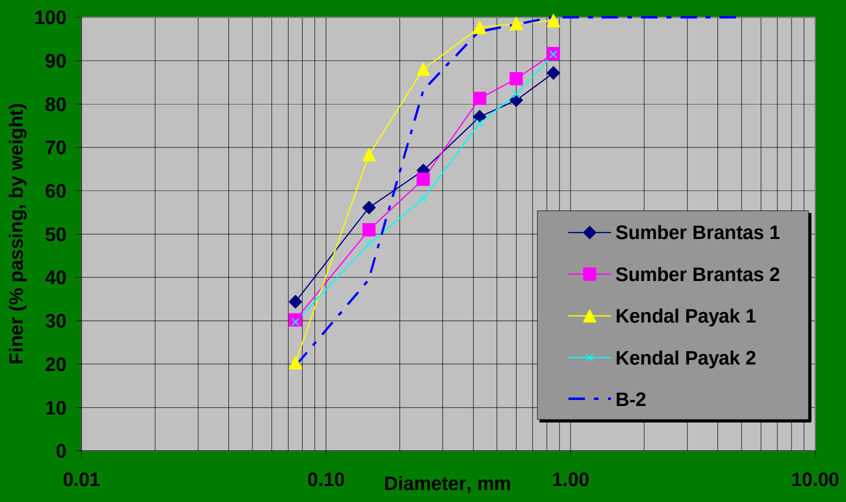
Source : Fundamentals of Soil behavior, John-Willey & Sons, 1995

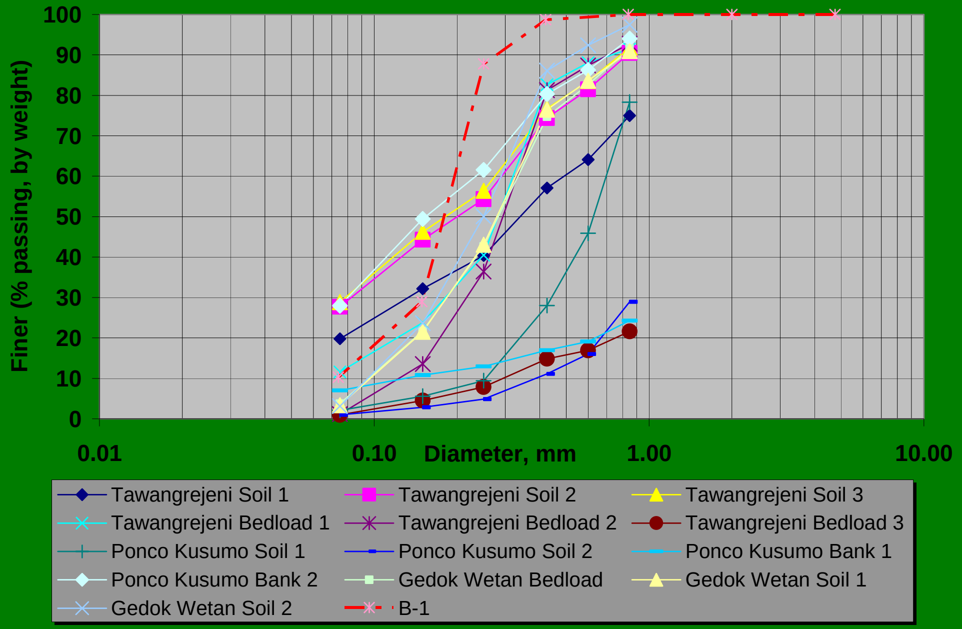
Mineral Decomposition



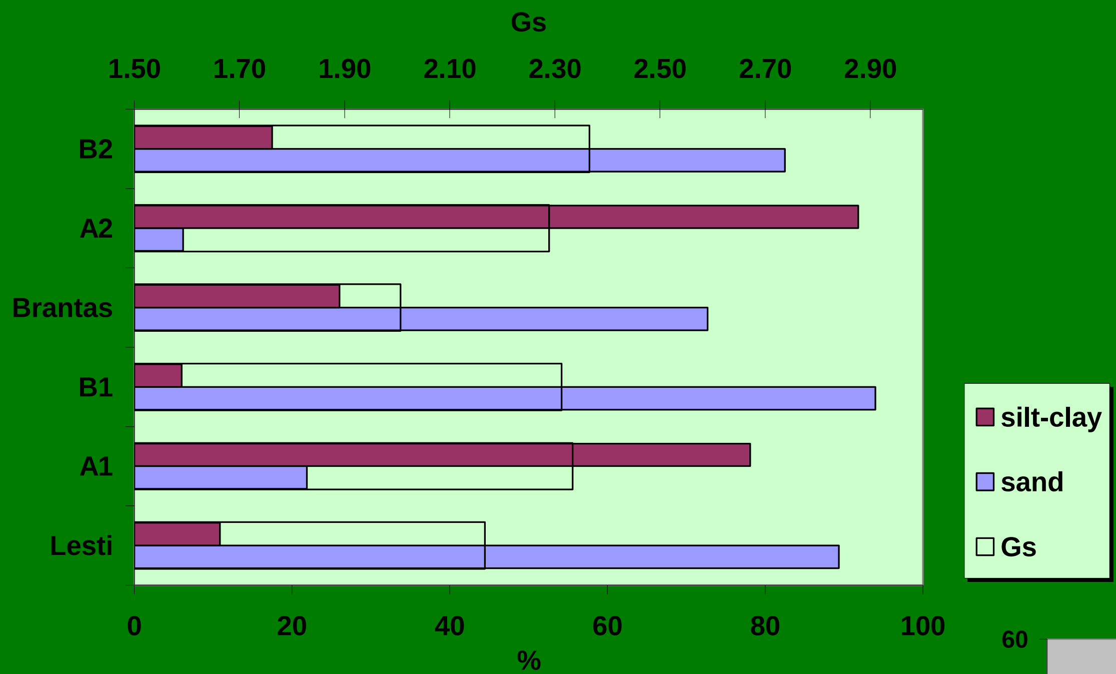


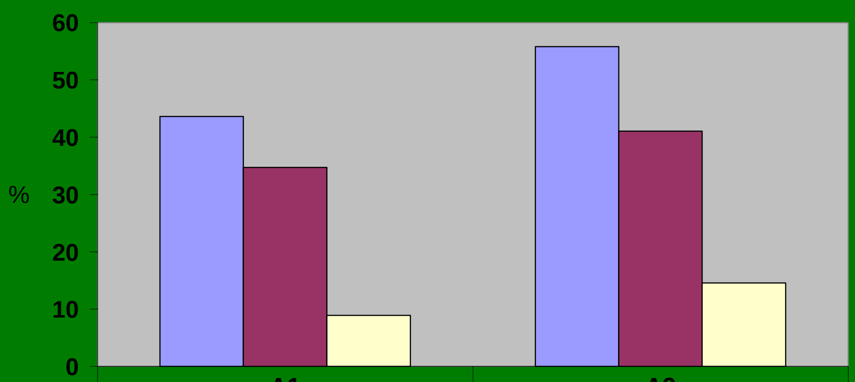
SOIL PROPERTIES





SEDIMENT DEPOSITED

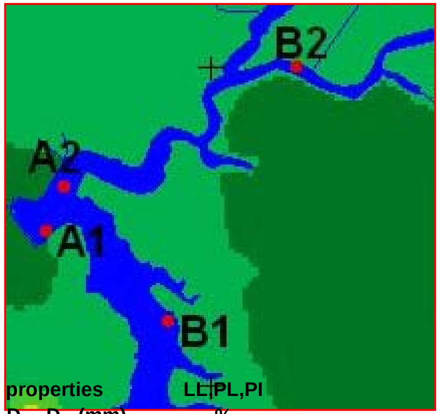




	A1	A2
LL	43.6	55.8
PL	34.7	41.0
IP	8.9	14.6

SEDIMENT DEPOSITED

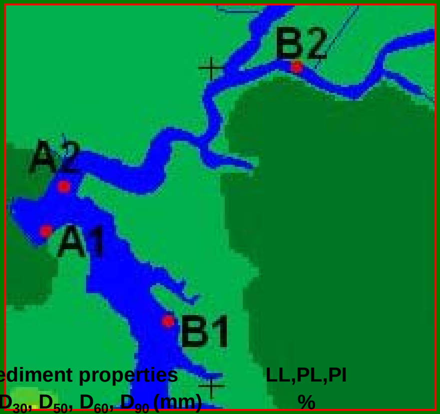
Physical Properties



WA/01/A1/13-5/04

Depth (m)	Parameter	Content Result	Content Sd	Unit	Mineral composition X-ray diffraction	Average Natural Water Content (%)	Sediment properties D_{10}, D_{30}, D_{50}, D_{60}, D_{90} (mm)	LL,PL,PI %
	pH	8.06	0.00	-			0.000	56.37
	CO_3^{2}	881.64	0.54	ppm	Magnetite (Fe_3O_4)		0.000	43.16
1	Cl^{-}	22.04	0.06	ppm	Anorthite Sodian Diso	86.49	0.010	13.21
	loss on ignition	89.70	2.02	%	(Ca,Na) (Si, Al)$_4O_8$		0.017	
	TOC	8.09	0.00	%			0.099	
	Total SO_4^{2}	0.17	0.00	%				
	pH	8.06	0.00	-			0.000	45.07
	CO_3^{2}	874.86	1.60	ppm			0.005	38.00
2	Cl^{-}	13.74	0.00	ppm	Magnetite (Fe_3O_4)	83.49	0.012	7.07
	loss on ignition	88.52	0.03	%			0.030	
	TOC	7.24	0.01	%			0.123	
	Total SO_4^{2}	0.11	0.00	%				
	pH	7.78	0.00	-			0.000	30.46
	CO_3^{2}	901.40	2.99	ppm	Anorthite Sodian Diso		0.007	21.97
3	Cl^{-}	12.84	0.00	ppm	(Ca,Na) (Si, Al)$_4O_8$	64.31	0.029	8.50
	loss on ignition	85.15	0.05	%	Magnetite (Fe_3O_4)		0.043	
	TOC	10.21	0.05	%			0.123	
	Total SO_4^{2}	0.28	0.00	%				
	pH	7.91	0.00	-			0.000	41.53
	CO_3^{2}	912.86	1.15	ppm	Anorthite Sodian Diso		0.005	32.89
4	Cl^{-}	14.95	0.00	ppm	(Ca,Na) (Si, Al)$_4O_8$	62.72	0.015	8.64
	loss on ignition	88.85	0.05	%	Magnetite (Fe_3O_4)		0.027	
	TOC	7.32	0.02	%			0.171	
	Total SO_4^{2}	0.14	0.00	%				
	pH	7.62	0.00	-			0.000	44.67
	CO_3^{2}	899.10	1.24	ppm	Anorthite Sodian Diso		0.000	37.64
5	Cl^{-}	13.30	0.00	ppm	(Ca,Na) (Si, Al)$_4O_8$	60.89	0.010	7.02
	loss on ignition	84.67	0.11	%	Magnetite (Fe_3O_4)		0.025	
	TOC	10.14	0.04	%			0.104	
	Total SO_4^{2}	0.16	0.00	%				

SEDIMENT DEPOSITED



Physical Properties

WA/01/A2/13-5/04

Depth (m)	Parameter	Content Result	Sd	Unit	Mineral composition X-ray diffraction	Average Natural Water Content (%)	Sediment properties D_{10}, D_{30}, D_{50}, D_{60}, D_{90} (mm)	LL,PL,PI %
	pH	7.30	0.00	-			0.000	58.19
	CO_3^{2}	880.80	1.71	ppm	Anorthite Sodian Diso		0.000	44.39
1	Cl^-	25.73	0.00	ppm	(Ca,Na) (Si, Al)$_4$O$_8$	78.29	0.009	13.80
	loss on ignition	75.99	0.26	%	Magnetite (Fe_3O_4)		0.016	
	TOC	12.55	0.07	%			0.053	
	Total SO_4^{2}	0.23	0.00	%				
	pH	7.29	0.00	-			0.000	54.30
	CO_3^{2}	882.71	0.97	ppm	Magnetite (Fe_3O_4)		0.000	40.61
2	Cl^-	20.32	0.13	ppm	Anorthite Sodian Diso	106.15	0.006	13.69
	loss on ignition	78.22	0.01	%	(Ca,Na) (Si, Al)$_4$O$_8$		0.009	
	TOC	12.12	0.11	%			0.081	
	Total SO_4^{2}	0.25	0.00	%				
	pH	7.54	0.00	-			0.000	54.36
	CO_3^{2}	876.68	0.00	ppm	Anorthite Sodian Diso		0.000	40.57
3	Cl^-	14.58	0.62	ppm	(Ca,Na) (Si, Al)$_4$O$_8$	112.22	0.005	13.79
	loss on ignition	91.68	1.12	%	Magnetite (Fe_3O_4)		0.008	
	TOC	1.77	0.00	%			0.062	
	Total SO_4^{2}	3.24	0.00	%				
	pH	8.15	0.00	-			0.000	56.70
	CO_3^{2}	915.08	0.12	ppm	Magnetite (Fe_3O_4)		0.000	41.26
4	Cl^-	20.26	0.07	ppm	Anorthite Sodian Diso		0.006	15.44
	loss on ignition	86.07	0.56	%	(Ca,Na) (Si, Al)$_4$O$_8$	103.83	0.010	
	TOC	4.25	0.01	%			0.050	
	Total SO_4^{2}	0.06	0.00	%				
	pH	8.15	0.00	-			0.000	54.52
	CO_3^{2}	898.13	0.16	ppm	Anorthite Sodian Diso		0.000	38.38
5	Cl^-	21.29	0.00	ppm	(Ca,Na) (Si, Al)$_4$O$_8$		0.007	16.14
	loss on ignition	84.09	0.06	%	Magnetite (Fe_3O_4)	96.42	0.012	
	TOC	1.00	0.00	%			0.057	
	Total SO_4^{2}	0.39	0.06	%				

Source : Sediment Survey and Laboratory Test for Sediment of Dam Reservoirs and Sabo Facilities, BPP-FTUB, 2004

SEDIMENT DEPOSITED

Chemical Properties

WA/01/B1/13-5/04

Depth (m)	Parameter	Content			Average Natural Water Content (%)	Sediment properties D_{10}, D_{30}, D_{50}, D_{60}, D_{90} (mm)
		Resul t	Sd	Unit		
1	pH	8.07	0.00	-		0.0740
	CO_3^2	898.7 1	0.18	ppm		0.1272
	Cl^-	19.38	0.06	ppm	50.96	0.1697
	TOC	2.80	0.00	%		0.1909
	Total SO_4^2	0.11	0.00	%		0.2844

Source : Sediment Survey and Laboratory Test for Sediment of Dam Reservoirs and Sabo Facilities, BPP-FTUB, 2004

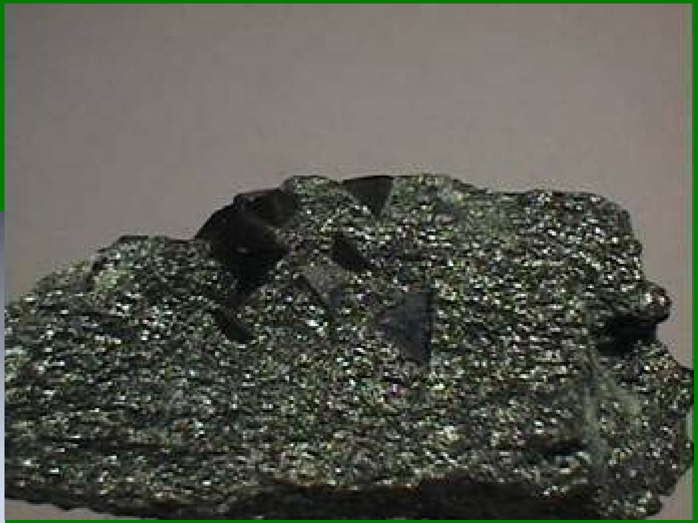
SEDIMENT DEPOSITED

Chemical Properties

WA/01/B2/13-5/04

Depth (m)	Parameter	Content			Average Natural Water Content (%)	Sediment properties D_{10}, D_{30}, D_{50}, D_{60}, D_{90} (mm)
		Result	Sd	Unit		
1	pH	8.15	0.00	-	49.78	0.0000
	CO_3^{2}	915.08	0.12	ppm		0.1013
	Cl^-	20.26	0.07	ppm		0.1553
	TOC	4.25	0.01	%		0.1838
	Total SO_4^{2}	0.06	0.00	%		0.3358

Source : Sediment Survey and Laboratory Test for Sediment of Dam Reservoirs and Sabo Facilities, BPP-FTUB, 2004



Magnetite

Anorthite ($CaAl_2 Si_2 O_8$),

Calcium aluminum silicate

WEAK-SUMMARY

1. The Sumber brantas and Lesti sub-basins are vulnerable to surface erosion due to the slope of area and soil type (mostly dominated by alluvial)

2. Based on grain size, it is shown that properties of material deposited in Sengguruh reservoir (B1) have a good agreement with source material from Tawangrejeni (Lesti) than other locations (Poncokusumo, Gedok Wetan). In B2, the dominant sources (Sumber brantas, Kendal payak) have also good relationship with deposited sediment. From Brantas river, sand material is higher than Lesti river.

3. The chemical properties of sediment deposited, most of samples have pH-value between 7 until 8, Carbonate content of most samples is 850 – 950 ppm. LOI (*Loss on Ignition*) of A1(Lesti) > A2 (Brantas). TOC (total organic carbon) in B1(Lesti)<B2 (Brantas).Lower value of TOC shows that surface erosion higher, because inorganic can dilute organic matter during surface erosion process.

4. The mineralogy of sediment deposited in reservoir are Magnetite (Fe_3O_4), (Ca, Na) $(Si,Al)_4O_8$ and Anorthite Sodian Diso

THANK YOU

The authors express the deep thanks to JASA TIRTA I, CREST Project and other AUTHORITIES/INSTITUTIONS for providing data and supports

Reservoir Sedimentation Prediction Based on Pollutant Characteristic in Watershed

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Ery Suhartanto
Tri Budi Prayogo

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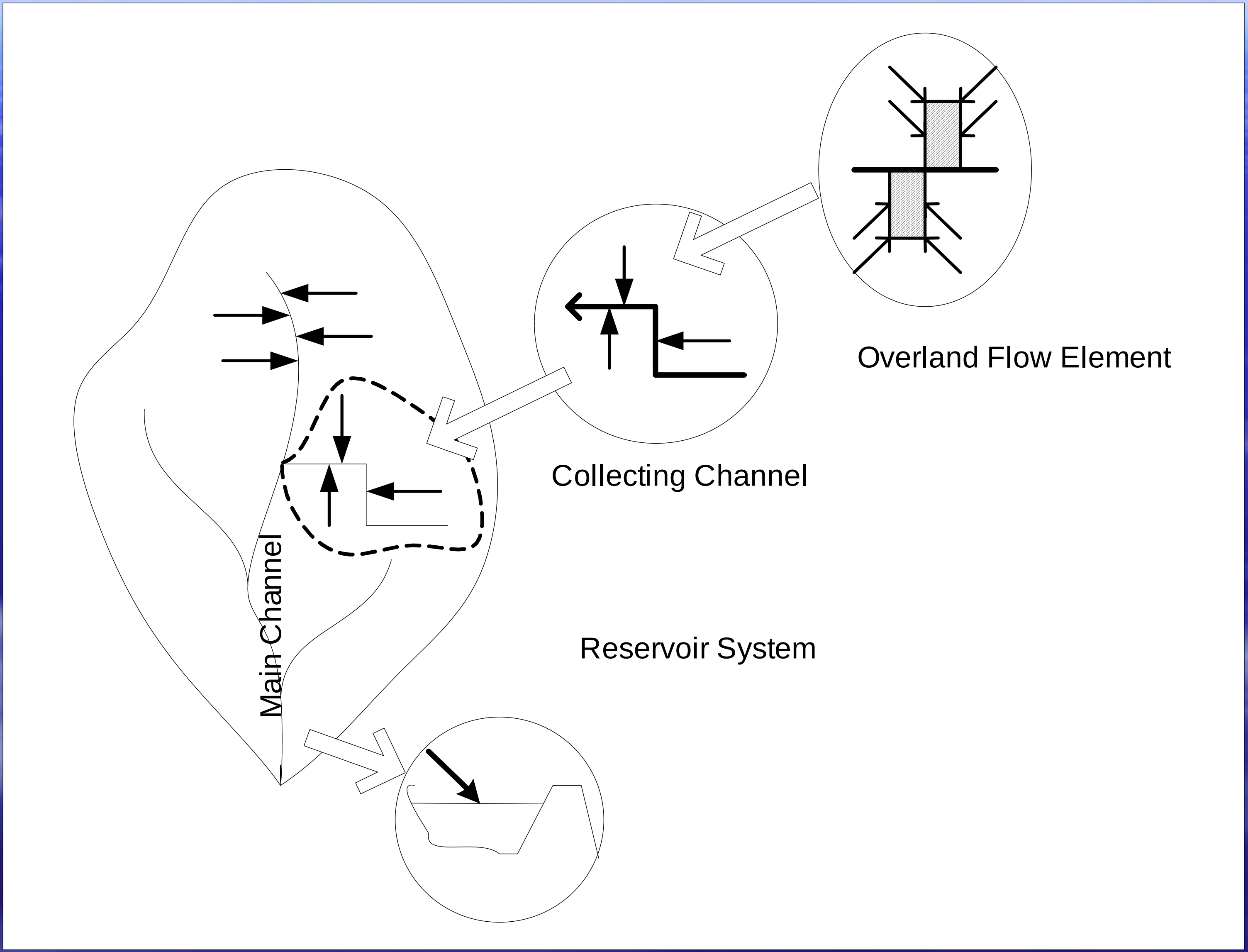
Engineering Faculty,
Brawijaya University

Background

- Sedimentation increasing in the river and reservoir
- Effective capacity of reservoir decreasing
- Sediment prediction base on the parameter in the watershed
- Using the water quality as the one of parameter (the pollutant parameter)
- Making correlation between the sedimentation in reservoir with the increasing of the pollutant

Model Developing



Model Developing

Overland Flow element (Erosion, Sediment, and Runoff)

Collecting Channel (Water Quality)

Result As Input

Reservoir System Predicting The Reservoir Sedimentation

Model Developing of the Overland Flow Element

- The model was develops at the land or in the watershed that produce the amount of sediment from the land.
- This model was using the mathematical approaching to predict the erosion, sediment, and runoff in the land.
- The watershed physical component was using as the basic for developing the model.
- GIS approaching conducted to changing the physical component to the spatial data

Model of the Overland Flow Element

Predicting of Erosion, Sediment and Runoff

Model of the Overland Flow Element

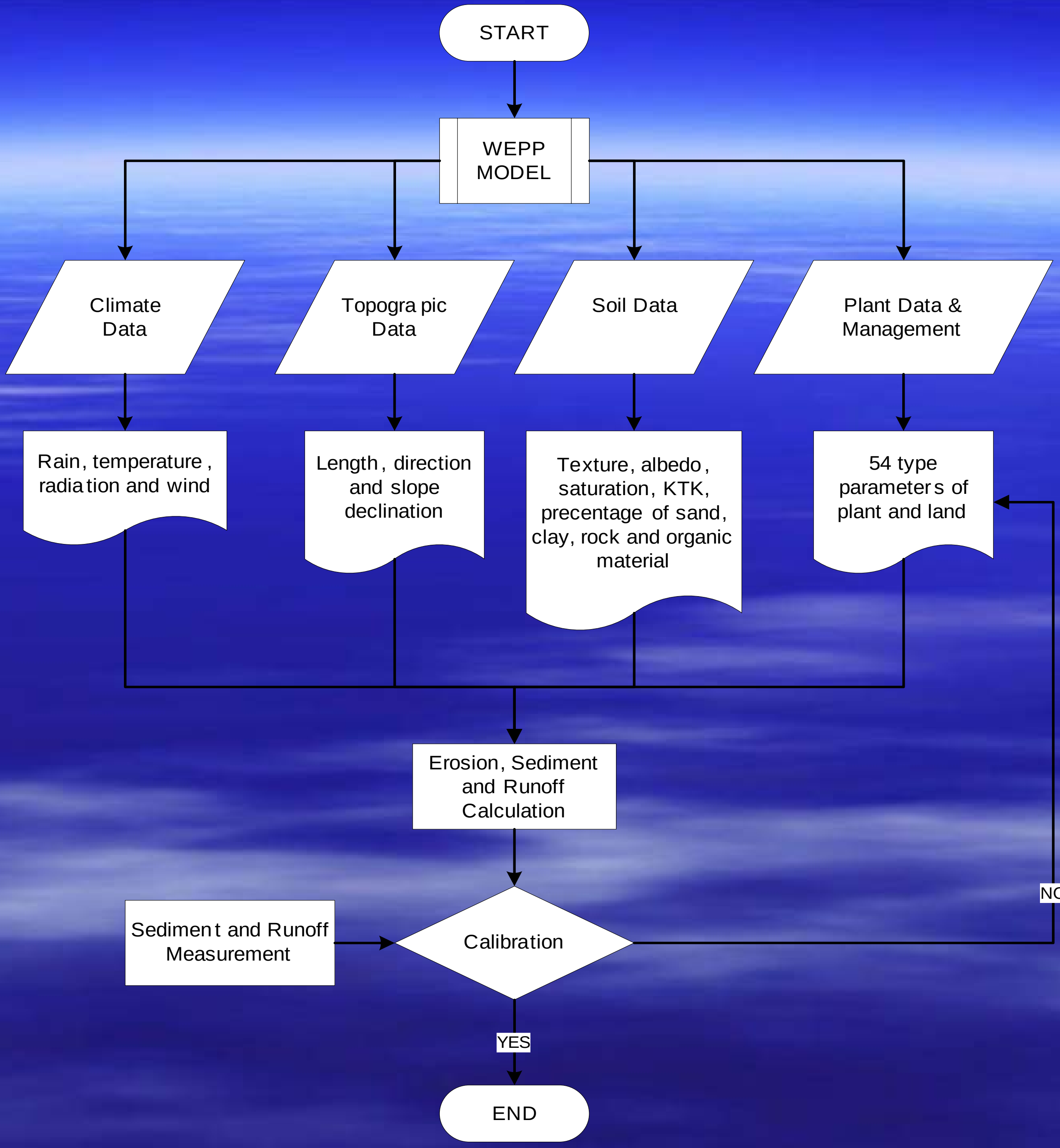
- Using the WEPP mathematic analysis
- Requiring the data of climate, topographic, soil, and data of plant and land management
- Model Analysis Process:

  - Analysis of rainfall and temperature

  - Analysis of discharge data

  - Analysis of sediment data

Predicting of Erosion, Sediment and Runoff Model



Model Developing of the Collecting Channel

- This model develops in the collecting channel or in the river.
- The model actually was the water quality and sediment model.
- The model was accommodating the pollutant influence from the land that caused by the domestic activity, the agricultural activity and the influence from the industry activity.

Model of the
Collecting Channel

Predicting of River
Water Quality, and
Sediment

Model of the Collecting Channel

- Using the AVSWAT as the supporting software
- Source of Pollutant:
  - Domestic pollutant (Non point source pollutant)
    Parameter : BOD and DO
  - Land pollutant (Non point source pollutant)
    Parameter : BOD, Phosphor and Nitrogen
  - Industry pollutant (Point source pollutant)
    Parameter : BOD and DO
- Pollutant routing river using QUAL – 2K as the sofware

Model Developing of the Reservoir System

- The model was the result of these two models.
- The sediment amount and the amount of the pollutant will be use as the basic of the prediction model in the reservoir.
- In this model the correlation between the amounts of the sediment that entering to the reservoir and the amount of the pollutant will develop.
- This model will define the influence of the pollutant to the sedimentation in the reservoir, including the distribution pollutant and sediment in the reservoir and the characteristic of the sediment that lay in the reservoir, and the cause of the increasing of the sedimentation correlating with the pollutant in the watershed, river and the reservoir.

Model of the Reservoir System

Predicting of, Sedimentation in the Reservoir

Model of the Reservoir System

- Combination between the biological and technical process
- Pollutant as the catalyst agent in the reservoir sedimentation
- Parameter Analysis:

  - Type and amount of the pollutant

  - Distribution of pollutant

  - Type and amount of the sediment

  - Distribution of sediment

Thank You

Arrigato Ghosaimas tha

EROSION, SEDIMENTATION AND RUNOFF PREDICTION BASED ON WEPP MODEL

Ery Suhartanto

Water Resources Department

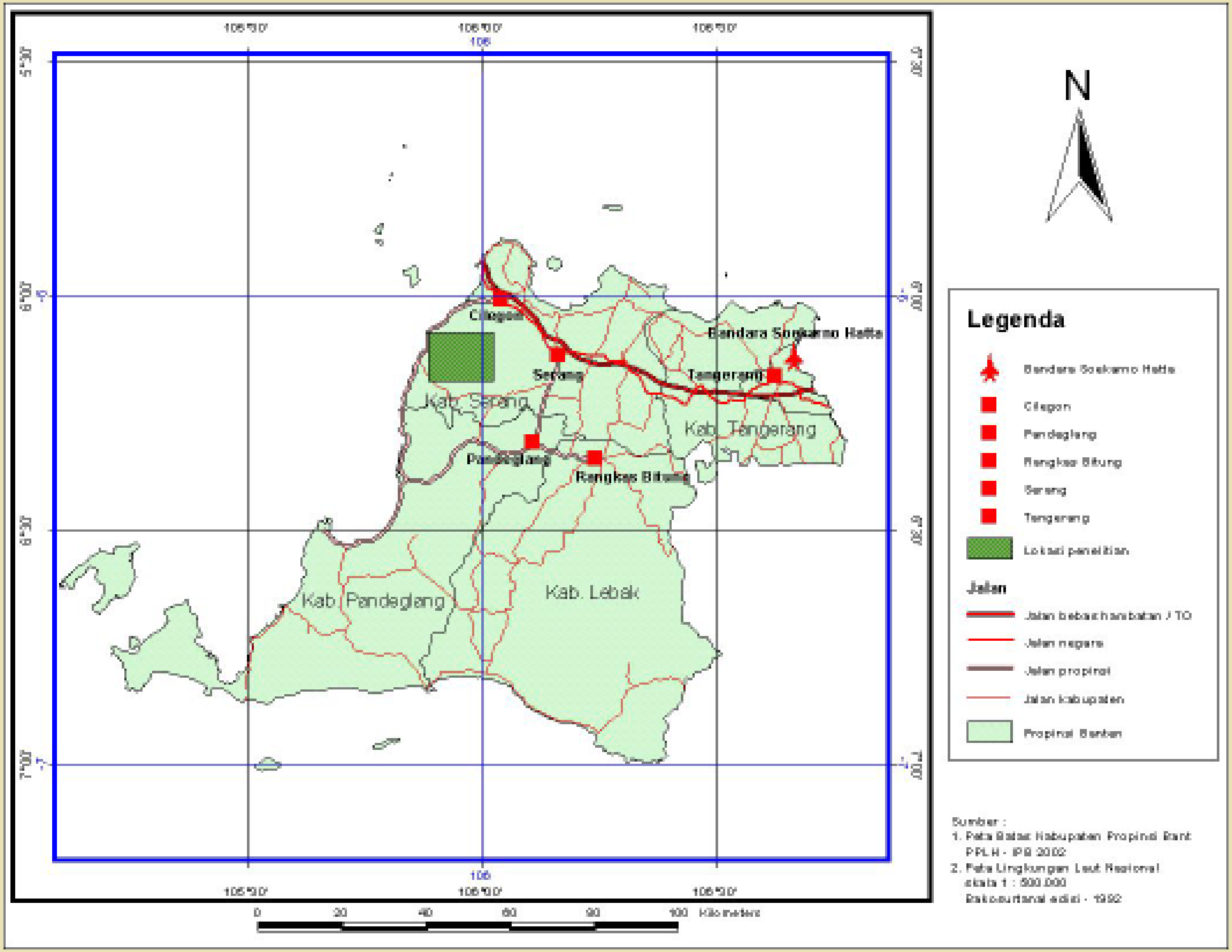
Faculty of Engineering

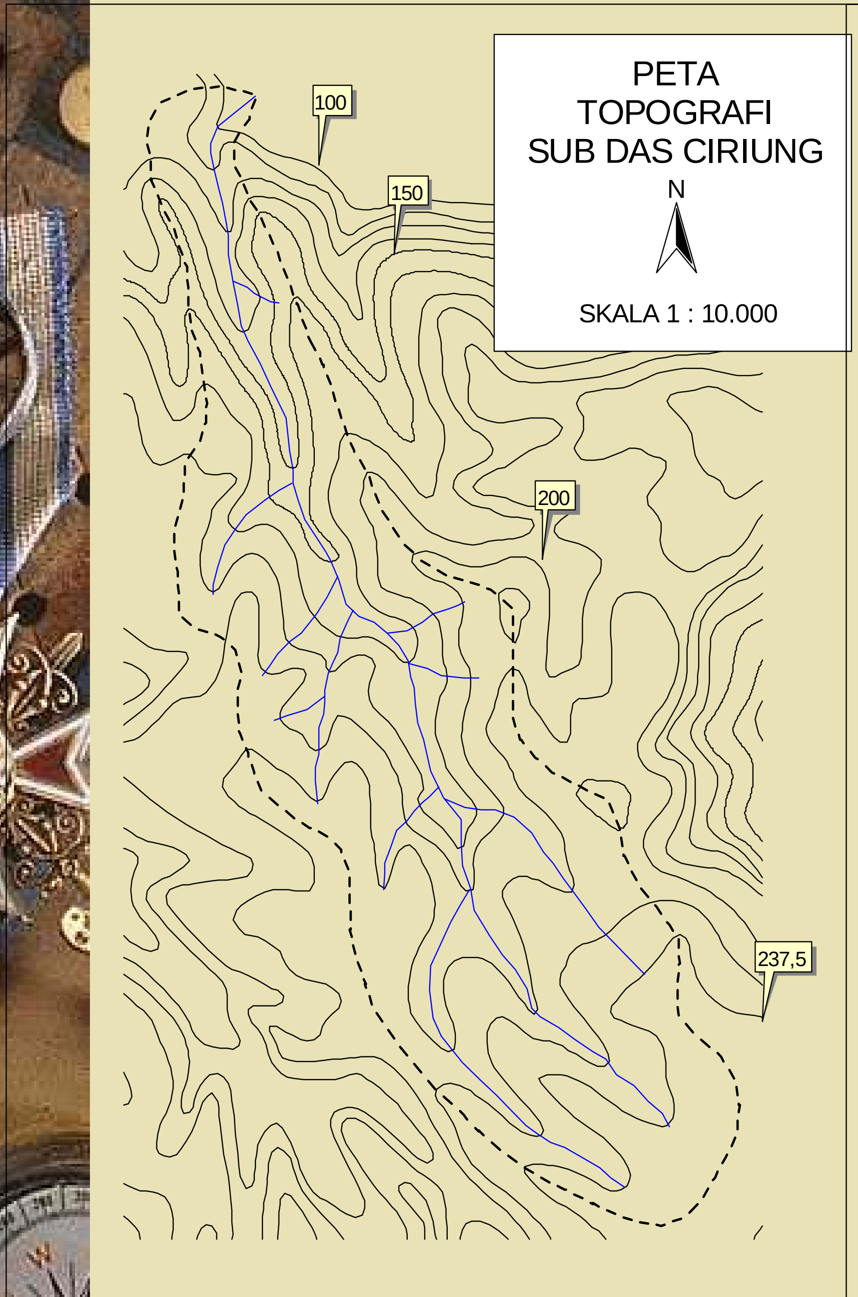
Brawijaya University

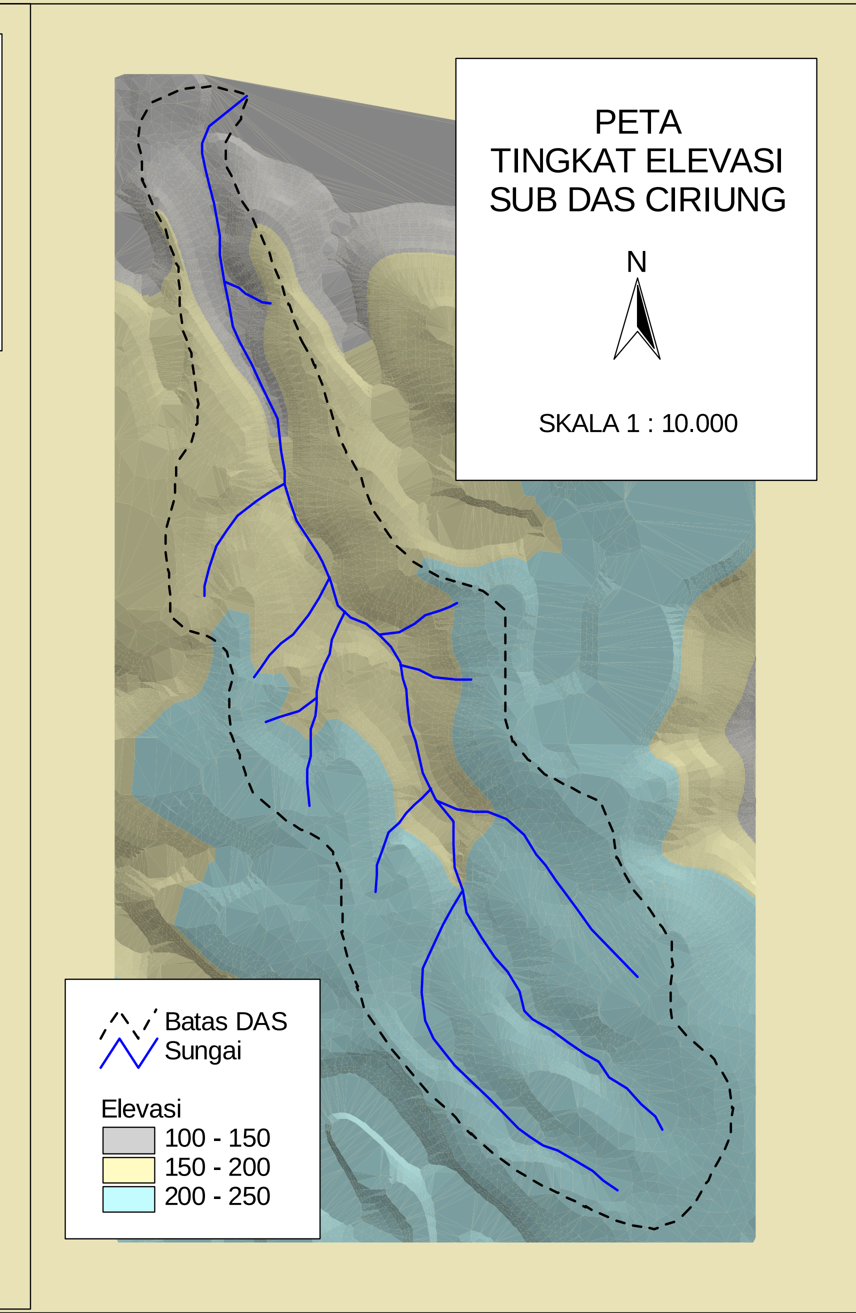
Background

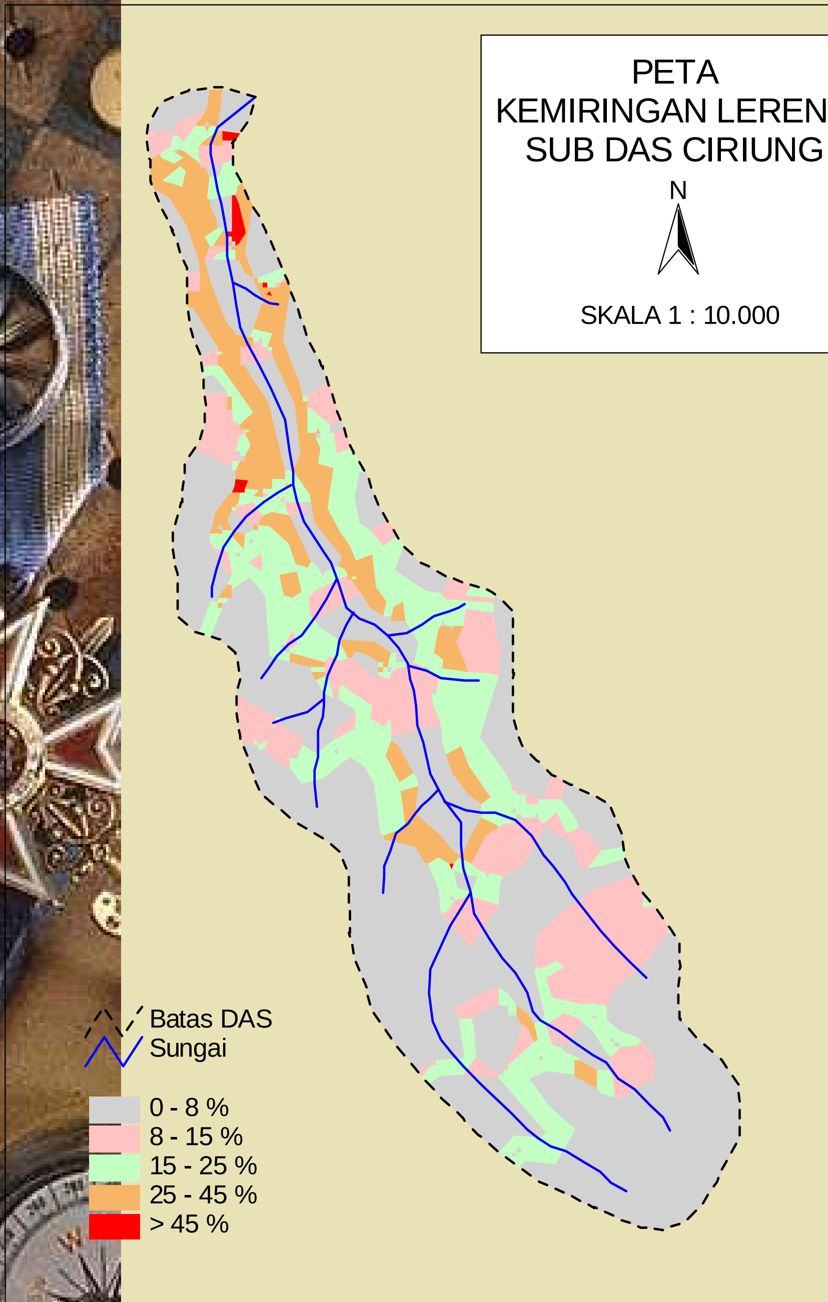
- Critical Watershed :
  - Percentage Land cover is lower
  - Annually erosion rate is higher
  - Ratio of Q max and Q in is higher
  - Sediment load in river is higher
- Critical Watershed in Indonesia increased from 22 (1984) become 62 (Soenarno, 2004)
- It needed model that accurate to predict erosion and to find conservation method that can decrease erosion, sedimentation and runoff.

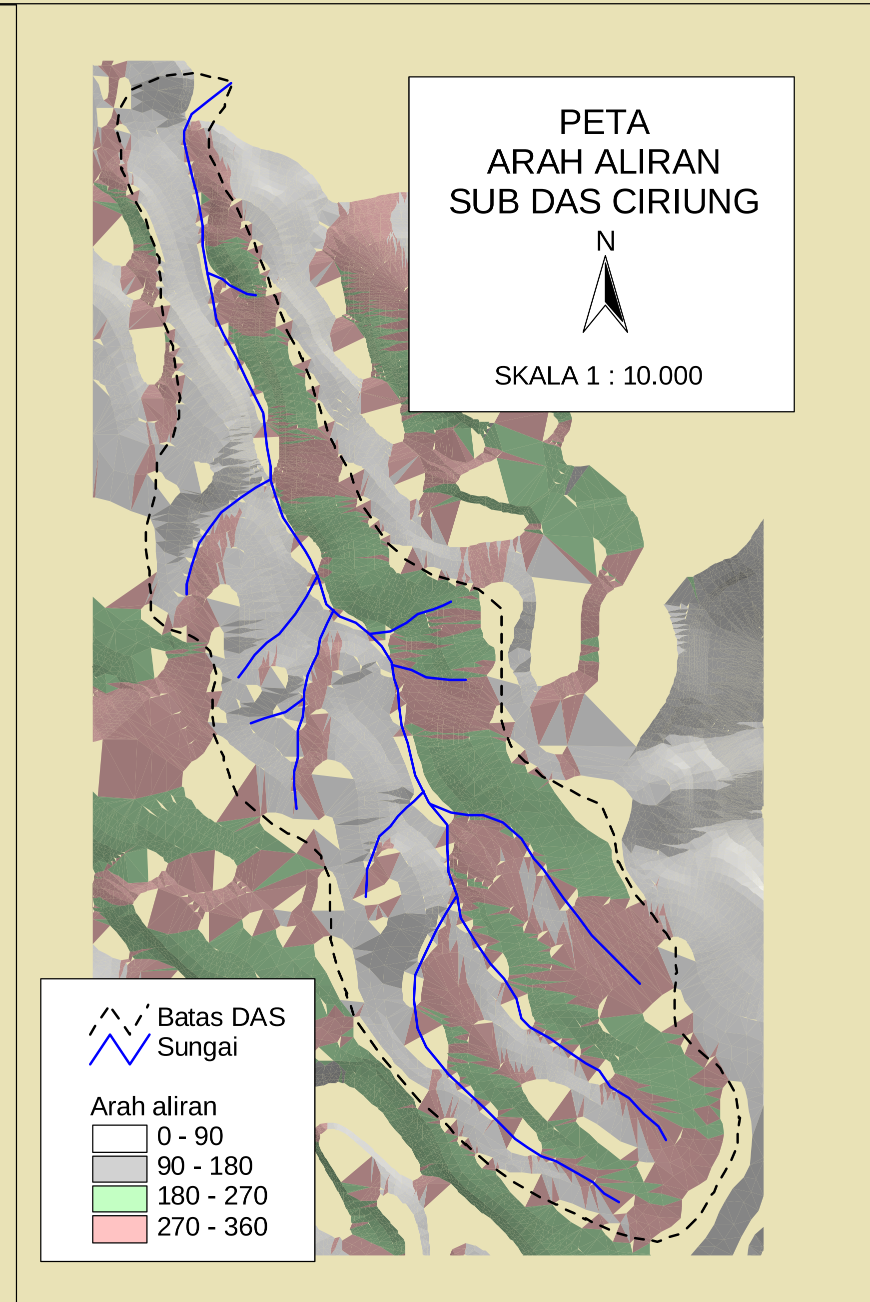
LOCATION OF RESEARCH

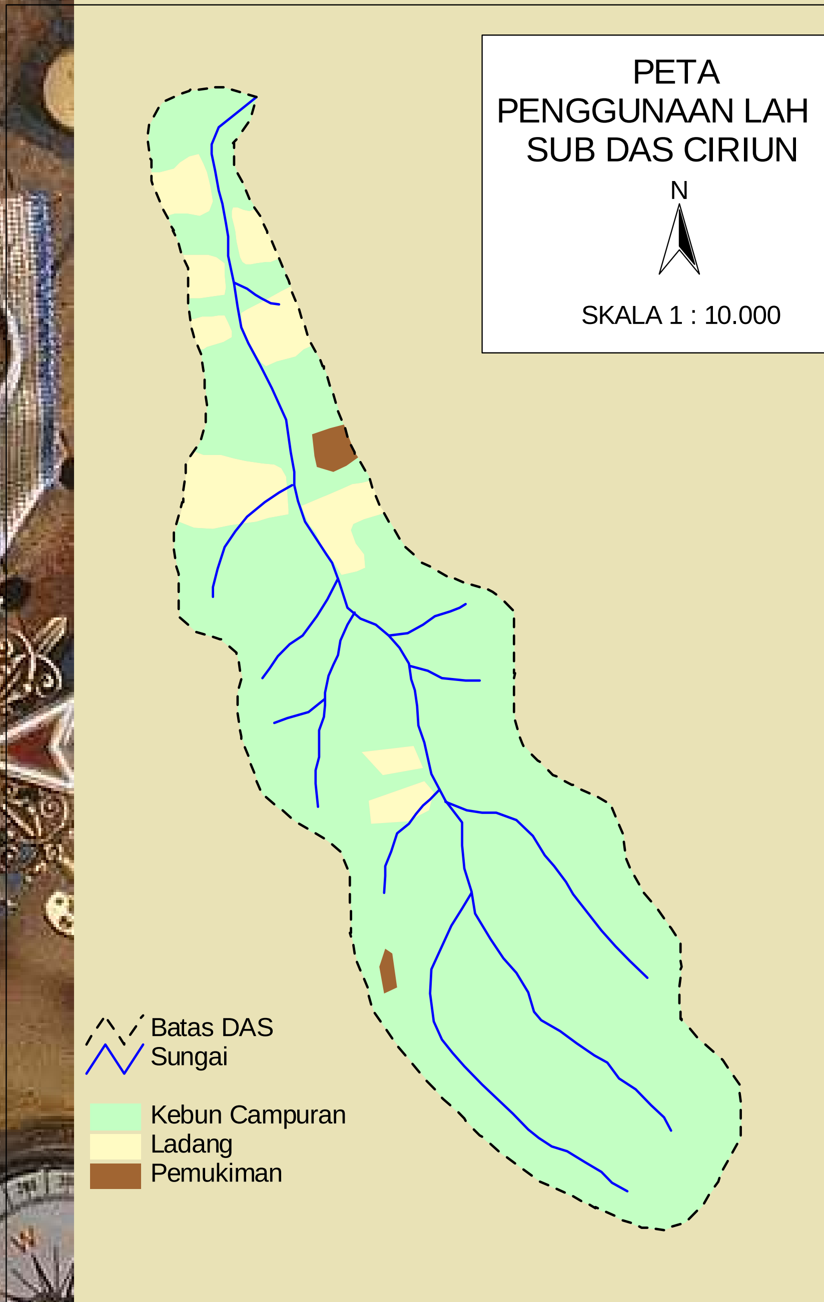


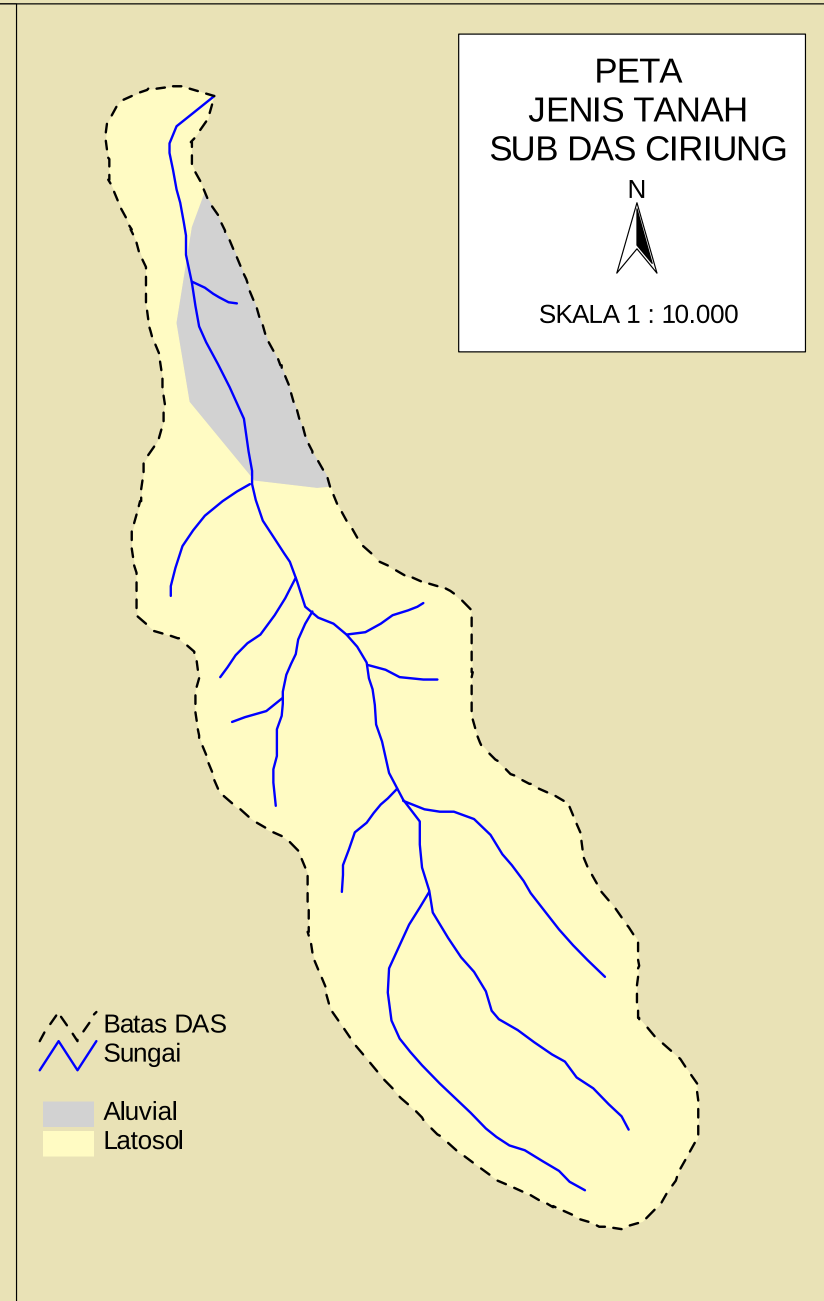

PETA
TOPOGRAFI
SUB DAS CIRIUNG
N
SKALA 1 : 10.000
100
150
200
237,5


PETA
TINGKAT ELEVASI
SUB DAS CIRIUNG
N
SKALA 1 : 10.000
Batas DAS
Sungai
Elevasi
100 - 150
150 - 200
200 - 250

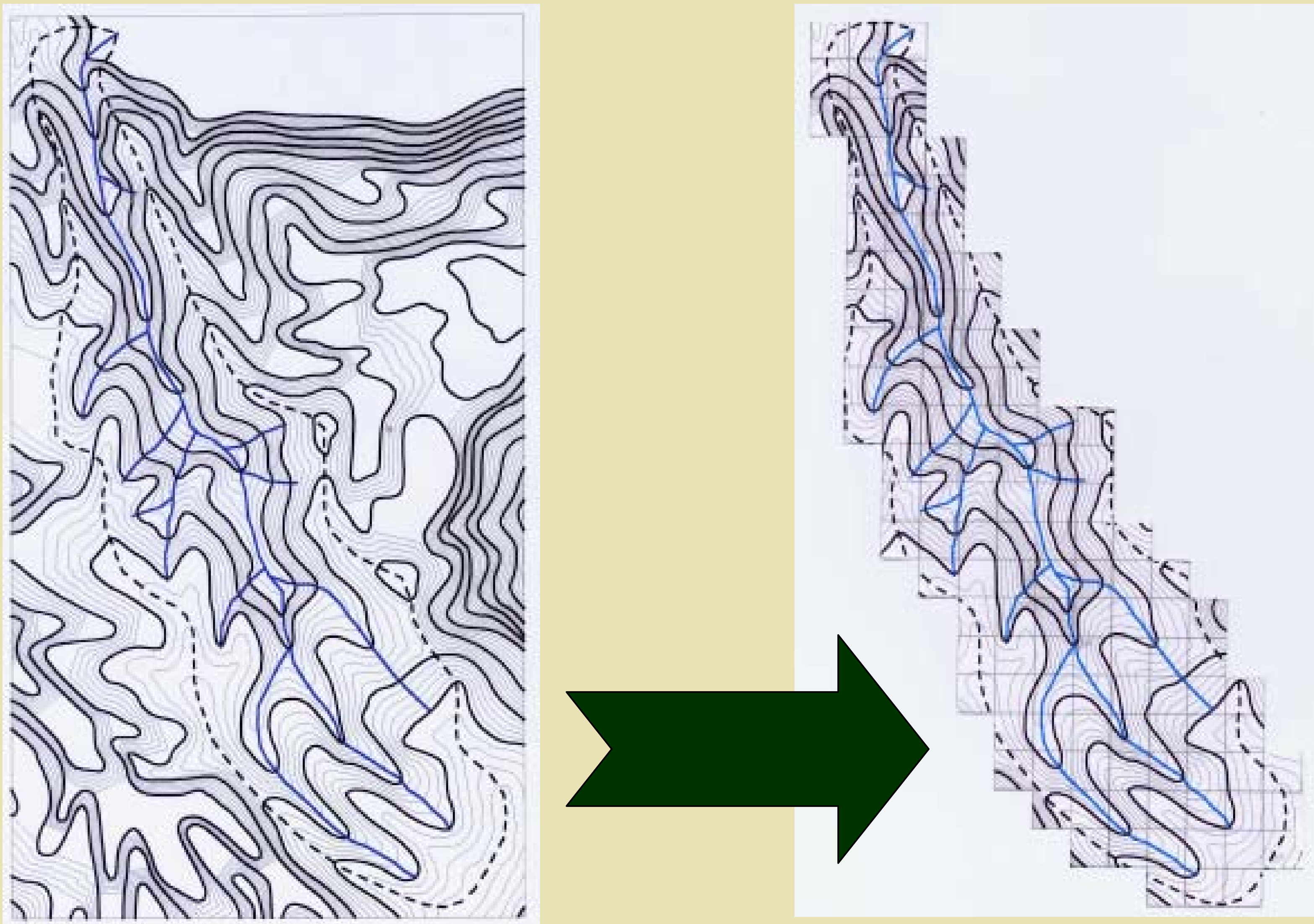

PETA
KEMIRINGAN LERENG
SUB DAS CIRIUNG
N
SKALA 1 : 10.000
Batas DAS
Sungai
0 - 8 %
8 - 15 %
15 - 25 %
25 - 45 %
> 45 %


PETA
ARAH ALIRAN
SUB DAS CIRIUNG
N
SKALA 1 : 10.000
Batas DAS
Sungai
Arah aliran
0 - 90
90 - 180
180 - 270
270 - 360

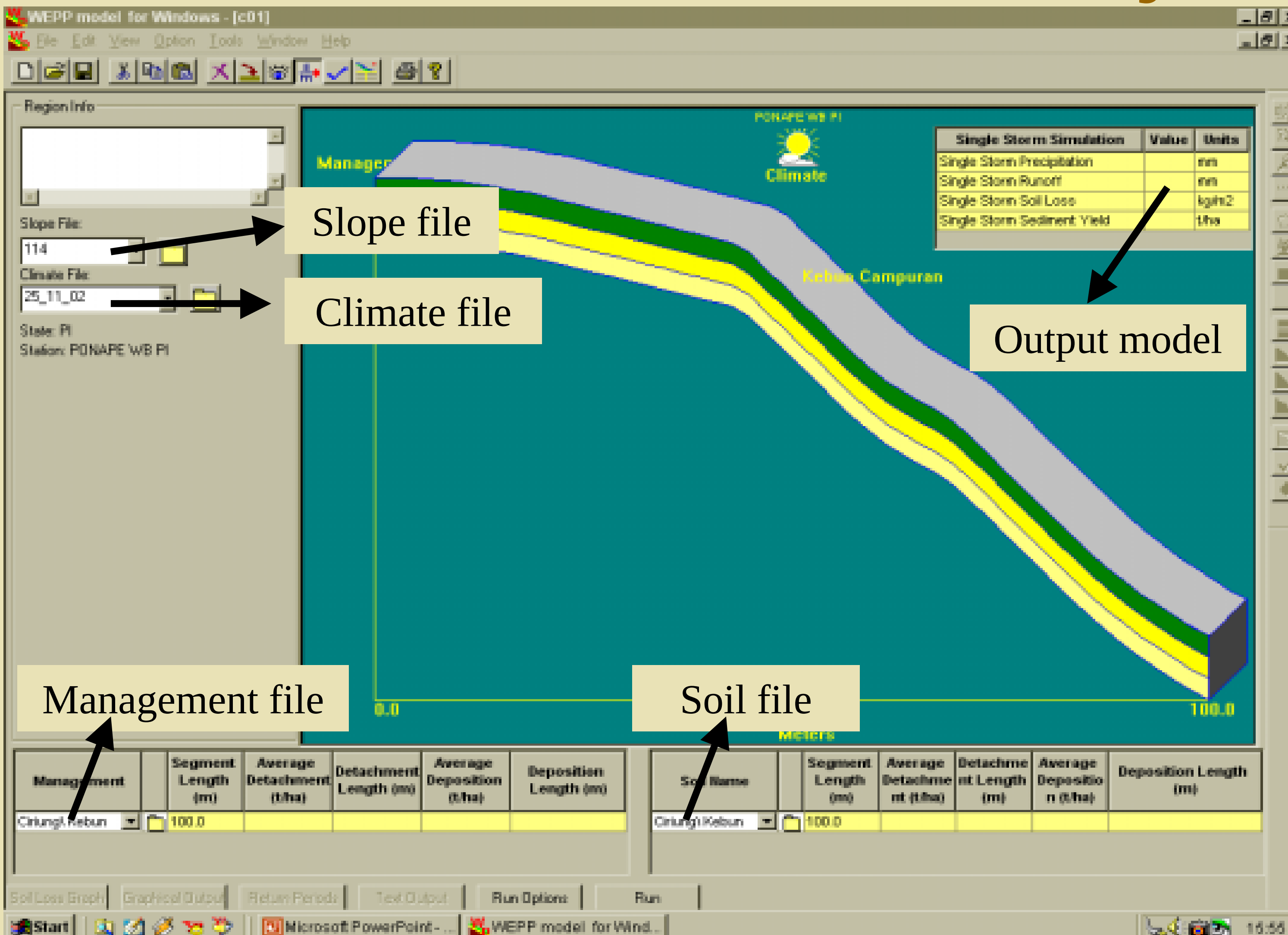

PETA
PENGGUNAAN LAH
SUB DAS CIRIUN
N
SKALA 1 : 10.000
Batas DAS
Sungai
Kebun Campuran
Ladang
Pemukiman


PETA
JENIS TANAH
SUB DAS CIRIUNG
N
SKALA 1 : 10.000
Batas DAS
Sungai
Aluvial
Latosol

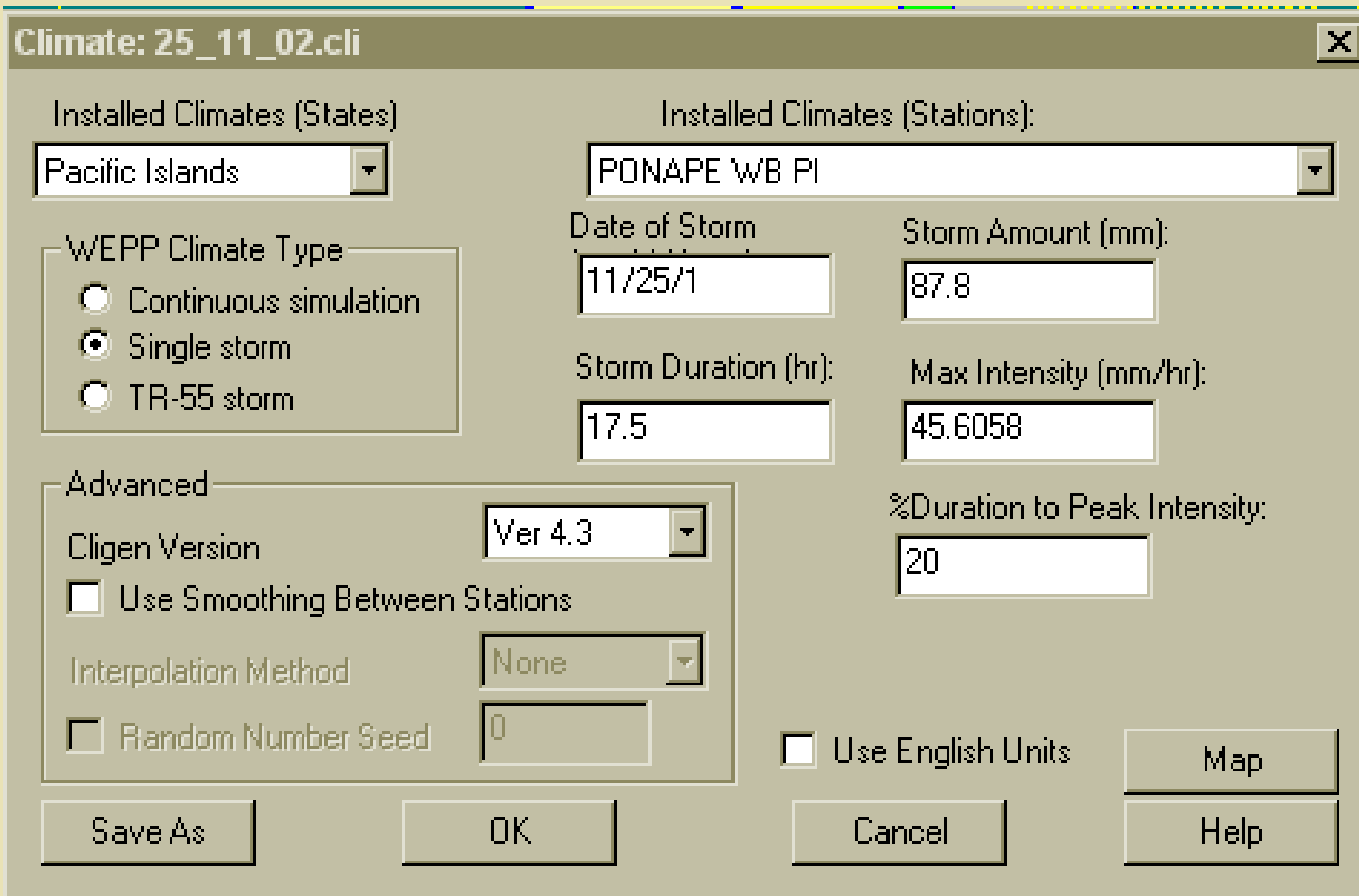
GRID VERSION



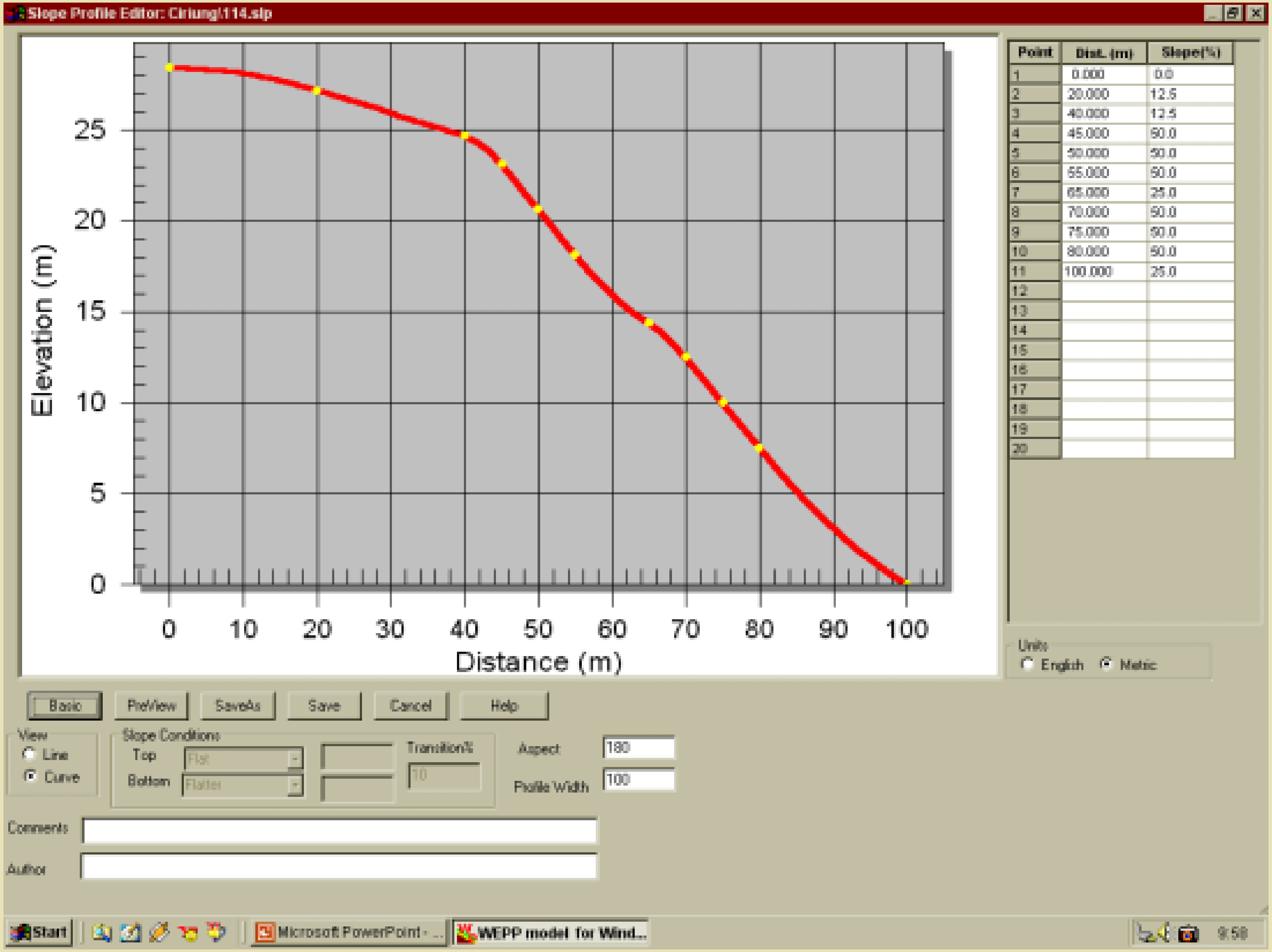
Water Erosion Prediction Project



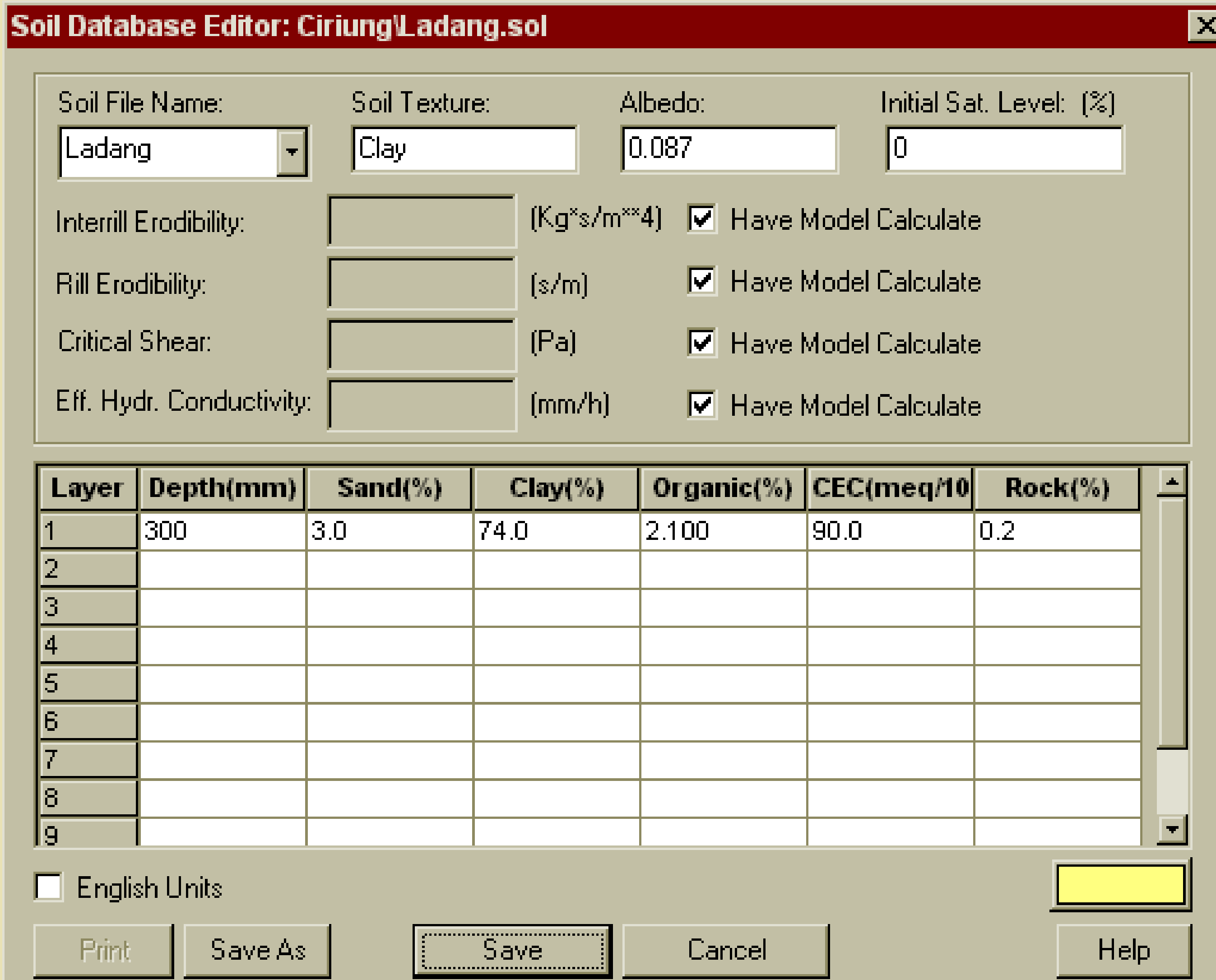
CLIMATE FILE



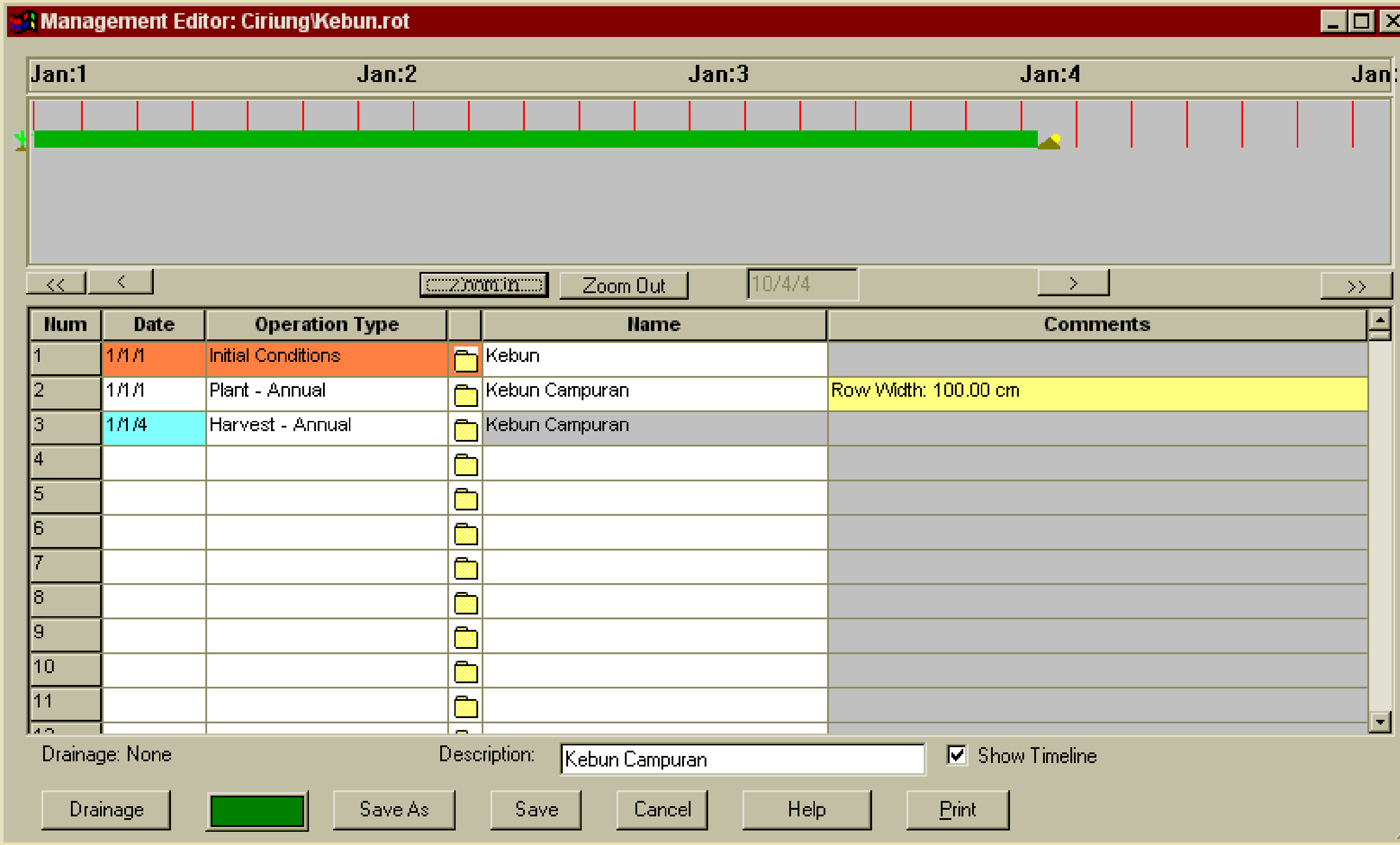
SLOPE FILE


Slope Profile Editor: Ciriung\114.slp
Elevation (m)
25
20
15
10
5
0
0
10
20
30
40
50
60
70
80
90
100
Distance (m)
Point
Dist. (m)
Slope(%)
1 0.000 0.0
2 20.000 12.5
3 40.000 12.5
4 45.000 50.0
5 50.000 50.0
6 55.000 50.0
7 65.000 25.0
8 70.000 50.0
9 75.000 50.0
10 80.000 50.0
11 100.000 25.0
12
13
14
15
16
17
18
19
20
Units
English
Metric
Basic
PreView
SaveAs
Save
Cancel
Help
View
Line
Curve
Slope Conditions
Top
Flat
Bottom
Flatter
Transition%
10
Aspect
180
Profile Width
100
Comments
Author
Start
Microsoft PowerPoint - ...
WEPP model for Wind...
9:58

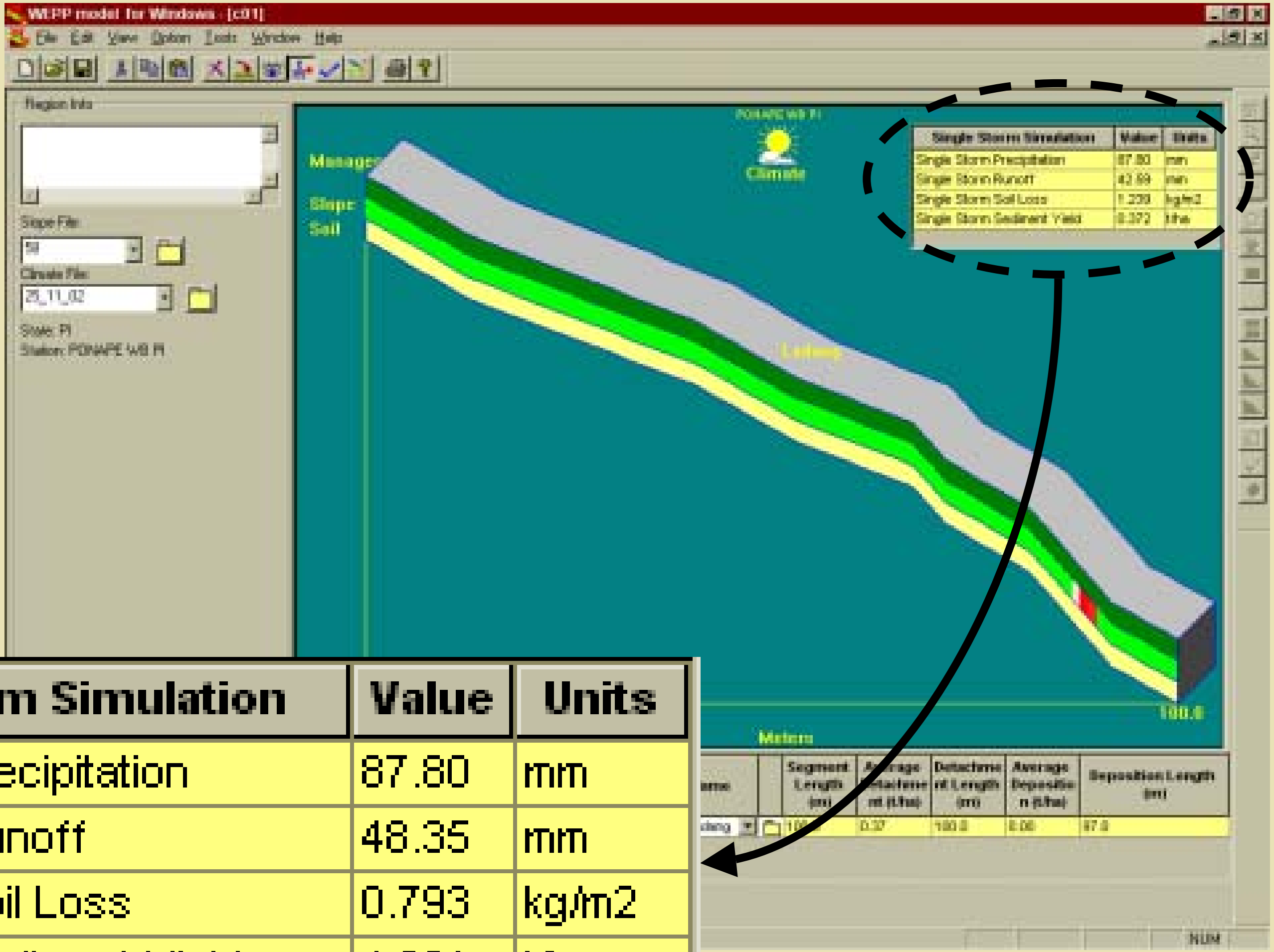
SOIL FILE


Soil Database Editor: Ciriung\Ladang.sol
Soil File Name: Ladang
Soil Texture: Clay
Albedo: 0.087
Initial Sat. Level: (%) 0
Interrill Erodibility: (Kg*s/m**4) Have Model Calculate
Rill Erodibility: (s/m) Have Model Calculate
Critical Shear: (Pa) Have Model Calculate
Eff. Hydr. Conductivity: (mm/h) Have Model Calculate
Layer | Depth(mm) | Sand(%) | Clay(%) | Organic(%) | CEC(meq/10 | Rock(%)
1 | 300 | 3.0 | 74.0 | 2.100 | 90.0 | 0.2
2
3
4
5
6
7
8
9
English Units
Print
Save As
Save
Cancel
Help

MANAGEMENT FILE

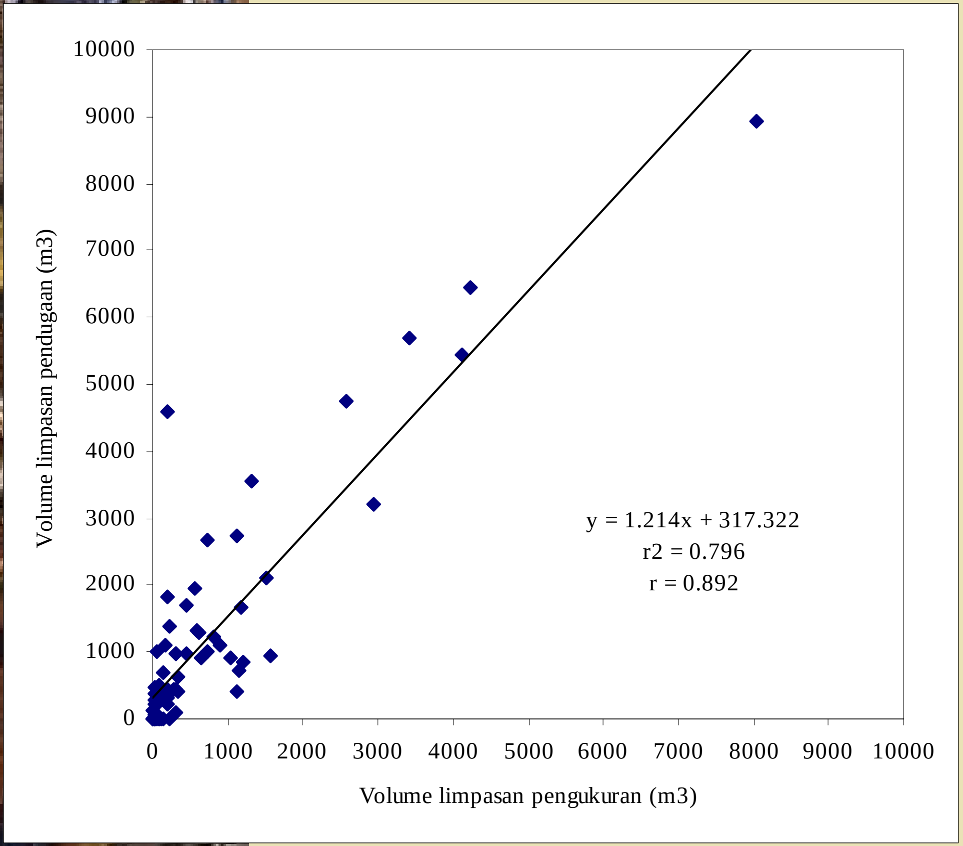


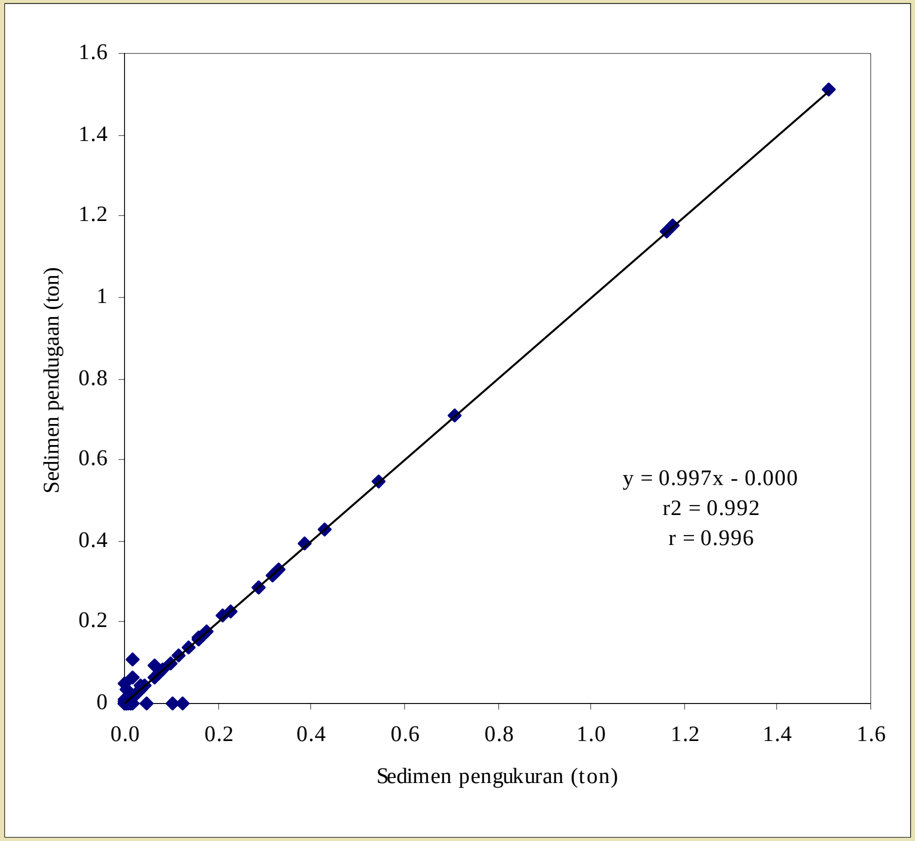
OUTPUT MODEL



Single Storm Simulation	Value	Units
Single Storm Precipitation	87.80	mm
Single Storm Runoff	48.35	mm
Single Storm Soil Loss	0.793	kg/m2
Single Storm Sediment Yield	4.601	t/ha

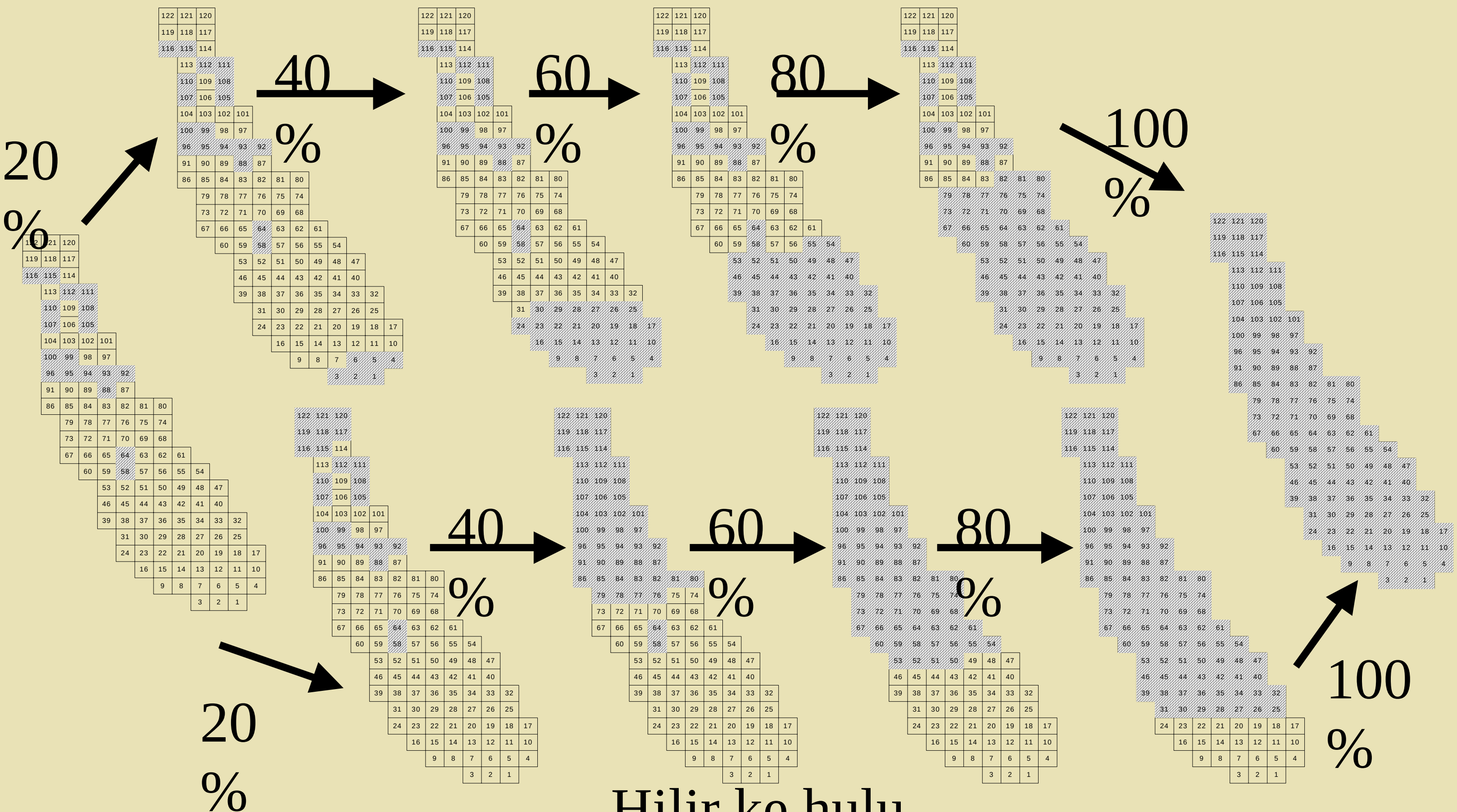
VERIFICATION





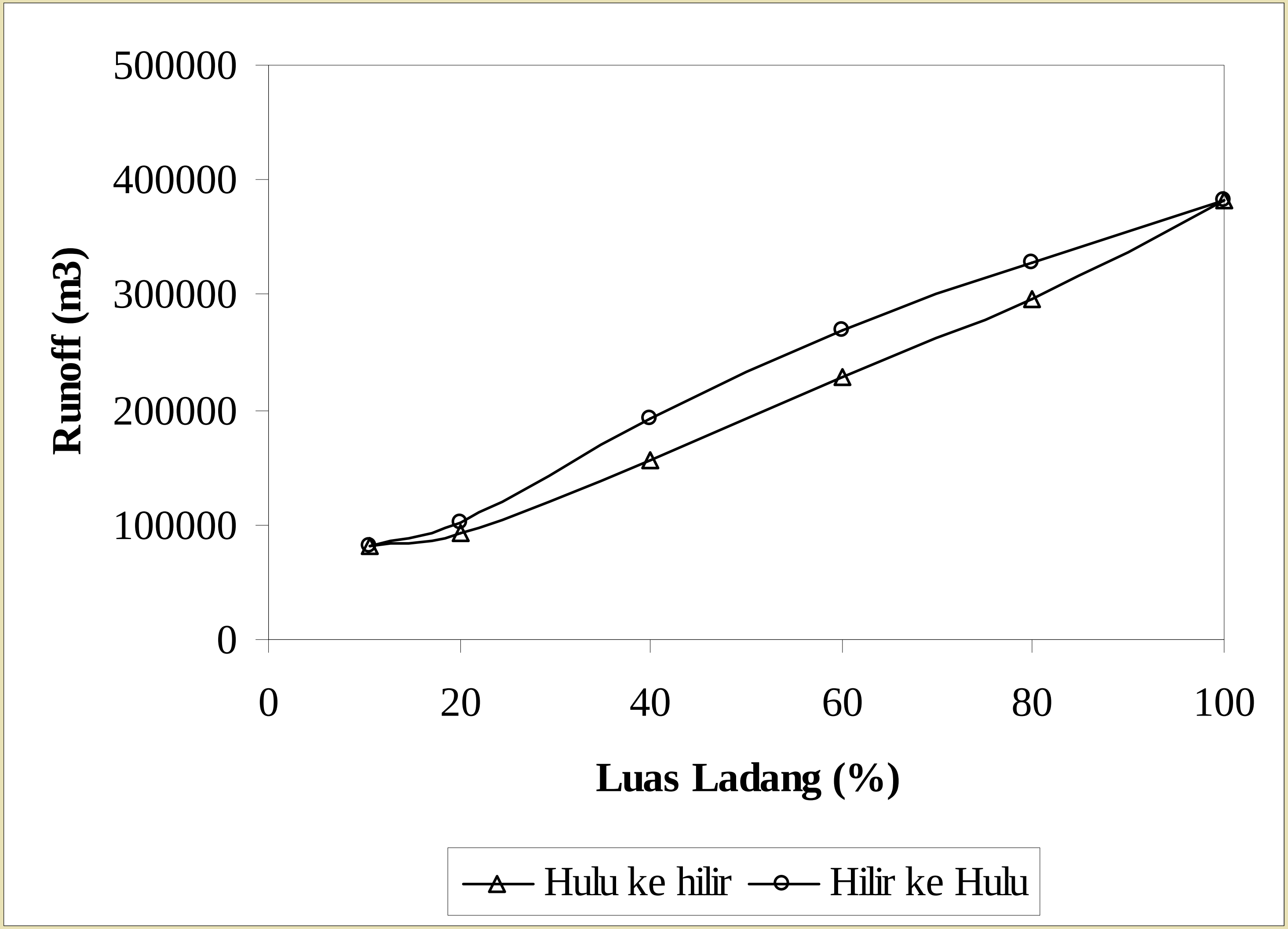
SIMULATION

Hulu ke hilir

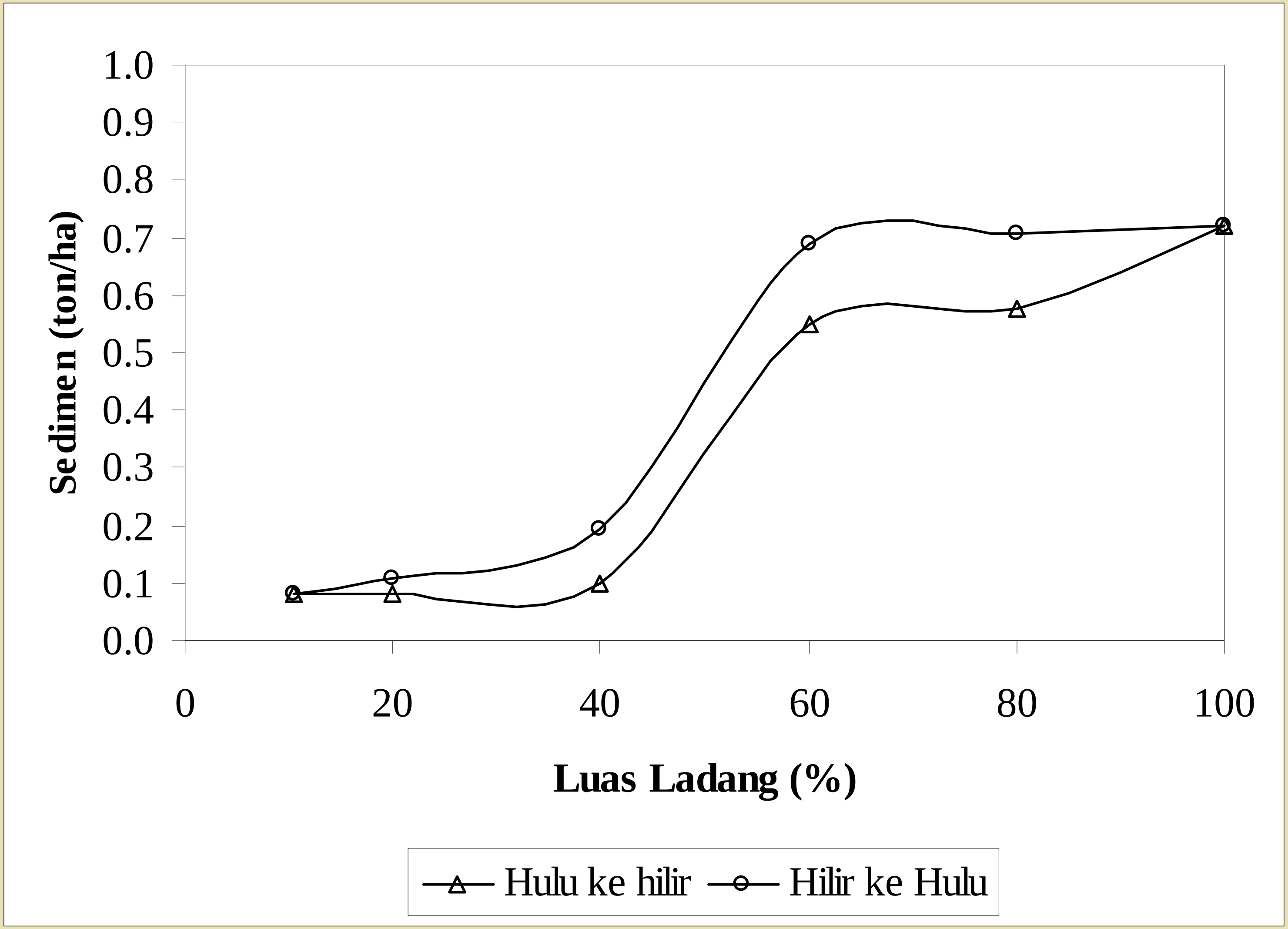


Hilir ke hulu

RESULT

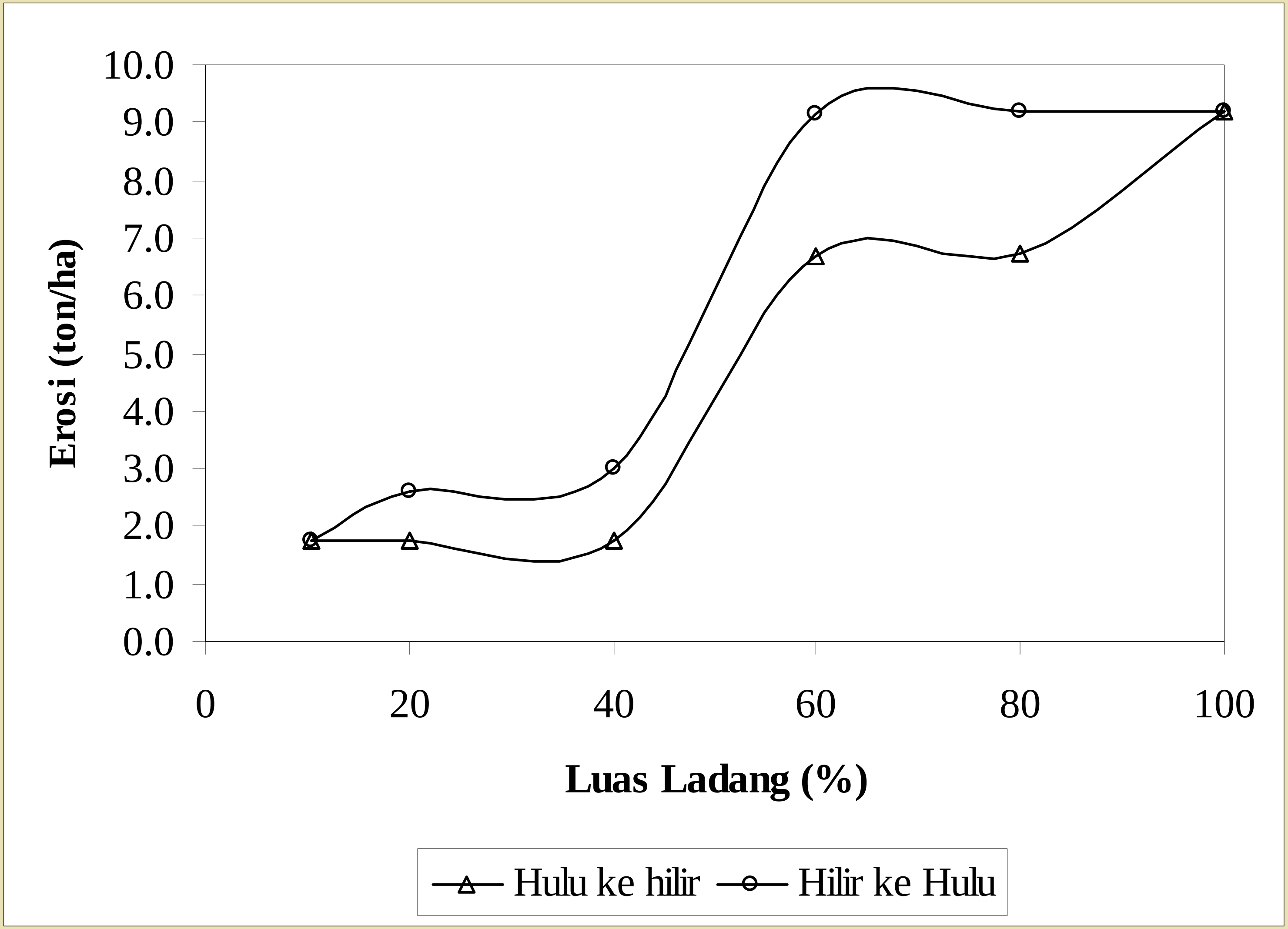

500000
400000
300000
200000
100000
0
Runoff (m3)
0
20
40
60
80
100
Luas Ladang (%)
Hulu ke hilir
Hilir ke Hulu

RESULT

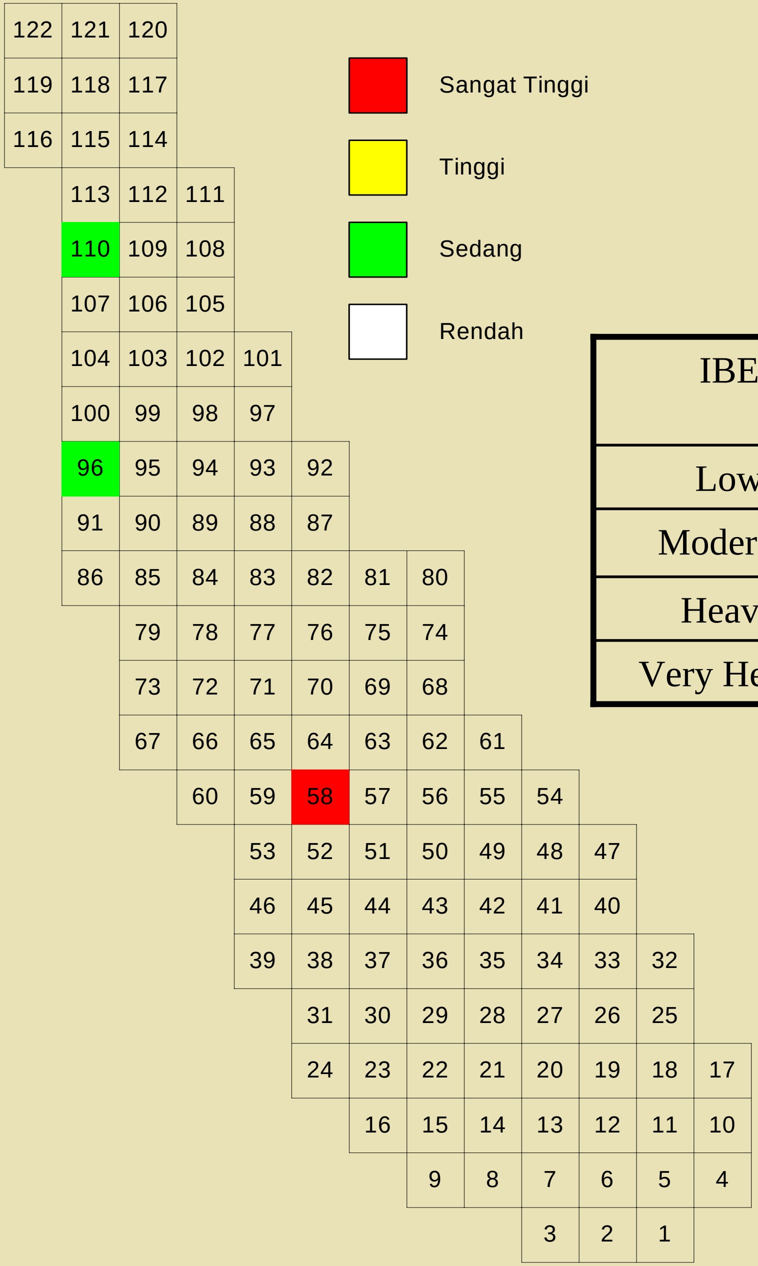


1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Sedimen (ton/ha)
0
20
40
60
80
100
Luas Ladang (%)
Hulu ke hilir
Hilir ke Hulu

RESULT



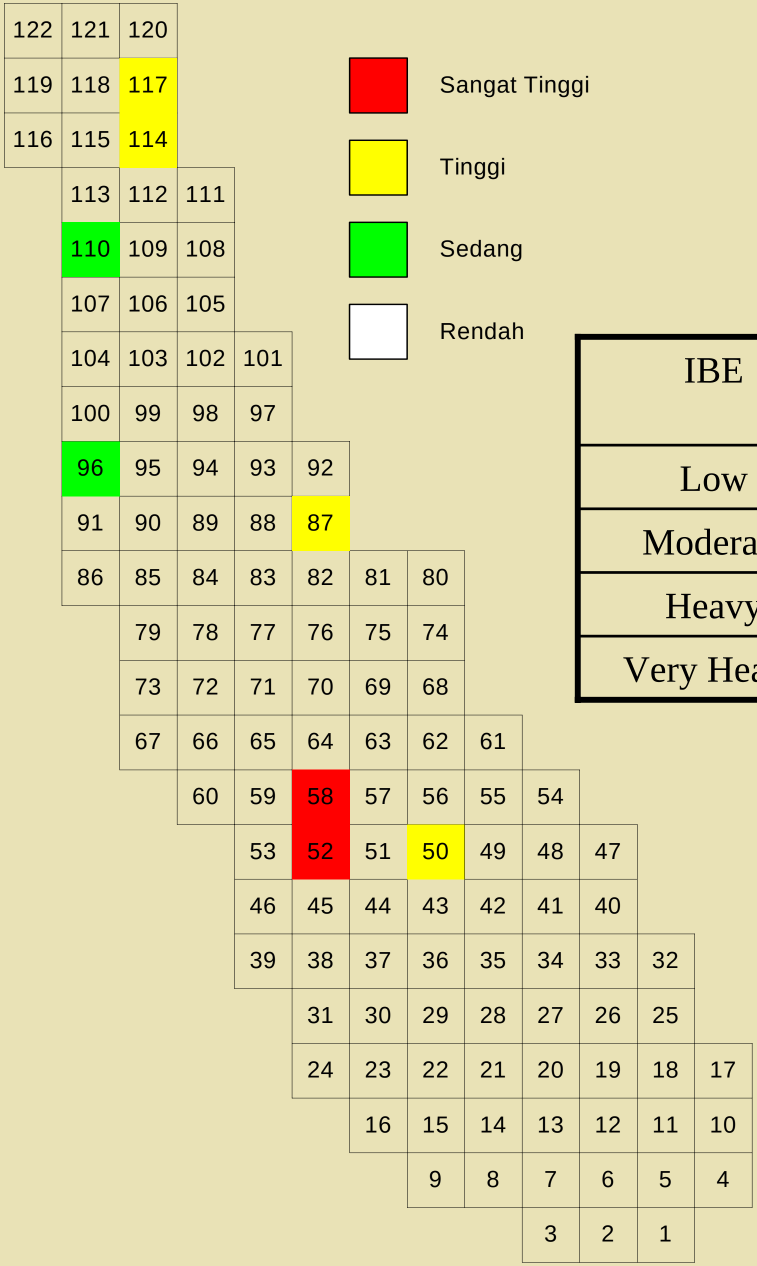
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Erosi (ton/ha)
0
20
40
60
80
100
Luas Ladang (%)
Hulu ke hilir
Hilir ke Hulu



RESULT

IBE	Grid (ha)	Runoff (m3)	Sediment (ton)	Erosion (ton)
Low	119	64659,70	2,72	2,37
Moderate	2	9920,60	1,43	60,78
Heavy	0	0	0	0
Very Heavy	1	6713,40	5,55	148,04

Existing condition



RESULT

IBE	Grid (ha)	Runoff (m3)	Sediment (ton)	Erosion (ton)
Low	114	342754,30	13,90	12,16
Moderate	2	9920,60	1,43	60,78
Heavy	4	18778,95	20,82	425,58
Very Heavy	2	11797,20	51,91	622,02

Un-irrigated 100%

CONCLUSION

- WEPP model is very accurate to predict sediment (r = 0.996) and runoff (r = 0,892), so it can use to predict erosion.
- The factors influence erosion, sedimentation and runoff are :
  - Initial Interrill Cover (%)
  - Initial Rill Cover (%)
  - Initial Roughness After Last Tillage
  - Rill Spacing (cm)
  - Initial Saturation Level (%)
- WEPP model can identify the land as source of erosion and sediment


THANK YOU VERY MUCH

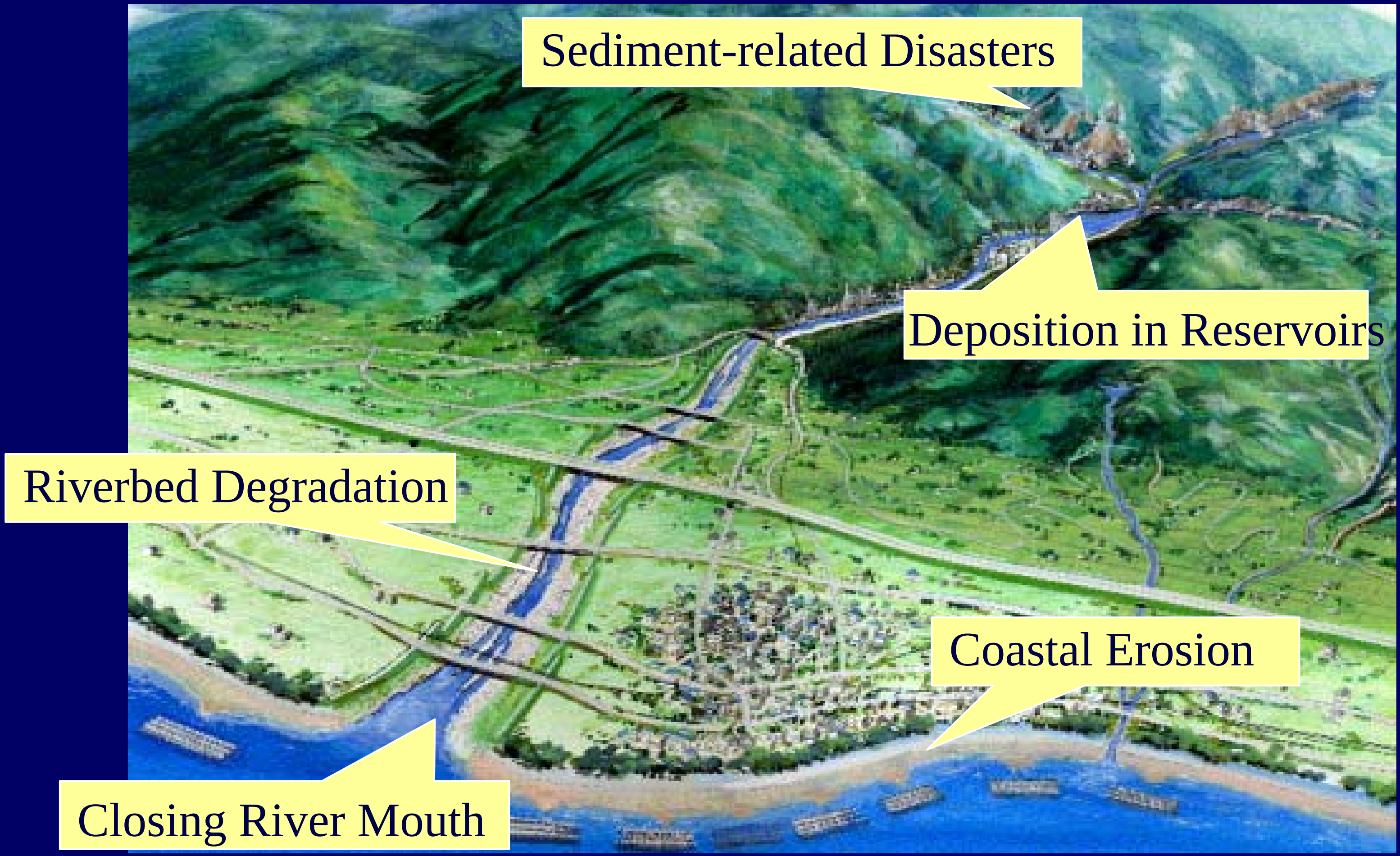
First International Workshop on Water and Sediment Management in Brantas River Basin

Assessing the sediment sources of deposited sediment in reservoirs using sediment tracer techniques

Nobutomo OSANAi, Tomoyuki NORO and Taro UCHIDA

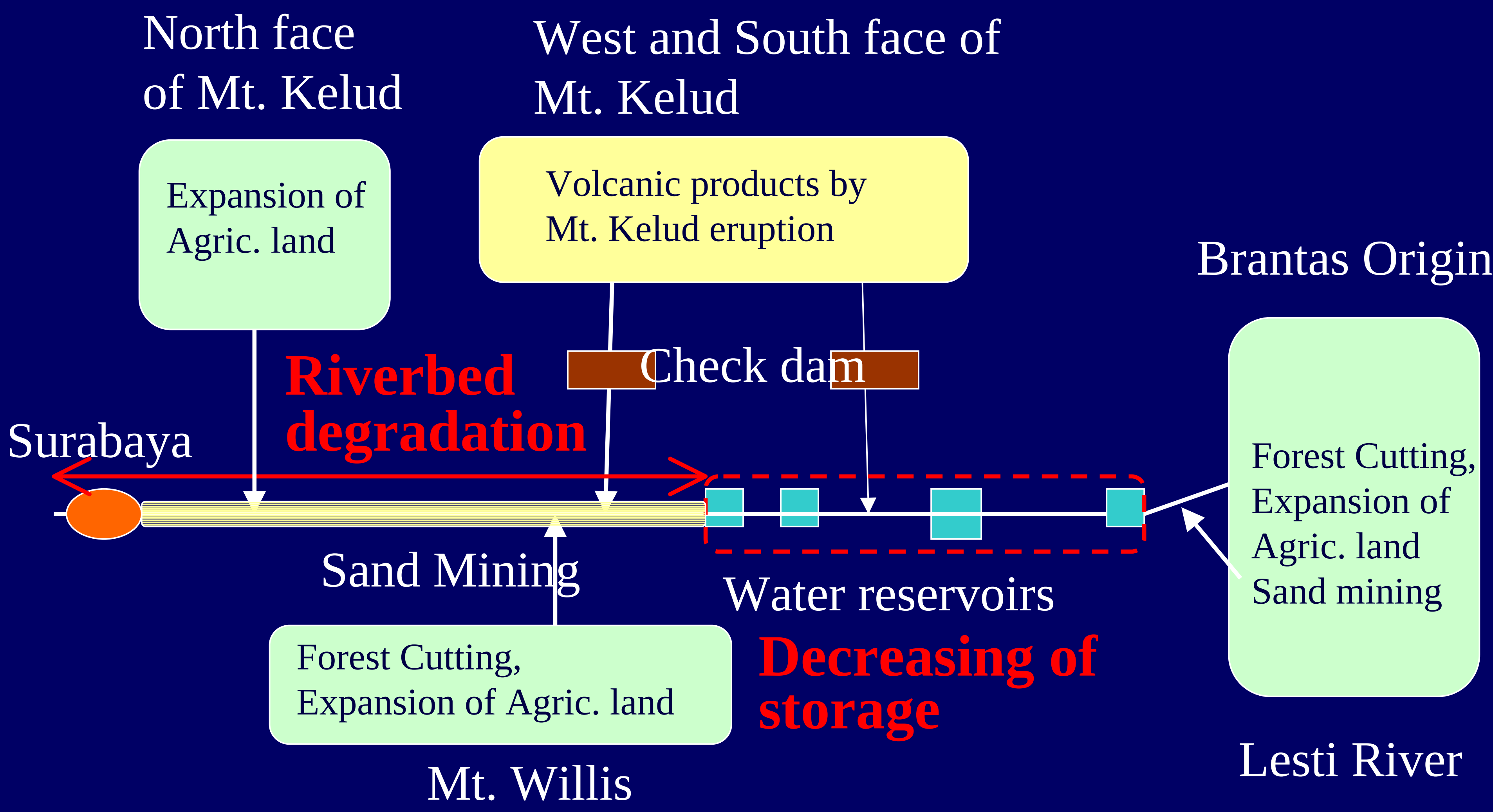
National Institute for Land and Infrastructure Management, Ministry of Land, Infrastructure and Transport, Japan

Sediment dynamics in River basin



These issues are strongly related to each other

Issues in Brantas



Both natural condition and human activity gave large impacts on “sediment dynamics” in River Basin

Clarification of sediment dynamics

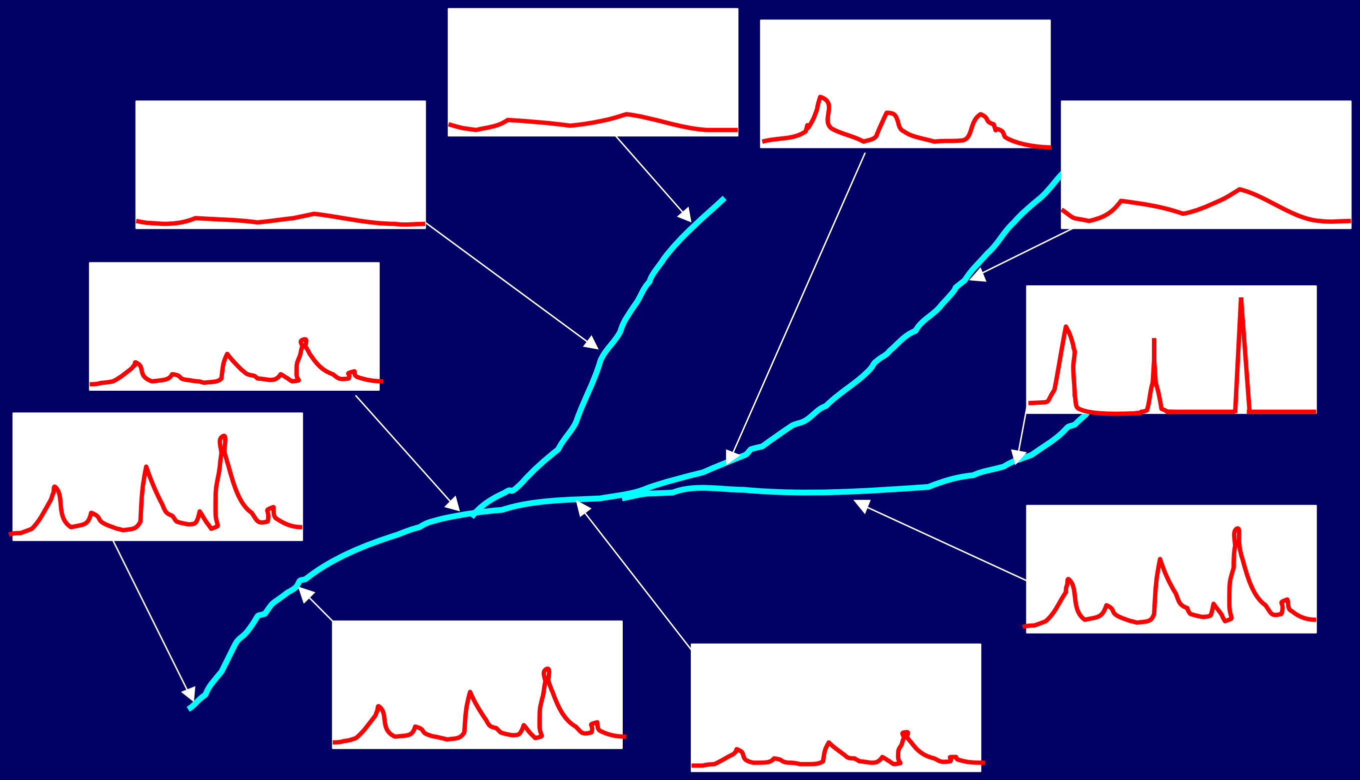
Field measurements and experiments

Modeling and numerical simulation

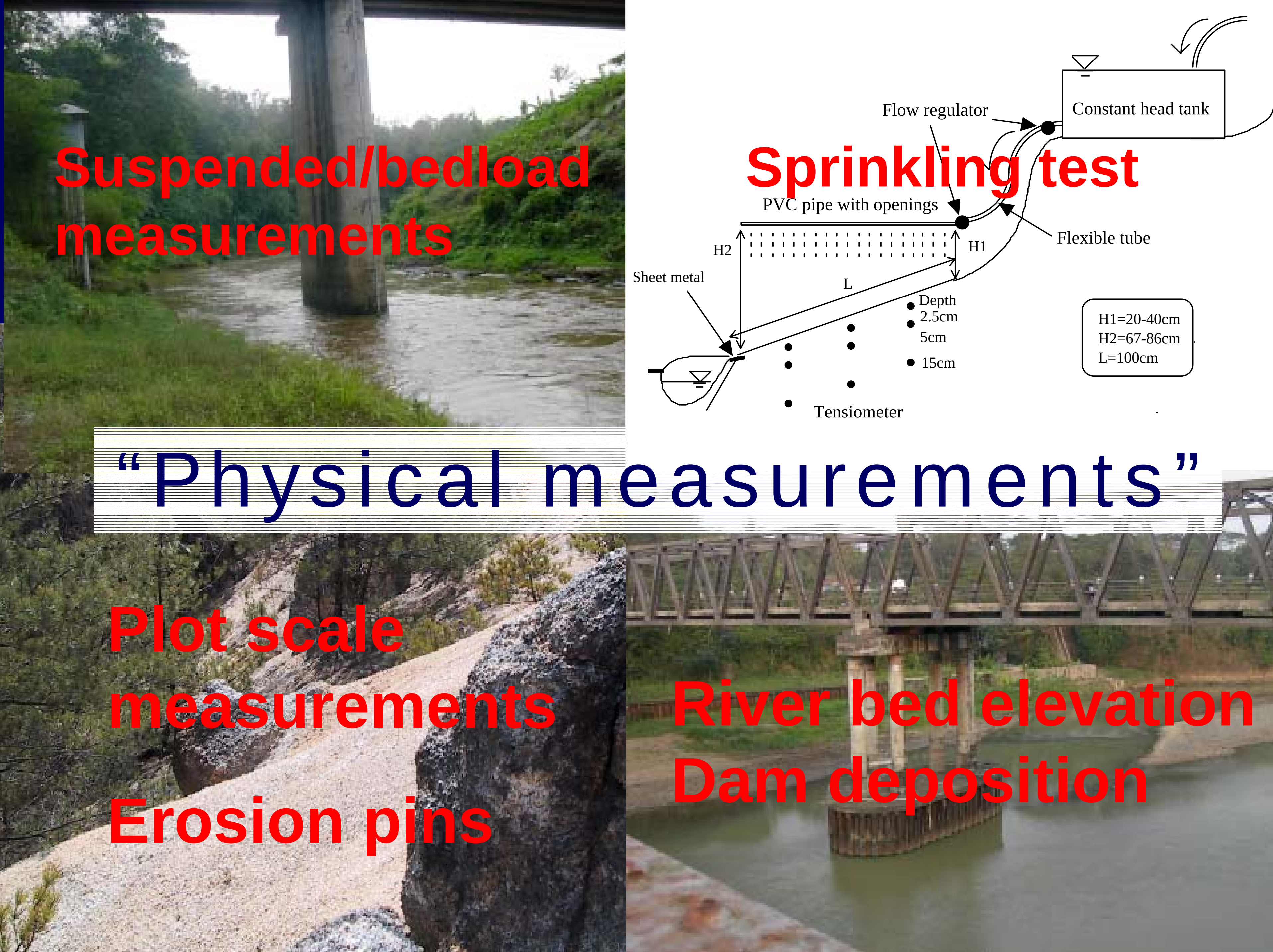
Information about model structure/parameter value
Validation of results

Extrapolation of field results

Numerical simulation

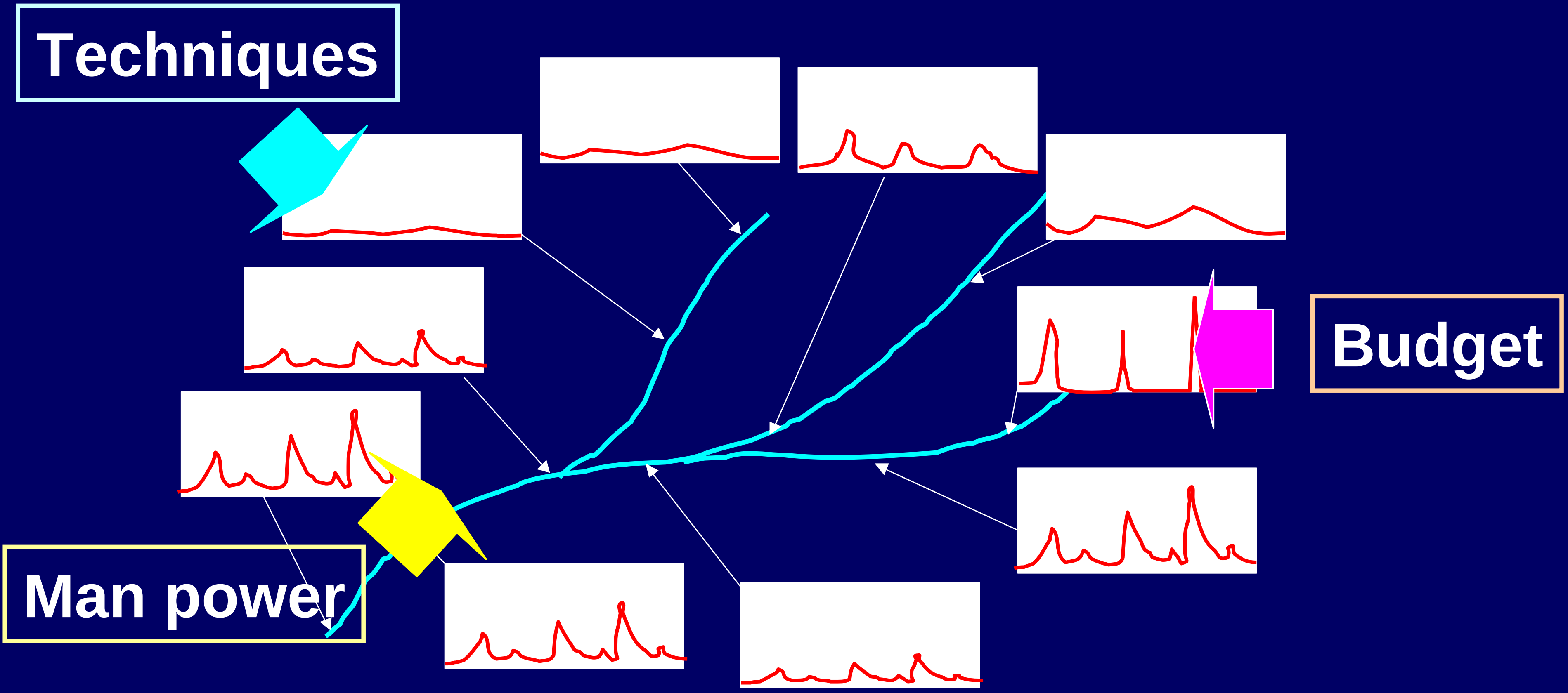


We can calculate (1) spatial variation,
(2) long-term data
(3) fine time resolution data

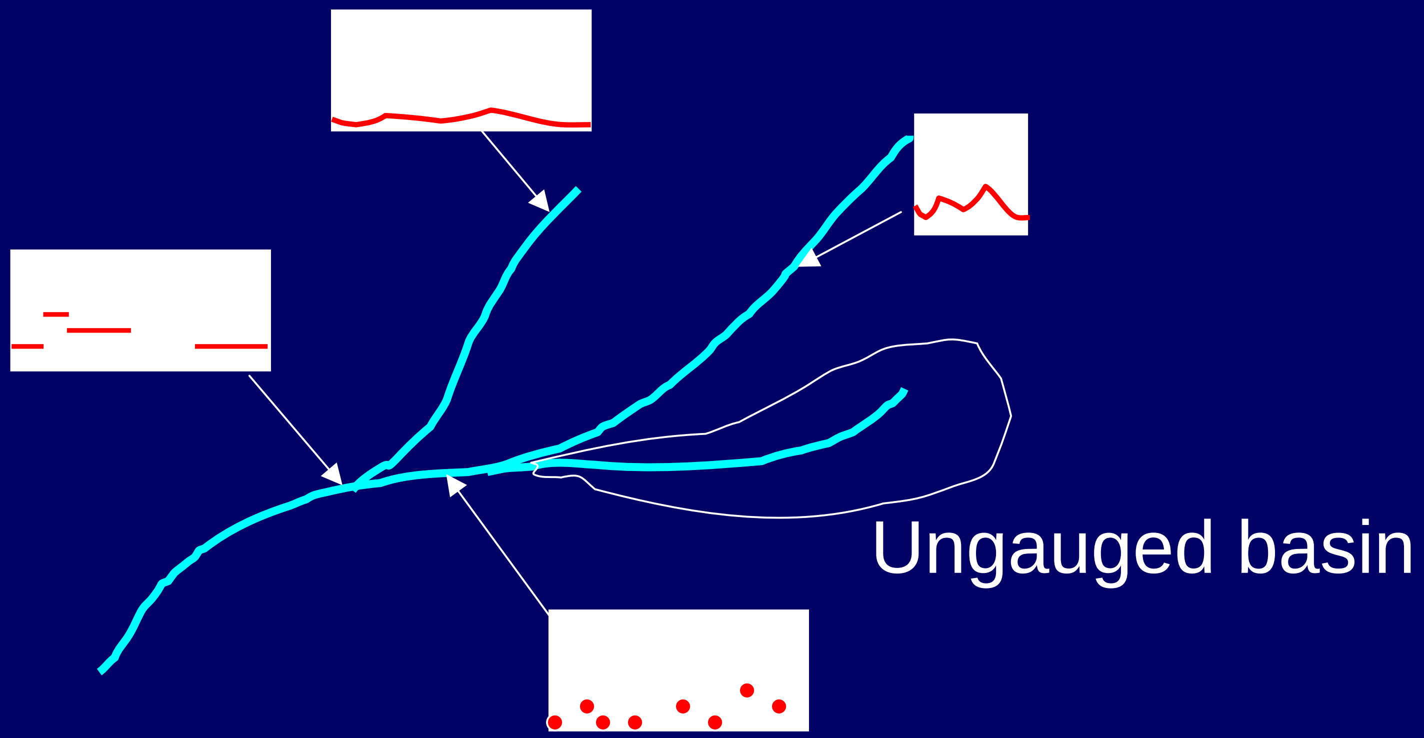


Suspended/bedload measurements
Sprinkling test
Constant head tank
Flow regulator
PVC pipe with openings
Flexible tube
H2
H1
Sheet metal
L
Depth
2.5cm
5cm
15cm
Tensiometer
H1=20-40cm
H2=67-86cm
L=100cm
"Physical measurements"
Plot scale measurements
Erosion pins
River bed elevation
Dam deposition

Physical Measurements



Physical Measurements



Usually we can observe

(1) several points in the basin,

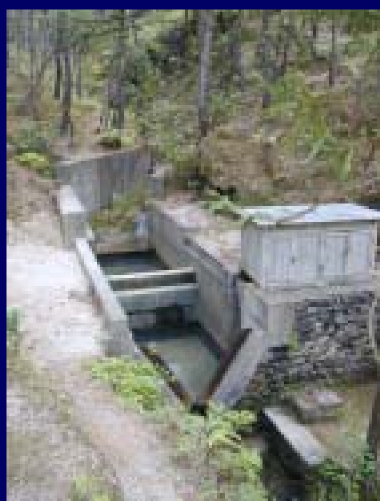
(2) part of sediment (suspended load)

(3) short/mid-term data (<10 years)

(4) coarse time resolution data

Gaps between model and physical measurements

Physical measurements ***Numerical simulation***

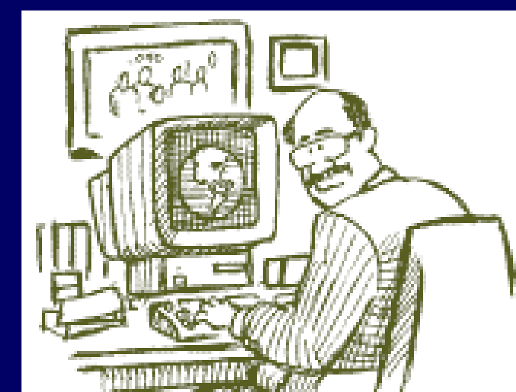


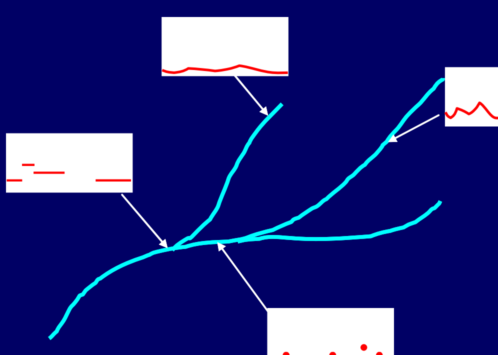
Period

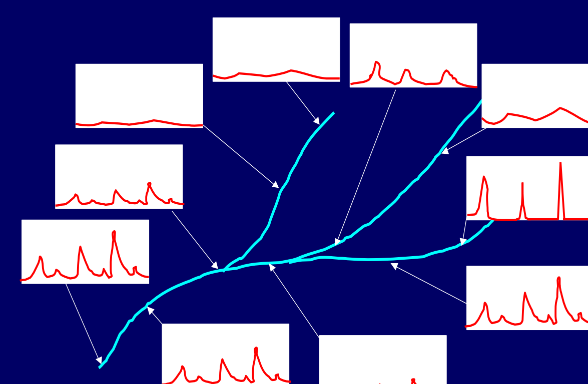
Temporal resolution

Spatial resolution

Grain size







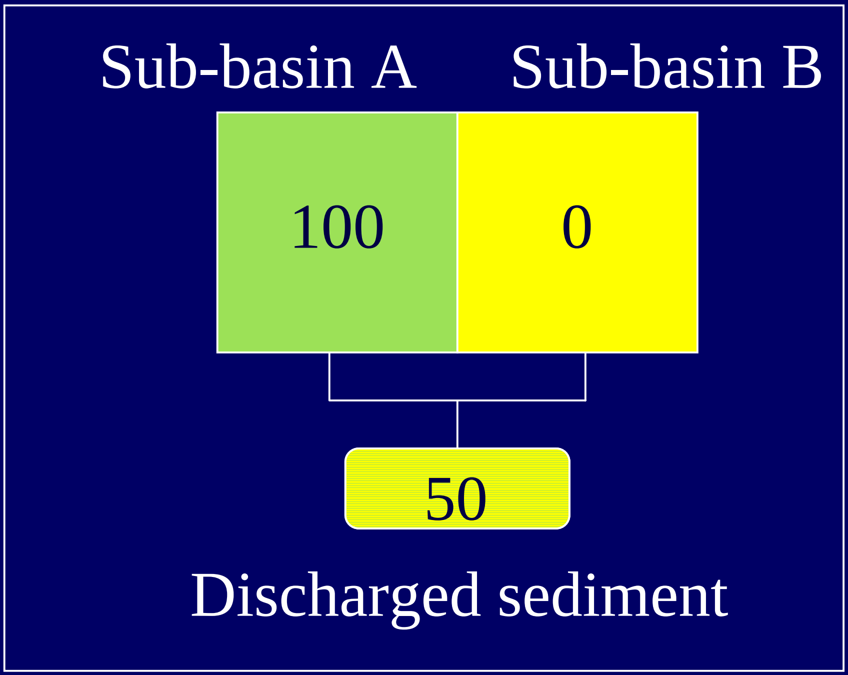
Other information?

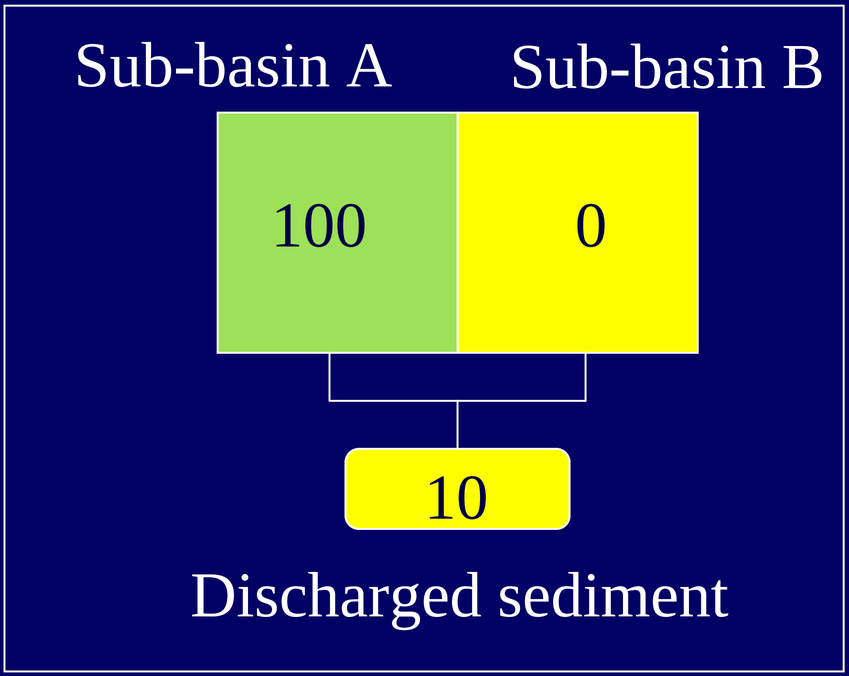
- Fingerprints of sediment
  - Grain size distribution
  - Organic contents
  - Geochemistry
  - Mineral magnetic
  - Radioisotope →

Grain size distribution, Organic contents, Geochemistry, Mineral magnetic } **source of sediment**

Radioisotope → {
source of sediment
net (ca. 40 years) soil flux
Erosion/deposition pattern

Why fingerprints of sediment is helpful?





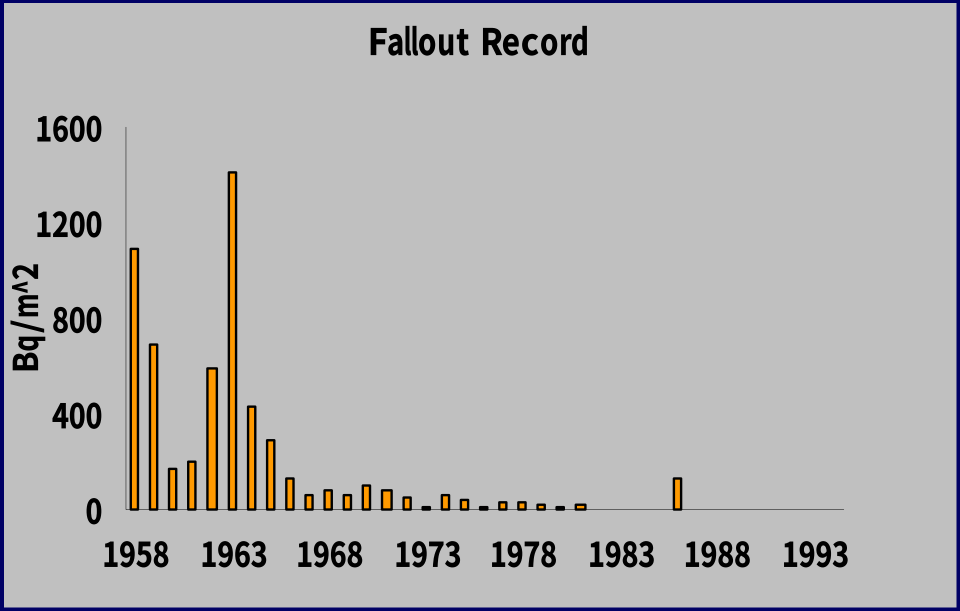
If there are any spatial variability in these tracers

<u>These tracers have used for quantifying source of sediment</u>

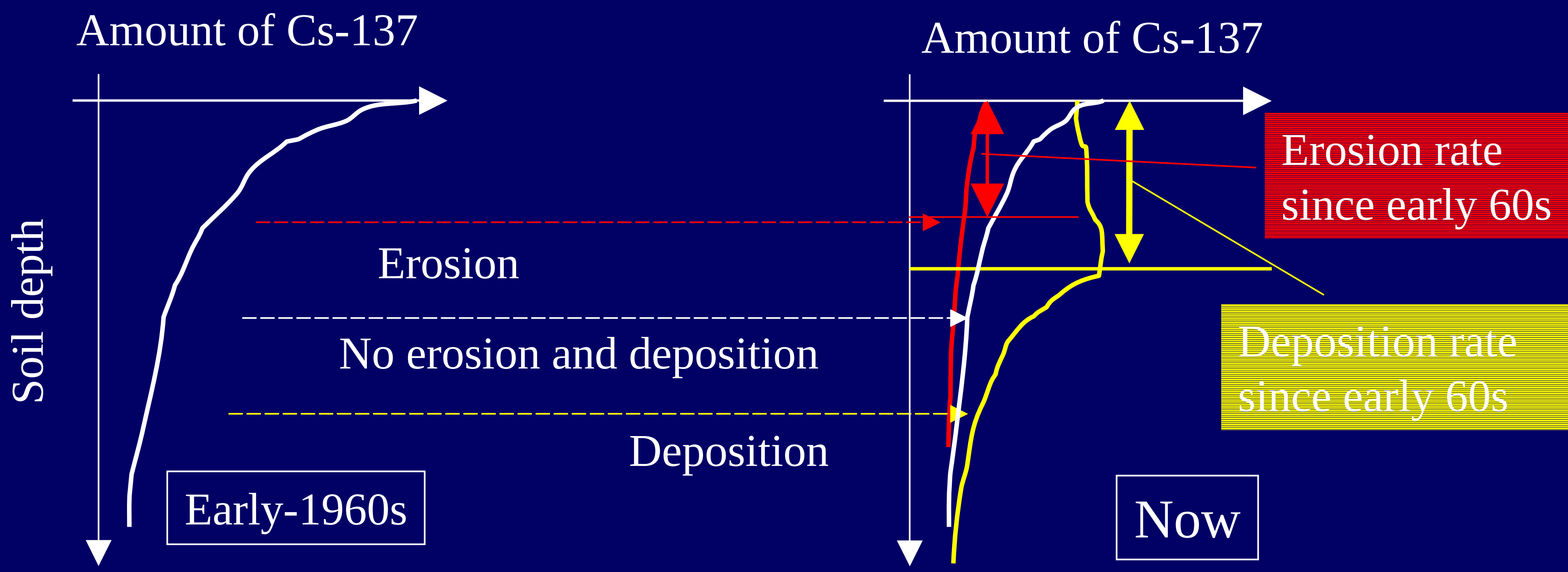
Fundamentals of Cs-137

Half life 30.2 years
Produced by nuclear weapon tests
Fallout in association with precipitation
Strong and rapid adsorption by soil

After the initial adsorption of Cs-137, all subsequent vertical and lateral redistribution occurs in association with erosion, transport and deposition of soil particles.



Profile in soil layer



<u>Cs-137 have used for estimating net (ca. 40 years) soil flux</u>

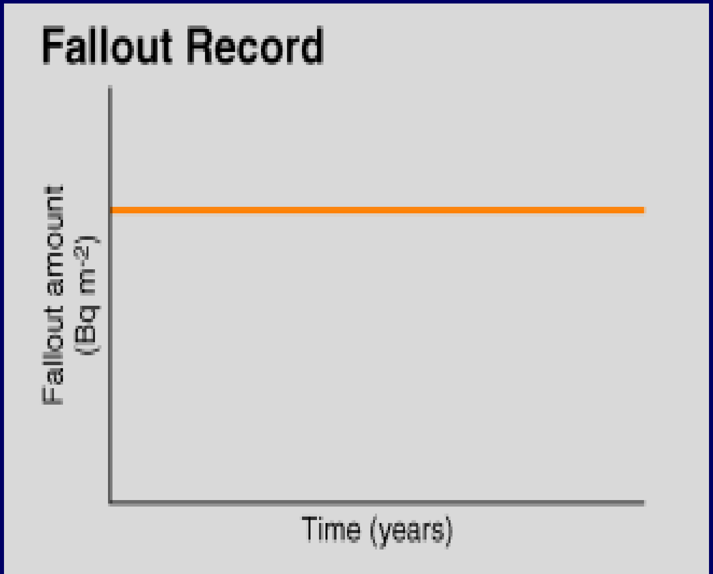
Fundamentals of Pb-210

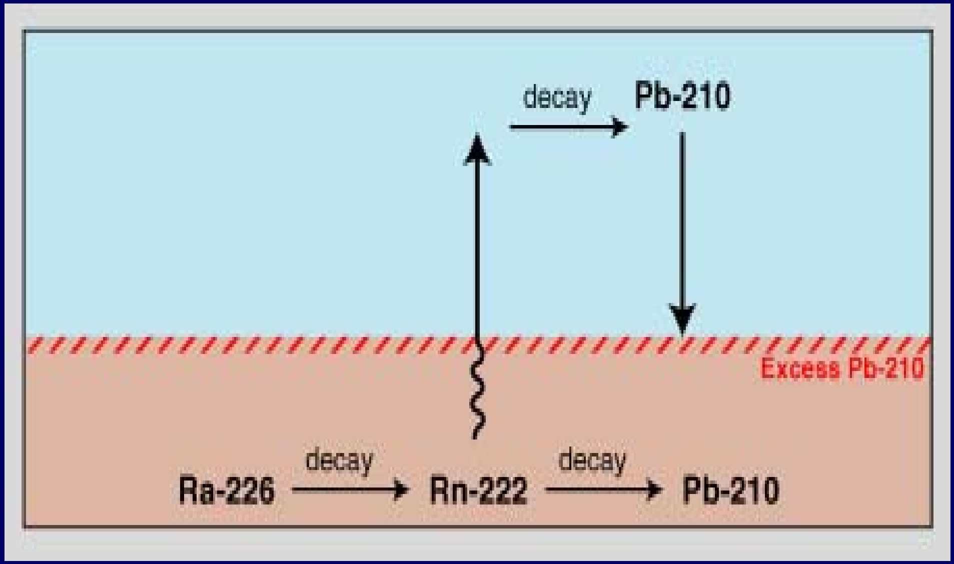
Half life 22 years

Fallout in association with precipitation

Strong and rapid adsorption by soil

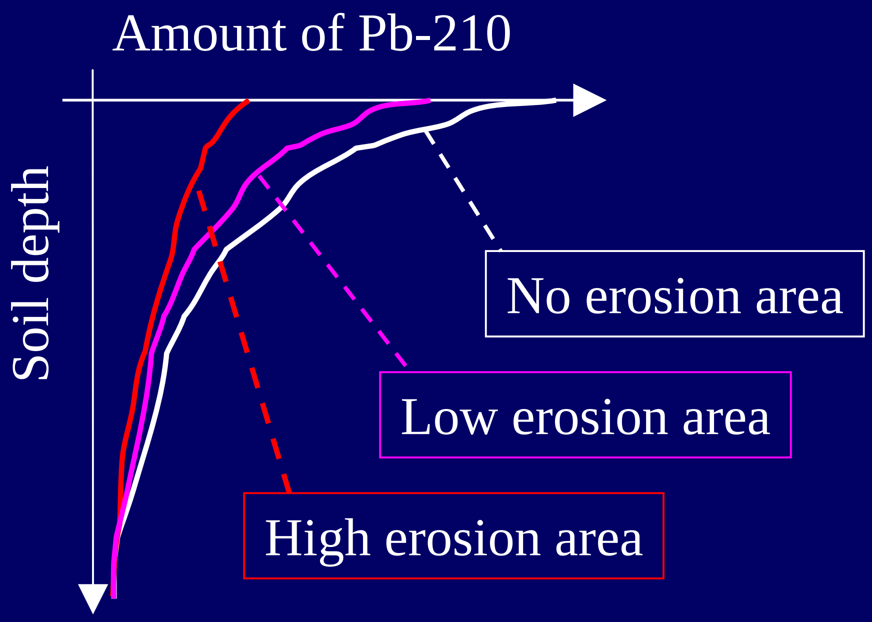
Naturally produced

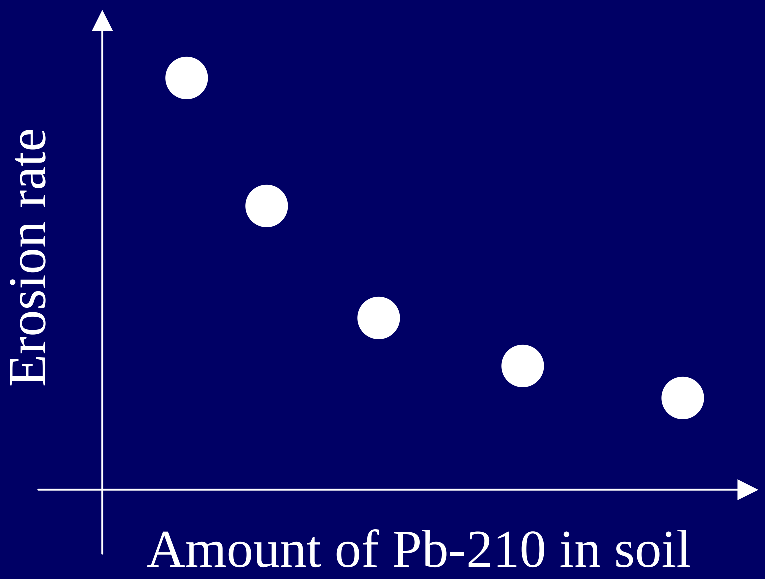




After the initial adsorption of Pb-210, all subsequent vertical and lateral re-distribution occurs in association with erosion, transport and deposition of soil particles.

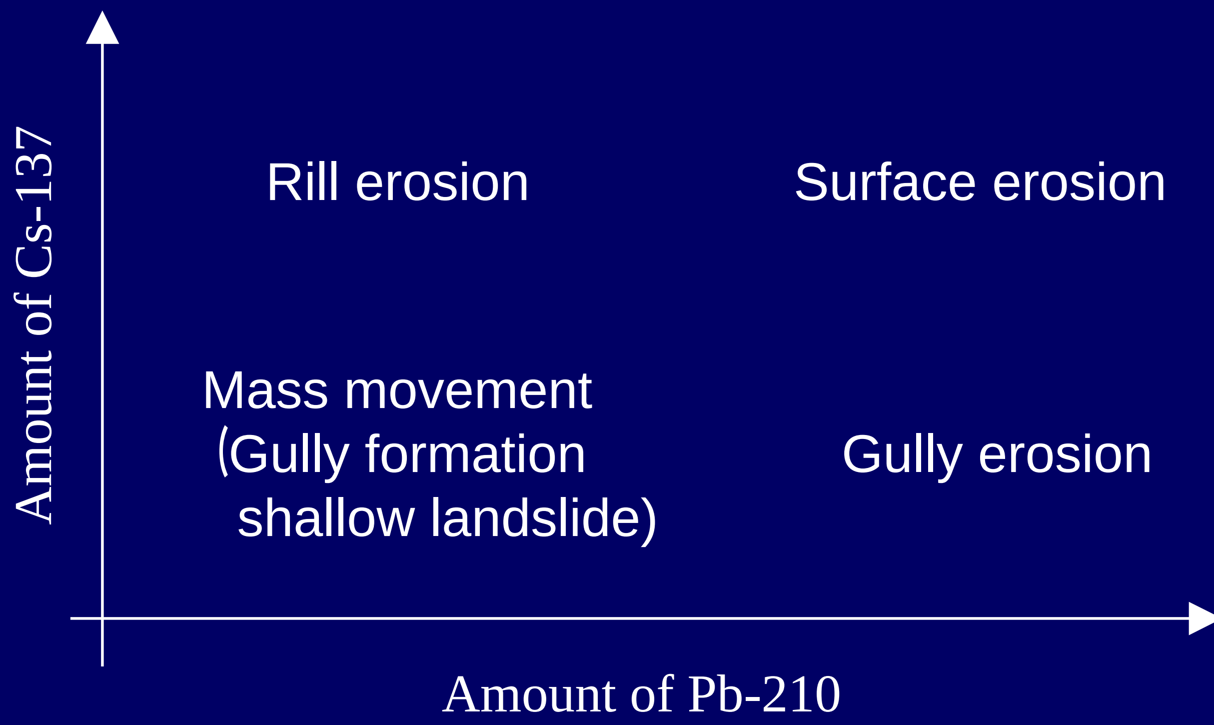
Profile in soil layer





<u>Pb-210 have used for estimating net (ca. 40 years) soil flux</u>

Discharged sediment



<u>Both Cs-137 and Pb-210 have used for clarify the source of sediment and erosion processes</u>

Potential usefulness to problems in Brantas

Quantifying source of sediment in Reservoirs

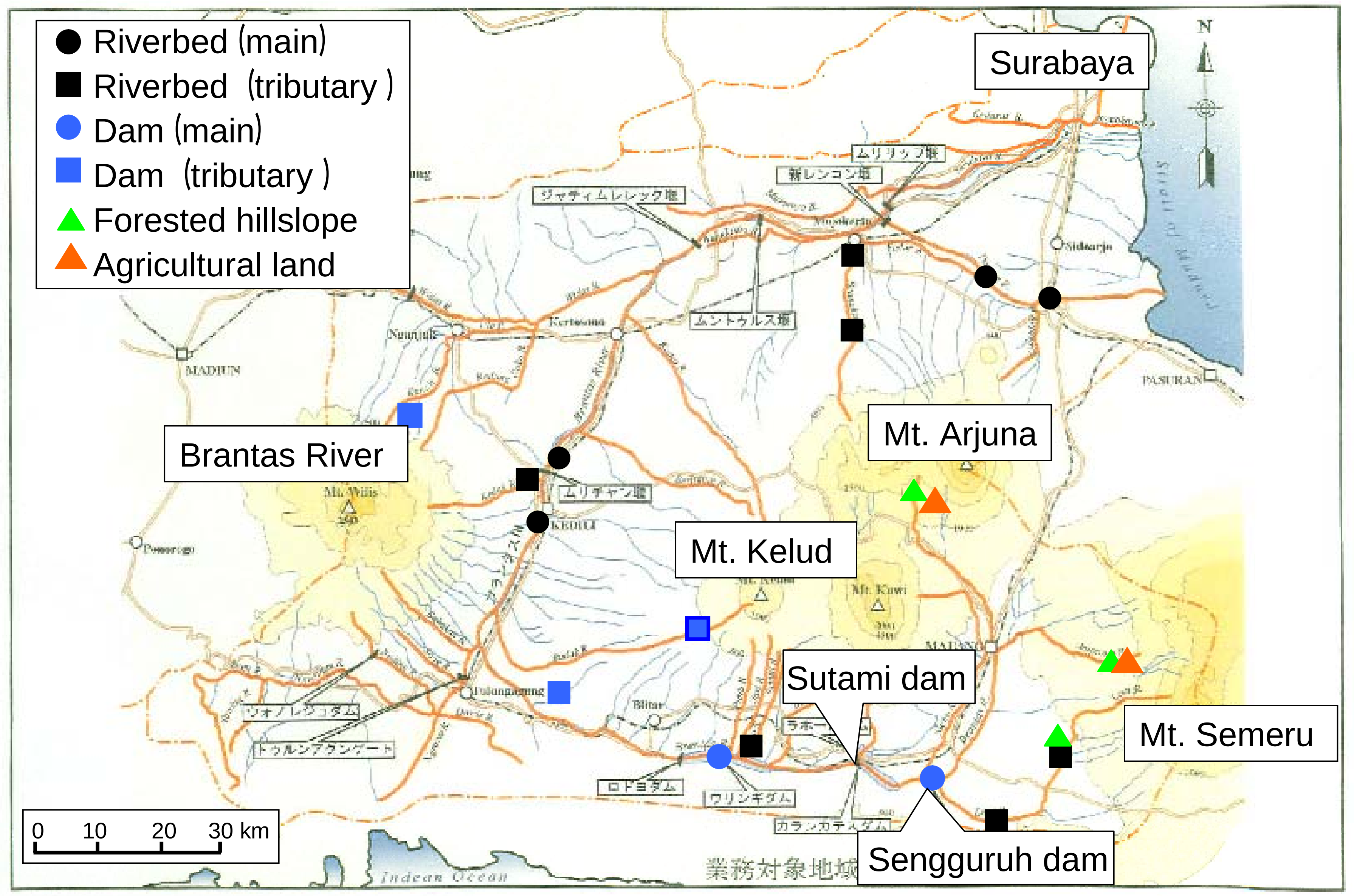
Clarifying dominant processes of sediment yield

Quantifying net erosion rate in forest hillslope and agricultural land

Quantifying role of sand mining on sediment discharged

Preliminary results in Brantas River Basin

Sampling site



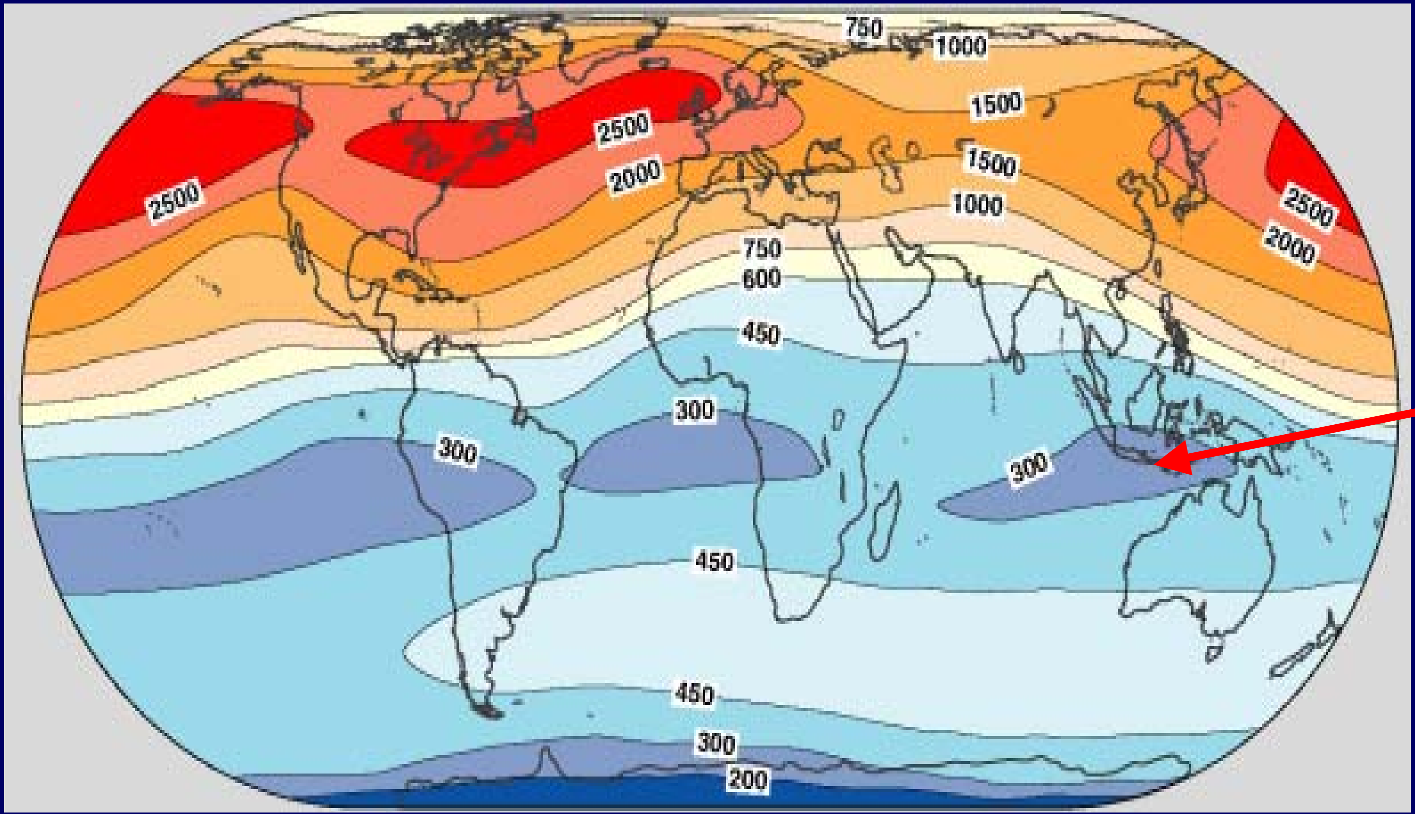
Cs-137 measurements

- Cs-137 activities of all samples in Brantas River Basin were smaller than the detection limit

↓

- Cs-137 cannot be used for the fingerprints of sediment in Brantas River Basin

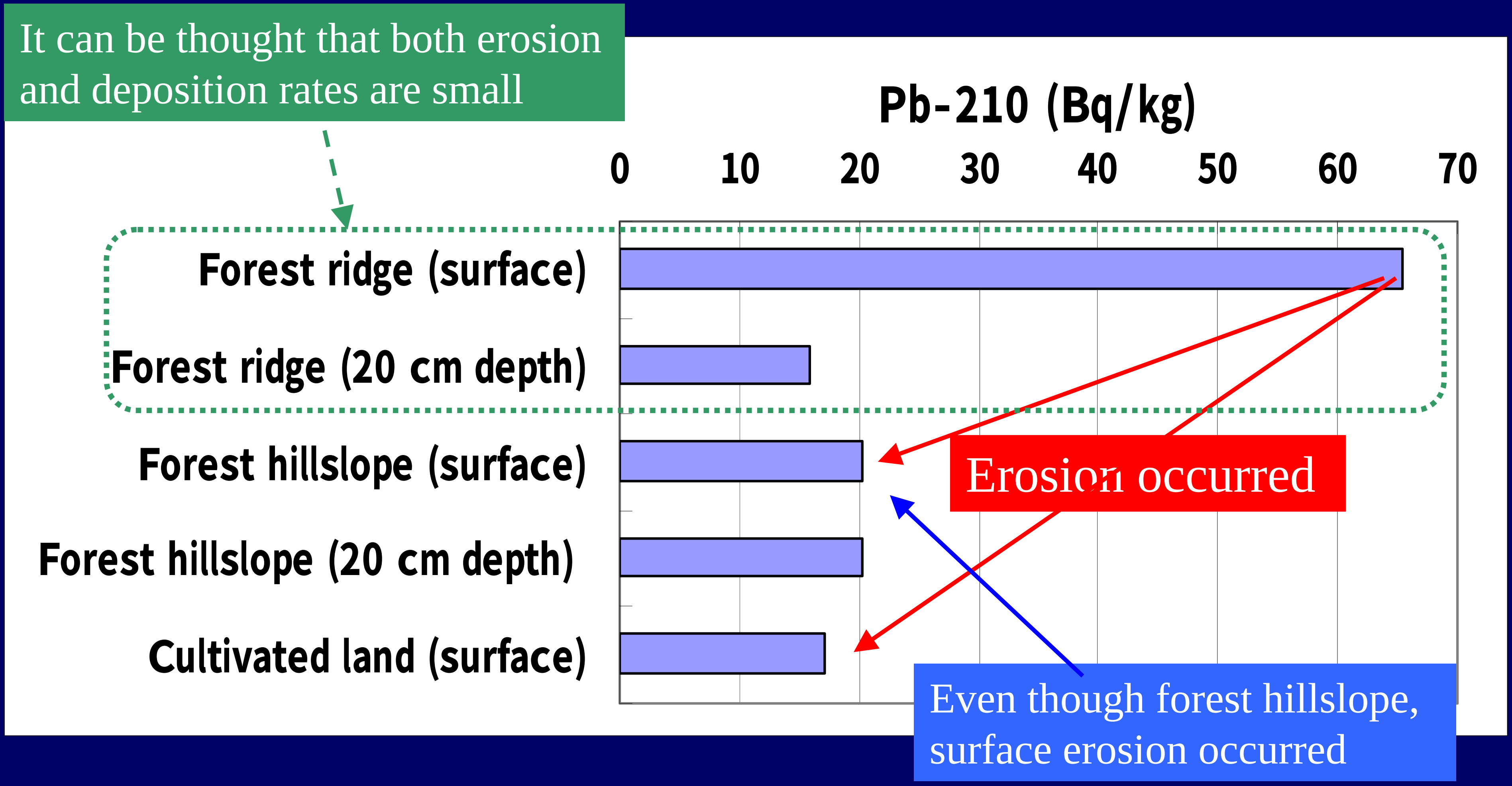
Global distribution of fallout rate



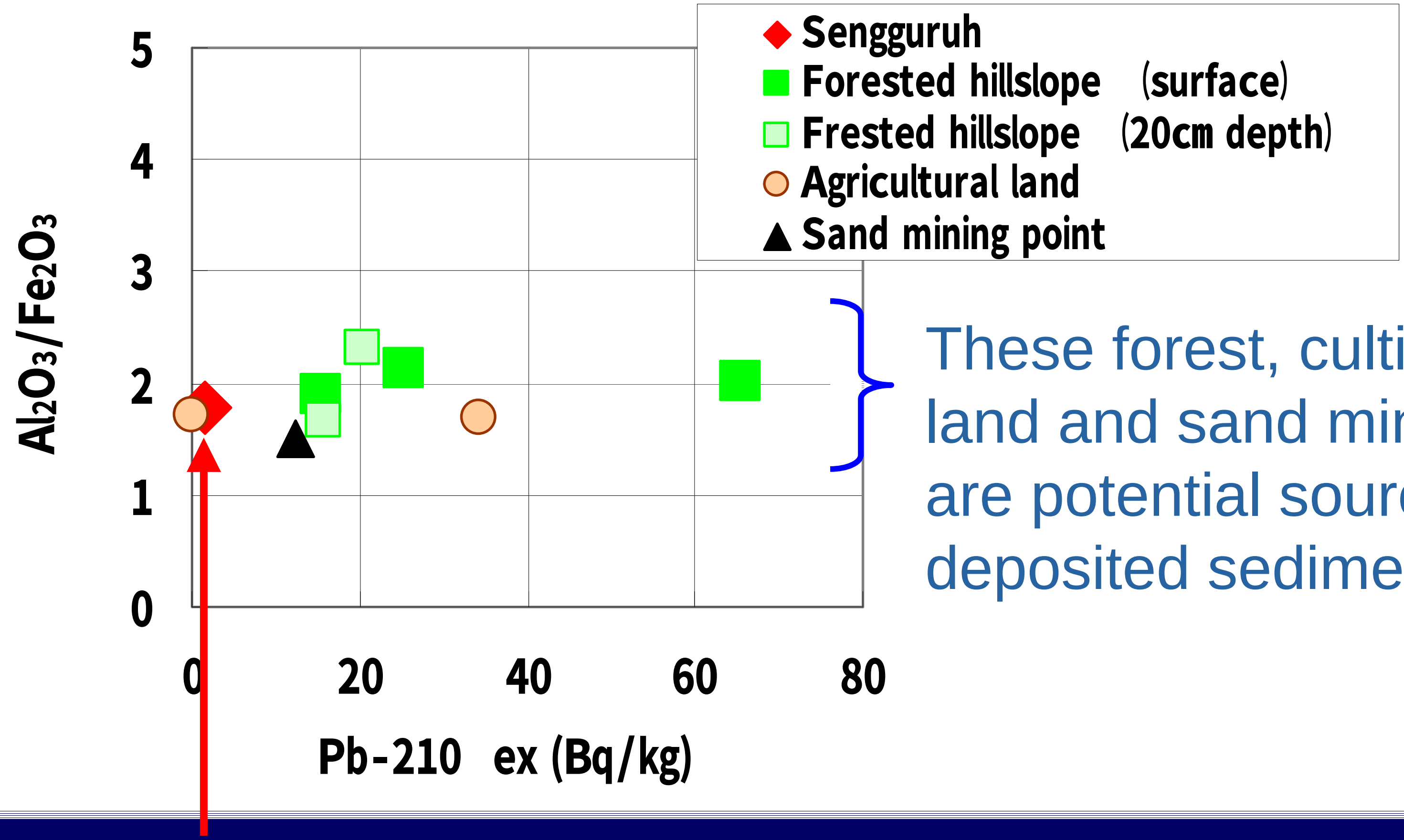
Very low fallout rate!!

Perhaps Cs-137 may not use in Brantas River Basin

Pb-210 measurements



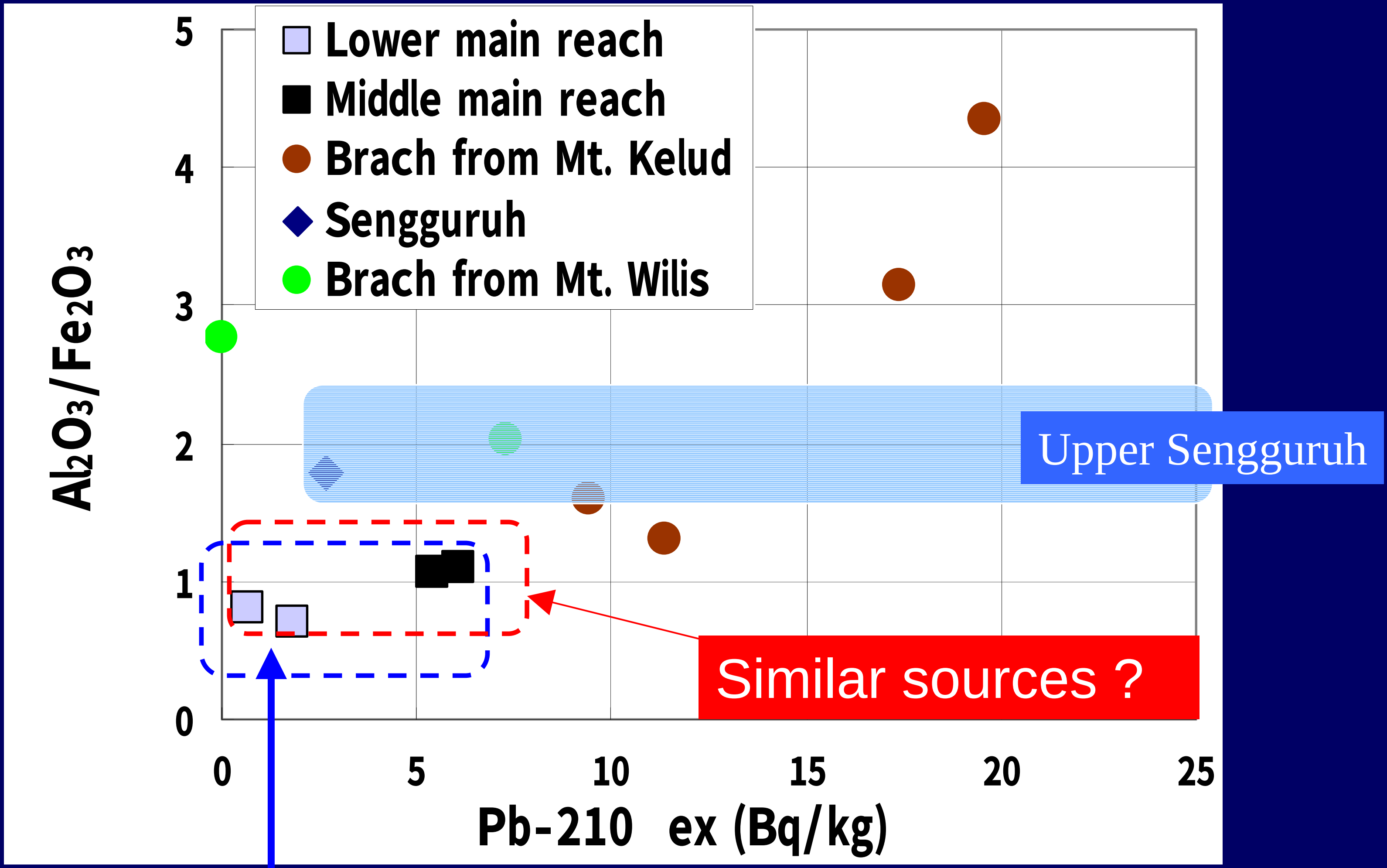
Upper Sengguruh



These forest, cultivated land and sand mining are potential source of deposited sediment

Sheet erosion is not dormant processes of sediment yield to Sengguruh.

Lower and middle reach



Sheet erosion is not dormant processes of sediment yield

Suggestions from preliminary results

Sheet erosion occurred in cultivated land.
However, sheet erosion may give a small impact on sediment supply to reservoirs

Suggestions from preliminary results (cont')

Shallow landslide/gully formation may play an important role in sediment discharge from headwaters

Sand mining may be one of sources of deposited sediment in reservoirs

Suggestions from preliminary results (cont')

Although sheet erosion occurred in hillslopes covered by forests, sheet erosion gave small impacts on downstrem

Shallow landslide/gully formation in forest and cultivated area may contribute to sediment supply to reservoirs

Brantas Origin

Future survey..

- We have to do more systematic samplings
  - To clarify distribution of reference site (no erosion/deposition)
  - To clarify the spatial variability
- We will try to get information about
  - Effects of agricultural activity on erosion rate over mid-term
  - Dominant source and processes of deposited sediments in reservoirs

Conclusions

Tracer techniques give us new information for clarification of sediment dynamics in Brantas River Basin

Physical measurements

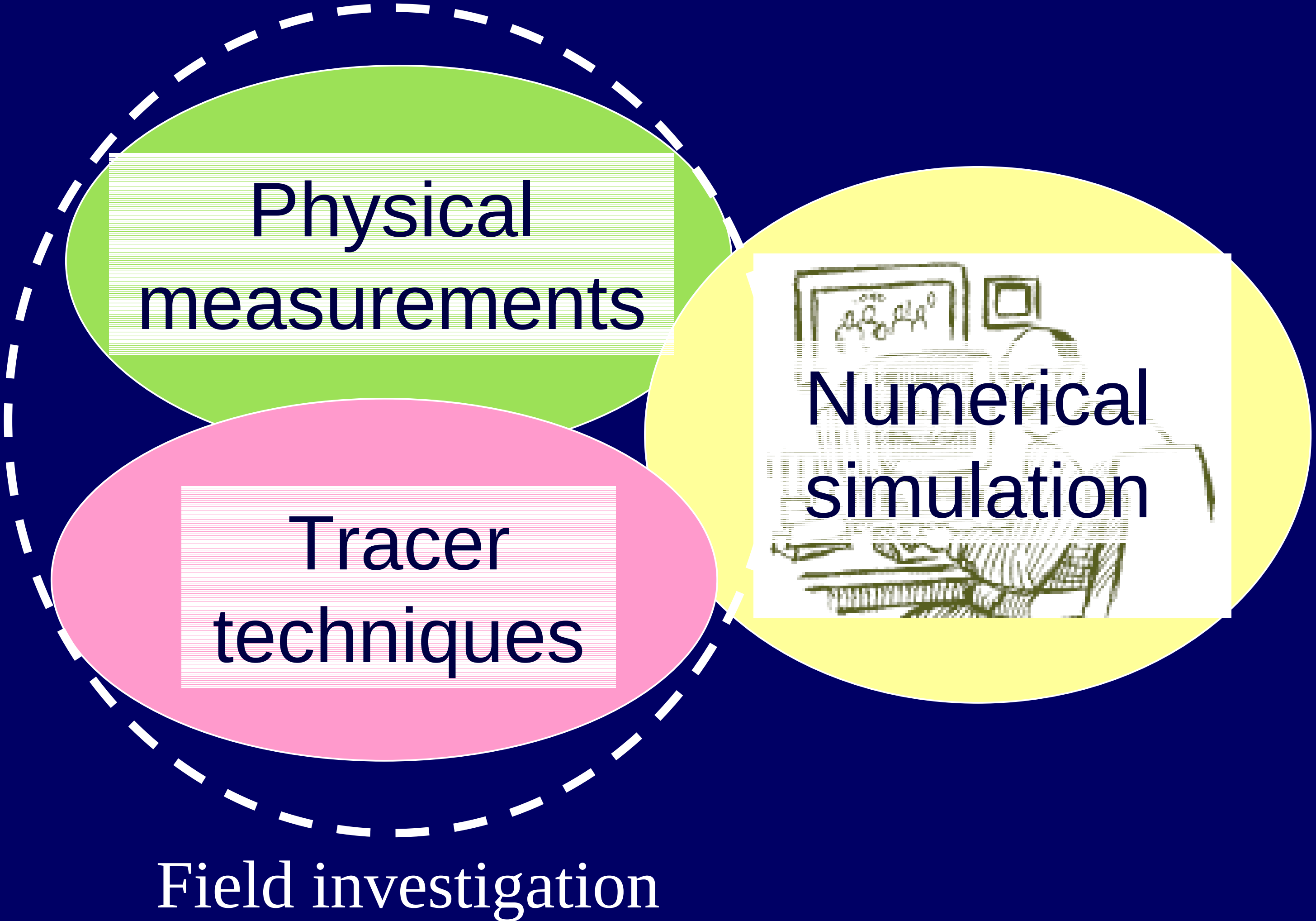
Tracer techniques

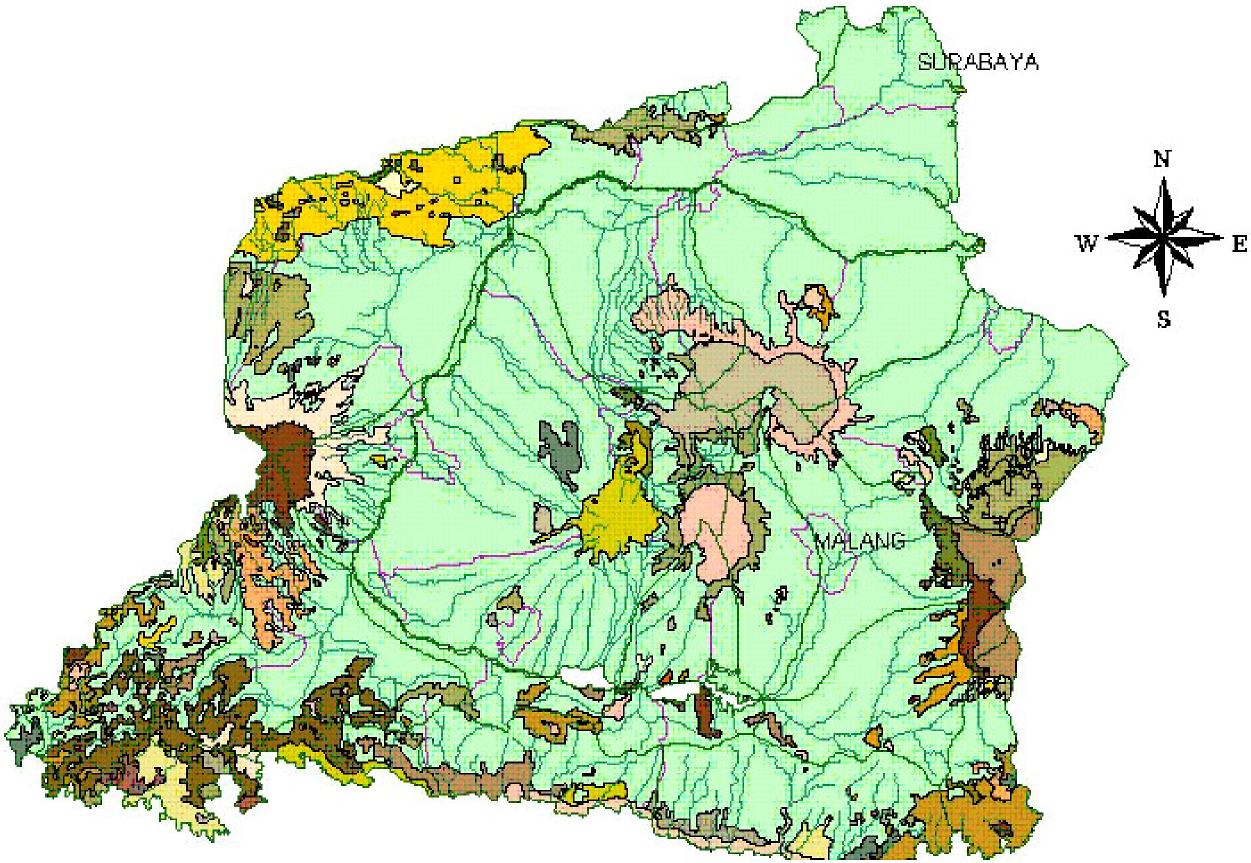
"snapshot" data

"time integrated " data

The way forward

To clarify sediment dynamics...





PENGELOLAAN KALI BRANTAS

DARI ASPEK PEMANFAATAN & PENGENDALIAN

Pemerintah Propinsi Jawa Timur

DINAS PU PENGAIRAN

Pendahuluan

- Pemanfaatan sumberdaya air di DAS Brantas untuk memenuhi kebutuhan antara lain : domestik, municipal (penggelontoran sungai di Perkotaan, atau maintenance river), industri dan irigasi.
- SDA mempunyai dua potensi : potensi manfaat dan potensi daya rusak air.
- Dari dua aspek yang kontradiktif ini perlu kebijakan pengelolaan sungai Brantas secara terpadu dan berkesinambungan dari hulu sampai ke hilir, baik pada saat sekarang maupun yang akan datang

Aspek Pemanfaatan Air

Potensi air di DAS Brantas yang dapat dimanfaatkan berasal dari beberapa sumber air, antara lain ;

- Mata air sejumlah 1.597 buah (misal : Kab/Kota Batu = 487 buah, Blitar = 162 buah, dst…) dengan debit rerata 27,94 m^3/det dan volume tahunan 881,02 juta m^3
- Waduk / Long Storage sebanyak 21 buah (misal : Sutami, Lahor, Sengguruh, dst…), dengan volume tampungan 459,488 juta m^3 dan kapasitas efektif 412,640 juta m^3
- Embung sebanyak 102 buah (misal : Kab. Malang : 43 buah, Kab. Blitar : 4 buah dst….), dengan volume tampungan 5,5 juta m^3 dan kapasitas efektif 4,35 juta m^3

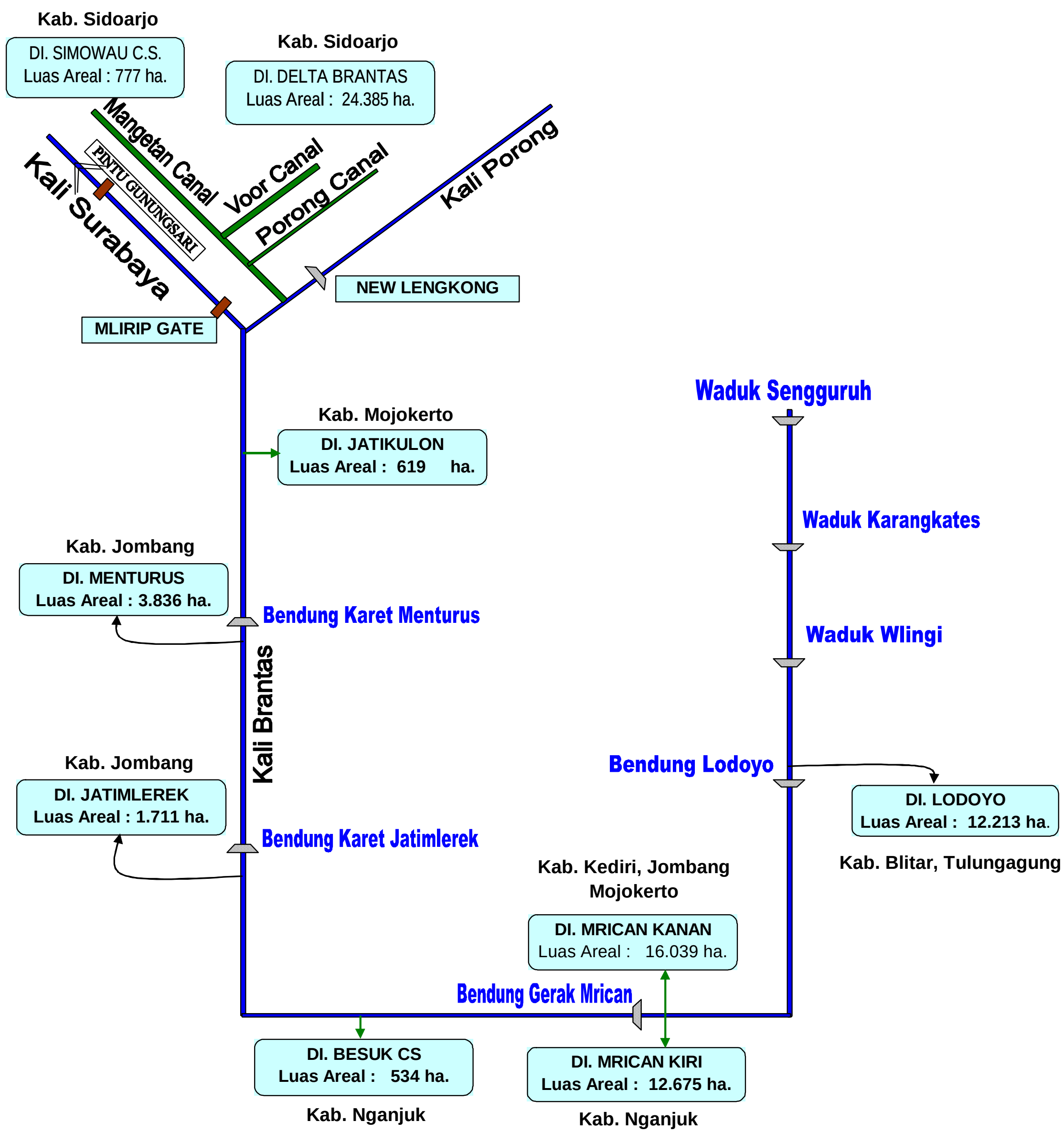
Dari potensi air diatas sebagian besar dimanfaat kan untuk keperluan irigasi dengan rincian sebagai berikut :

- **Irigasi teknis : 246.122 Ha**
- **Irigasi semi teknis : 24.297 Ha**
- **Irigasi sederhana : 31.604 Ha**
- **TOTAL 302.718 Ha**

(Lokasi tersebar pada 15 Kabupaten / Kota)

Sedangkan pemanfaatan di tahun 2004 adalah untuk 126 Industri di 10 Kab/Kota (misal : Surabaya, Gresik, Malang, Batu, Tulungagung, dst…) dengan kebutuhan sebesar 124,46 Juta m^3/tahun serta pemanfaatan untuk PDAM Gresik, Surabaya, Malang, Mojokerto, Sidoarjo dan Tulungagung sebesar 270,7 Juta m^3/tahun

PEMANFAATAN UNTUK IRIGASI
PENGAMBILAN LANGSUNG DARI S. BRANTAS



◈ Aspek Pengendalian Banjir

Sumber Daya Air, selain dimanfaatkan bagi kese jahteraan manusia, juga dapat menimbulkan keru sakan dan kerugian bagi manusia, salah satunya adalah bencana banjir.

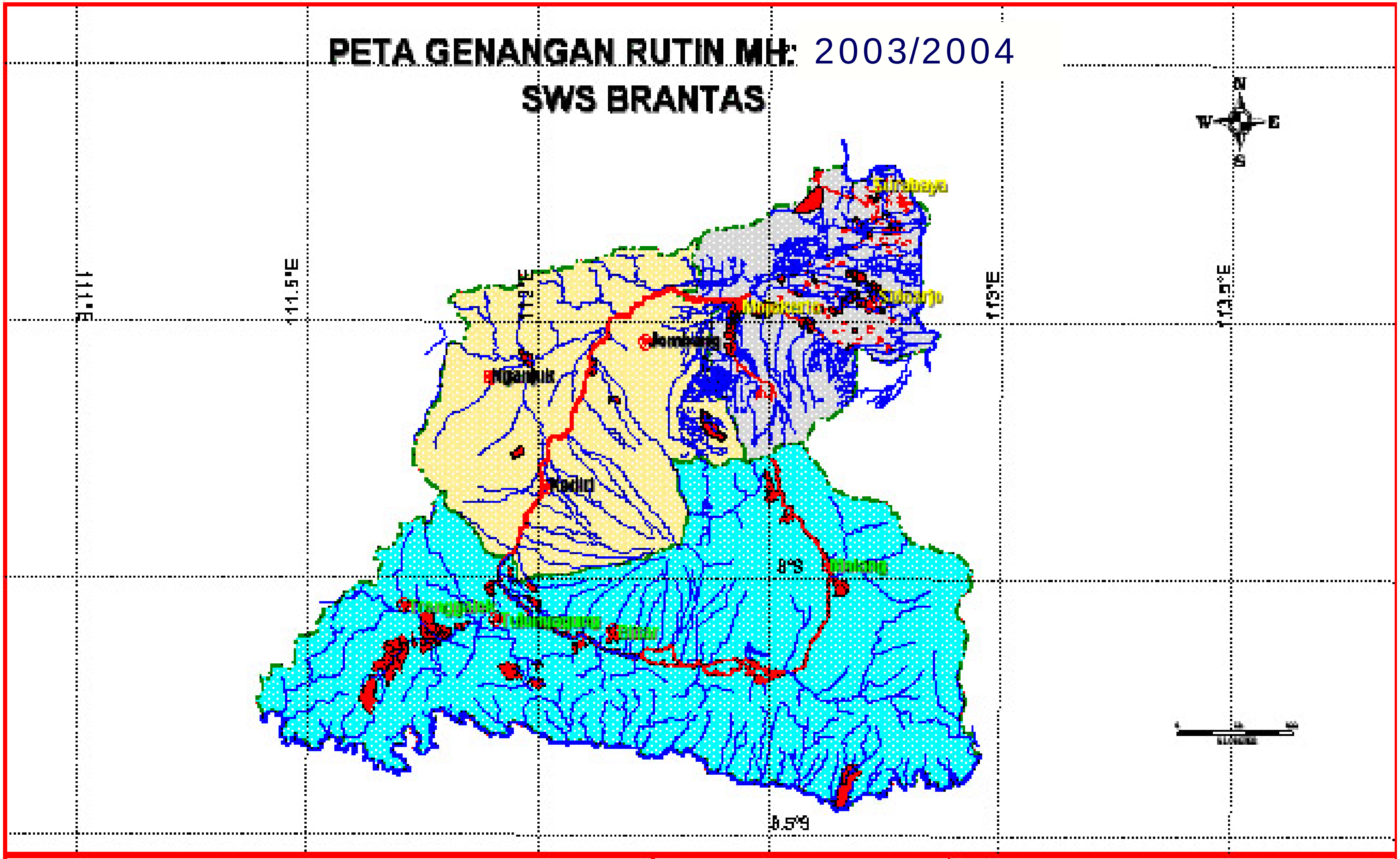
- Musim hujan Th.2003 / 2004 di DAS Brantas
  - Terdapat daerah genangan ± 248 lokasi di 11 Kab/Kota (misal : Malang, Batu, Blitar, Tulung agung, Surabaya, dst…), dng capaian luas ± 17.154 Ha, durasi berkisar 1 jam s/d 168 jam (Desa : Gesikan, Kec.Pakel & Desa Salak kembang Kec. Kalidawir Kab.Tulungagung).
  - Genangan dng kedalaman berkisar 30 cm s/d 300 cm (Desa : Sumber Manjing Wetan, Kab. Malang).
  - Total tanggul kritis DAS Brantas = 73.850 m (misal : Kali Kedung Pedet : 7.400 m, Kabupaten Nganjuk)

- Musim hujan Th. 2004/2005

  - Daerah genangan sebanyak ± 132 lokasi di 15 Kab / Kota (misal : Malang, Batu,Tulungagung, Surabaya, dst…), genangan ± 3.398 Ha, durasi berkisar 1 jam s/d 168 jam (Desa : Mubalen, Kec. Kalidawir Kab. Tulungagung).

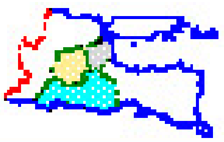
  - Genangan dng kedalaman berkisar 30 cm s/d 200 cm (Desa : Tulungrejo, Bumi Aji, Kota Batu).

PETA GENANGAN RUTIN MH: 2003/2004
SWS BRANTAS

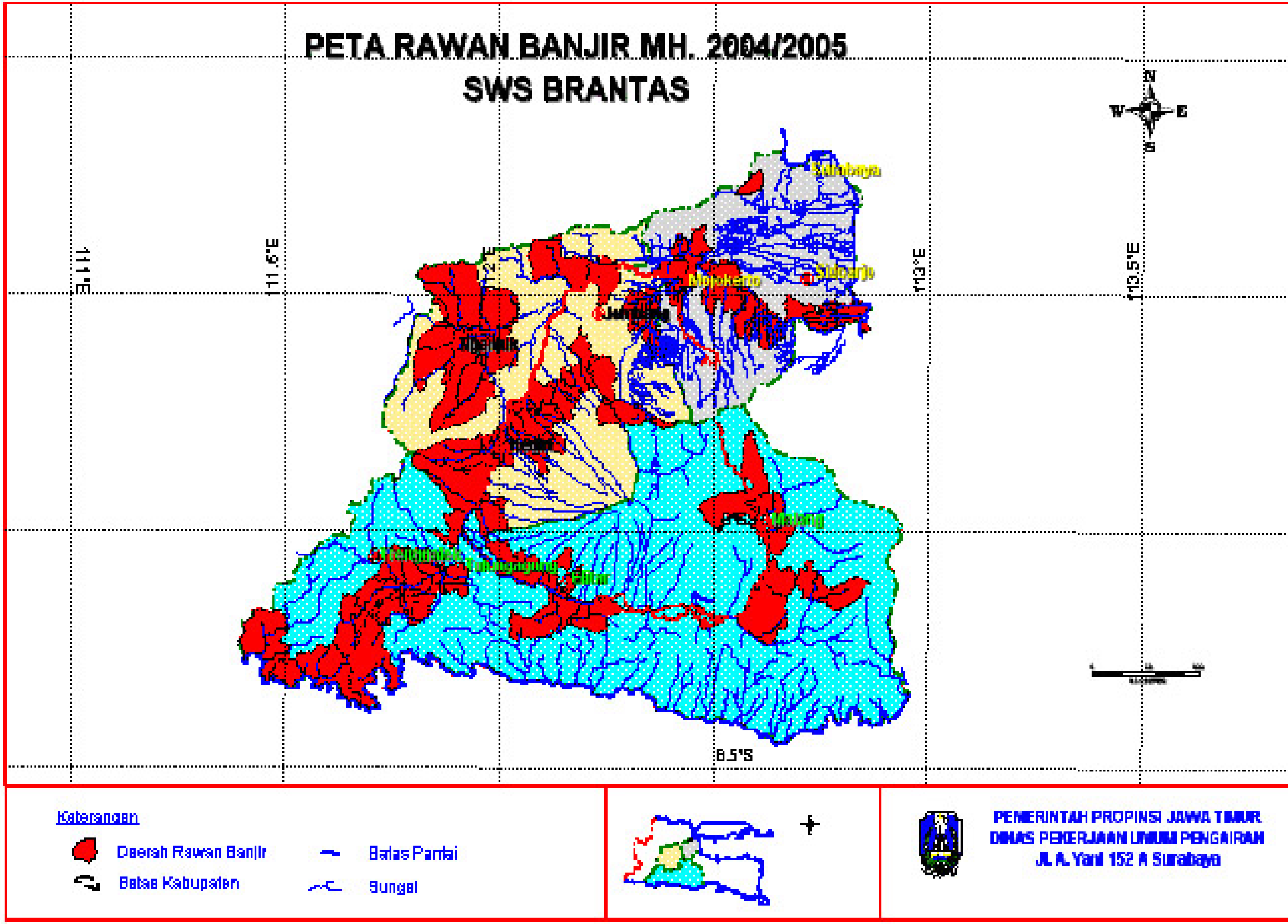


Keterangan

- Daerah Genangan
- Batas Kabupaten
- Batas Pantai
- Sungai



PEMERINTAH PROPINSI JAWA TIMUR
DINAS PEKERJAAN UMUM PENGAIRAN
JL. A. Yani 152 A Surabaya


PETA RAWAN BANJIR MH. 2004/2005
SWS BRANTAS
N
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Malang
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111°E
111.5°E
113°E
113.5°E
8.5°S
Keterangan
Daerah Rawan Banjir
Batas Kabupaten
Batas Pantai
Sungai
PEMERINTAH PROPINSI JAWA TIMUR
DINAS PEKERJAAN UMUM PENGAIRAN
JL. A. Yani 152 A Surabaya

◈ Upaya Penanganan Banjir

Pemerintah Propinsi Jawa Timur, melalui Dinas PU Pengairan Propinsi Jawa Timur berkoordinasi dengan SATKORLAK Banjir Pemerintah Kabupaten / Kota dan melakukan penanganan darurat terhadap bencana (banjir) yang terjadi di daerah dengan kriteria :

- Kecepatan pelaporan bencana (1 x 24jam)
- Ada rekomendasi Bupati/ Walikota
- Permintaan masyarakat

Jenis Penanganan Darurat (bencana Banjir) yang dilakukan dari Dinas PU Pengairan Propinsi Jawa Timur melalui Sub Dinas O&P serta Balai-Balai PSAWS dalam lingkup WS Brantas, yaitu Balai :

PSAWS Bango Gedangan di Malang, Balai PSWAS Puncu Selodono di Kediri dan Balai Buntung Peketingan di Surabaya, antara lain adalah:

- **Bantuan Kawat Bronjong, Bantuan Karung Plastik**
- **Pemasangan Karung Plastik diisi pasir, Gedeg, Sesek.**
- **Bongkotan Bambu & Dolken pancang**

Permasalahan / Kendala Pengelolaan DAS Brantas

- Ketidak keseimbangan upaya konservasi dan pendayagunaan Sumber Daya Air yang mengakibatkan penurunan kualitas dan kuantitas air.
- Peningkatan kebutuhan akan air.
- Penurunan daya dukung lingkungan Sumber Daya Air yang menyebabkan peningkatan ancaman daya rusak air sehingga mengakibatkan meningkatnya resiko akibat daya rusak air.

◈Permasalahan / Kendala Pengelolaan DAS Brantas

Lanjutan ...)

- Keterbatasan kemampuan penyediaan air.
- Kurangnya kesadaran masyarakat dalam pencegahan bahaya banjir.
- Rendahnya rasa memiliki dan tanggung jawab warga msyarakat terhadap keberadaan Sumber Daya Air .

◈ Kebijakan pengelolaan Sumber Daya Air

1. Pengelolaan DAS Brantas perlu memperhatikan asas kelestarian, keseimbangan, kemanfatan umum, keterpaduan dan kesera sian, serta keadilan.
2. Pengelolaan DAS Brantas harus dilakukan secara menyeluruh, terpadu dan berwawasan lingkungan, dengan tujuan mewujudkan kemanfaatan yang berkelanjutan.
3. Pola pengelolaan DAS Brantas perlu mengacu pada prinsip keseimbangan antara upaya konservasi & pendayagunaan Sumber Daya Air

Tantangan Pengelolaan Sumber Daya Air DAS Brantas

- Menjaga kelestarian ketersediaan sumber air agar dapat dimanfaatkan pada saat ini maupun waktu yang akan datang, baik kualitas maupun kuantitasnya
- Mempertahankan daya dukung lingkungan untuk menjamin ketersediaan air
- Mengamankan daerah produktif dan pemukiman dari bencana banjir
- Memulihkan ekosistem dari kerusakan akibat banjir
- Menjamin kebutuhan air untuk mendukung perkembangan sektor-sektor ekonomi diluar pertanian

◈ Upaya keberlanjutan pengelolaan Sumber Daya Air

DAS BRANTAS

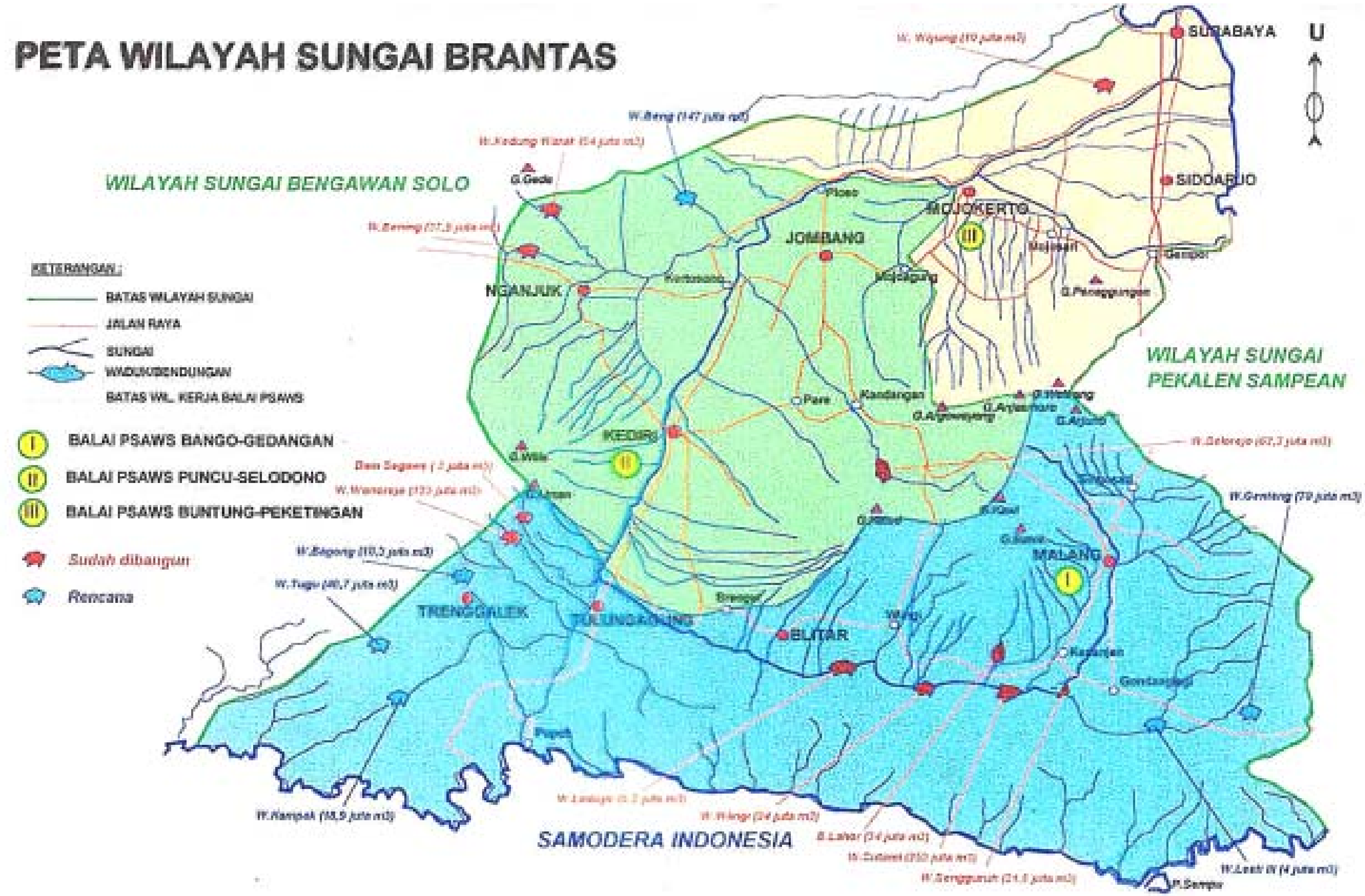
- Sungai Brantas sebagai sumber daya alam harus dikelola berdasarkan pengertian air adalah bagian integral (menyeluruh) dari ekosistem (lingkungan sekitarnya) yang ada.
- Pengelolaan DAS Brantas harus dilakukan secara menyeluruh dan terpadu dengan memperhatikan Daerah Aliran Sungai sebagai sebuah kesatuan sistem hydrologis berdasar prinsip satu sungai, satu rencana dan satu managemen terkoordinasi

◈ PENUTUP ◈

- **Pengelolaan DAS Brantas merupakan pengelolaan SDA yang bertujuan untuk memperbaiki, memelihara dan melindungi lingkungan DAS, agar menghasilkan SDA yang dimanfaatkan untuk keperluan pertanian, perkebunan, peternakan, perikanan, industri dll**
- **Keberhasilan pengelolaan DAS Brantas dengan indikatornya memperkecil fluktuasi debit yang akan membantu pengembangannya, oleh karena itu usaha konservasi perlu dilakukan secara terintegrasi dengan usaha pengembangannya**
- **Tujuan akhir dari pengelolaan DAS Brantas yaitu terwujudnya kondisi yang optimal dari SDA dan lingkungan DAS Brantas yang mampu memberi manfaat secara maksimal dan berkesinambungan bagi kesejahteraan masyarakat Jawa Timur baik pada saat ini maupun di masa mendatang.**

TERIMA KASIH

PENGEMBANGAN SUMBERDAYA AIR
WS. BRANTAS



RENCANA PENGEMBANGAN SUMBER DAYA AIR

Pembangunan

WS. Brantas	Kabupaten	Prakiraan Volume Tampungan	Keterangan
1. Waduk Beng	Jombang	147,00 juta m^3	F.S
2. Waduk Bagong	Trenggalek	10,00 juta m^3	F.S
3. Waduk Tugu	Trenggalek	40,70 juta m^3	F.S
4. Waduk Kampak	Trenggalek	18,90 juta m^3	F.S
5. Waduk Lesti III	Malang		F.S
	Malang		F.S
	TOTAL =	**290,60 juta m^3**	

KRONOLOGI KERUSAKAN SUMBER DAYA AIR

RANGKUMAN :

KETERKAITAN ANTARA :
- **KEHUTANAN**
- **PENGAIRAN**
- **LINGKUNGAN HIDUP**

LINGKUNGAN HIDUP
(KERUSAKAN EKOSISTEM)

LOW LAND

PESISIR / PANTAI

UP LAND

HUTAN

Pengelolaan Hutan
Timber Management ***bukan***
Forest Management.

Pengelolaan Hutan tidak Lestari

Penebangan Liar

Penjarahan

DAMPAK

Bencana Alam / Banjir !!!

Ketersediaan Air Berkurang !!!

Upaya Perbaikan Lingkungan DAS

Pembangunan Pengairan

Konsep

Tata Guna Air, Lahan,Kehutanan diselenggarakn secara terpadu.

Tujuan

Menjamin Kelestarian Fungsi SDA dan Lingkungan Hidup

Kegiatan

- Mengkonversikan SDA
- Mengelola Air Baku
- Memelihara Jl AP & ABT scr efektif & Efisien

Sasaran

Peningkatan Ketahanan Pangan dan Pembangunan Agrobisnis, pelestarian sumber - sumber air, Pengendalian banjir serta penyediaan air baku untuk berbagai keperluan.

Pembangunan Kehutanan

Sasaran

- Meningkatkan Pengelolaan Hutan yg kurang Produktif serta hutan rakyat.
- Meningkatkan Hutan Lindung dan Hutan Konservasi.
- Menurunkan Pencurian, Perambahan dan kebakaran.
- Berkurangnya lahan kritis & efisien Pembalakan (Logging) & Industri Kehutanan.

Program

Pengembangan dan Pengelolaan Hutan

Tujuan

Meningkatkan mutu & Produksifitas hutan melalui pengelolaan hutan scr effisien adil & berkelanjutan shg meningkatkan kontribusi hutan thd perekonomian nasional & daerah serta kesejahteraan masyarakat.

Sasaran

Peningkatan Ketahanan Pangan dan Pembangunan Agrobisnis, pelestarian sumber - sumber air, Pengendalian banjir serta penyediaan air baku untuk berbagai keperluan.

Program

1. Penyusunan data dasar perencanaan dan pengembangan sarana & prasarana SDA, rencana penatagunaan SDA serta Zona penggunaan SDA & peruntukannya.
2. Pembangunan Prasarana Penyediaan Air Baku.
3. Menciptakan Sistem Koordinasi Penanganan Banjir scr Optomal.
4. Pelayanan penertiban ijin secara proposional.

Tujuan

Meningkatkan mutu & Produksifitas hutan melalui pengelolaan hutan scr effisien adil & berkelanjutan shg meningkatkan kontribusi hutan thd perekonomian nasional & daerah serta kesejahteraan masyarakat.

Pelaksanaan Kegiatan

1. Rehabilitasi hutan rakyat tahun 2003 seluas 1.325 ha.
2. Pembuatan Dam Pengendali.
3. Pembuatan Dam Penahanan.
4. Pembuatan Pengendalian Jurang Kecil.
5. Pembuatan Sumur Resapan.

First International Workshop on Water and Sediment Management in Brantas River Basin, July 28-29, 2005, Batu, East Java, Indonesia

Application of Remote Sensing and GIS to Flood and Sediment Runoff Prediction

Kaoru Takara

Disaster Prevention Research Institute,

Kyoto University

Today's Talk

- Brief review of DPRI-KU's cooperation with Indonesia
- Hydrological modeling study using RS and GIS

  Putih and Mt. Kelud hillslopes (See OHP slides)

  Lesti (by Sayama, Tachikawa and Takara)
- International activities

  - GEOSS 10-year plan (2006-2015)
  - IFNet's GFAS
  - UNESCO-IHP, UNESCO-WMO's IFI/P and ISI
  - ICL's IPL
- Possible proposals

Cooperation since 1991 between Indonesia and DPRI, Kyoto University

- A Joint Research Project for IDNDR (Int'l Decade for Natural Disaster Reduction)

  Special Project supported by the Monbusho (Ministry of Education, Science, Sports and Culture of Japan) [currently MEXT (Ministry of Education, Culture, Sports, Science and Technology)]

  - 1st term: 1991-1993 (3 years)

  - 2nd term: 1994-1998 (5 years) MoU with Research Institute for Water Resources Development, Dept. of Public Works, and Volcanological Survey of Indonesia

- Follow-up Research by the Grant-in-Aid for Scientific Research (KAKENHI) and the CREST Fund

  - Prof. Takara: 2000-2002 (KAKENHI) + 2001-2006 (CREST)

  - Prof. Fujita: 2003-2005 (KAKENHI)

  MoU with Jasa Tirta I (Prof. Nakagawa)

  - ??? 2006-

DPRI-KU

Outputs of IDNDR Project and Its Follow-up

- Workshop on Disasters Caused by Floods and Geomorphological Changes and Their Mitigation, 1996, Yogyakarta, Indonesia
- Symposium on Japan-Indonesia IDNDR Project: Volcanology, Tectonics, Flood and Sediment Hazards, 1998, Bandung, Indonesia
- Strong cooperation and mutual understanding between Indonesia and Japan
- A number of papers

Papers (Reprints) distributed at 2005 Workshop in Batu

Takara, K., R. Uesaka and S. Egashira: Analysis of land surface conditions in the Brantas River basin --For prediction of rainfall and sedimentation runoff. Annuals, DPRI, Kyoto Univ., No. 40 IDNDR S.I., 1997, pp. 47-52 (in Japanese with English synopsis and captions).

Takara, K., R. Uesaka and K. Notsumata: Landcover classification and Sediment Runoff Analysis in the Brantas River Basin. Annuals, DPRI, Kyoto Univ., No. 42 B-2, 1999, pp. 291-310 (in Japanese with English synopsis and captions).

Takara, K., D. Nakayama, Y. Tachikawa, T. Sayama, H. Nakagawa, Y. Satofuka, S. Egashira and M. Fujita: A rainfall-sediment-runoff model in the upper Brantas River, East Java, Indonesia. Annuals, DPRI, Kyoto Univ., No. 44 B-2, 2001, pp. 247-257.

Sayama, T. and K. Takara: A distributed sheet erosion process model for sediment runoff prediction. Journal of Hydraulics and Environmental Engineering, JSCE, No. 726/II-62, 2003, pp. 1-9 (in Japanese with English abstract).

DPRI-KU

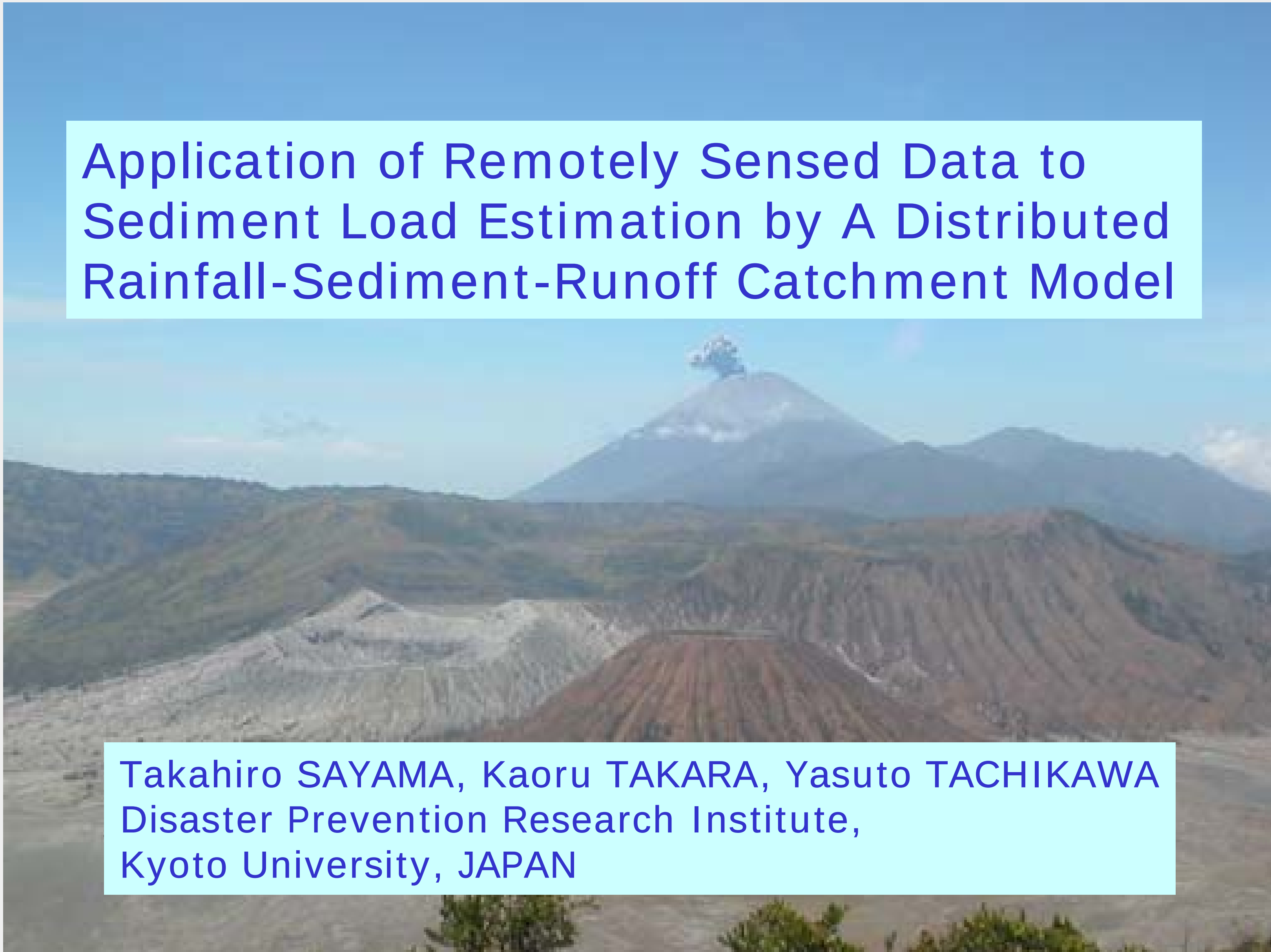
RS and GIS Study during IDNDR

Hydrological modeling study using RS and GIS Part 1 (See OHP slides)

- Eruption of Mt. Kelud in Feb. 10, 1990
  - previous eruptions: 1901, 1919, 1951, 1966
- Site visits to K. Putih, K. Badak, Brantas source to river mouth
- Collaboration with Research Center for River and Sabo in Solo and Perum Jasa Tirta in Malang
- Sediment yield in the Brantas River basin is very high: similar to the Kurobe, Oi, Tenryu Rivers in Japan
- Effectiveness of combination use of multi-spectral sensor (MOS-1/MSSR) and synthetic paerture radar (JERS-1/SAR) for better land cover classification
- Basic conceptualization of distributed hydrological modeling for rainfall-sediment runoff: sediment yield simulation for 8 years (1990-1998)

DPRI-KU

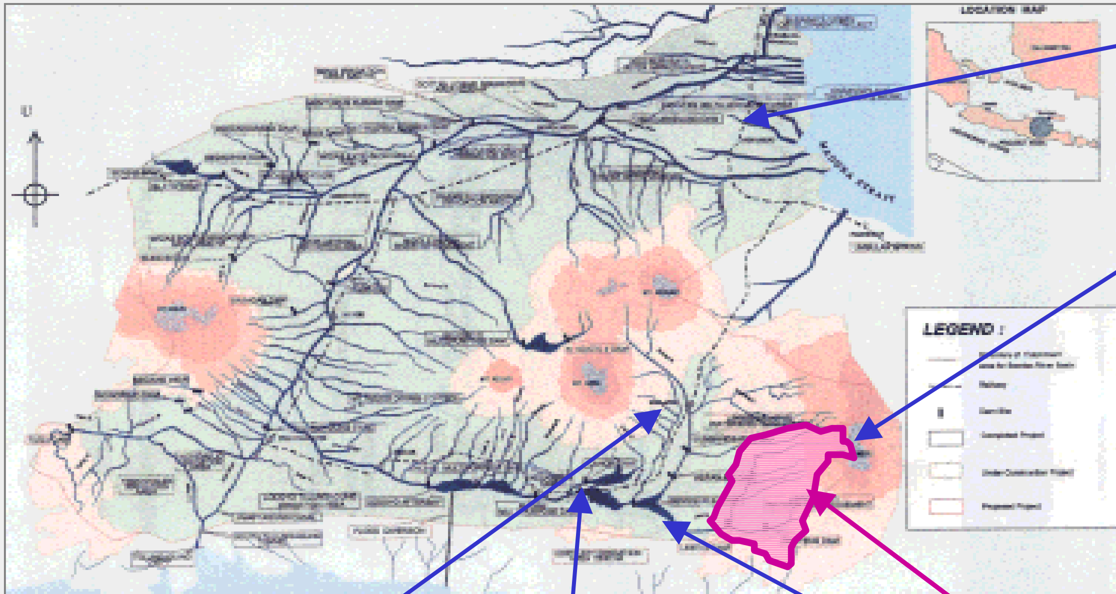
Application of Remotely Sensed Data to Sediment Load Estimation by A Distributed Rainfall-Sediment-Runoff Catchment Model



Takahiro SAYAMA, Kaoru TAKARA, Yasuto TACHIKAWA
Disaster Prevention Research Institute,
Kyoto University, JAPAN

Deforestation increased the risk of sediment problems?

Brantas River Basin (12500 km^2), Indonesia

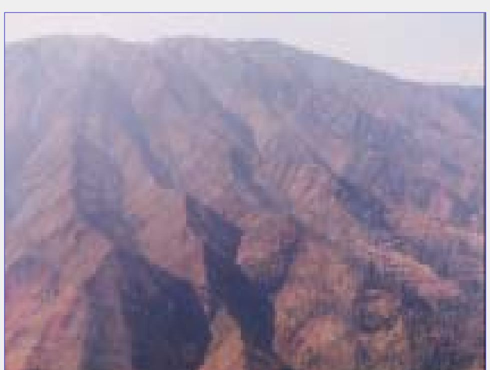


Surabaya City

Mt. Semeru

Lesti River Basin (625 km^2)

Deforestation



Sediment from Wlingi Dam

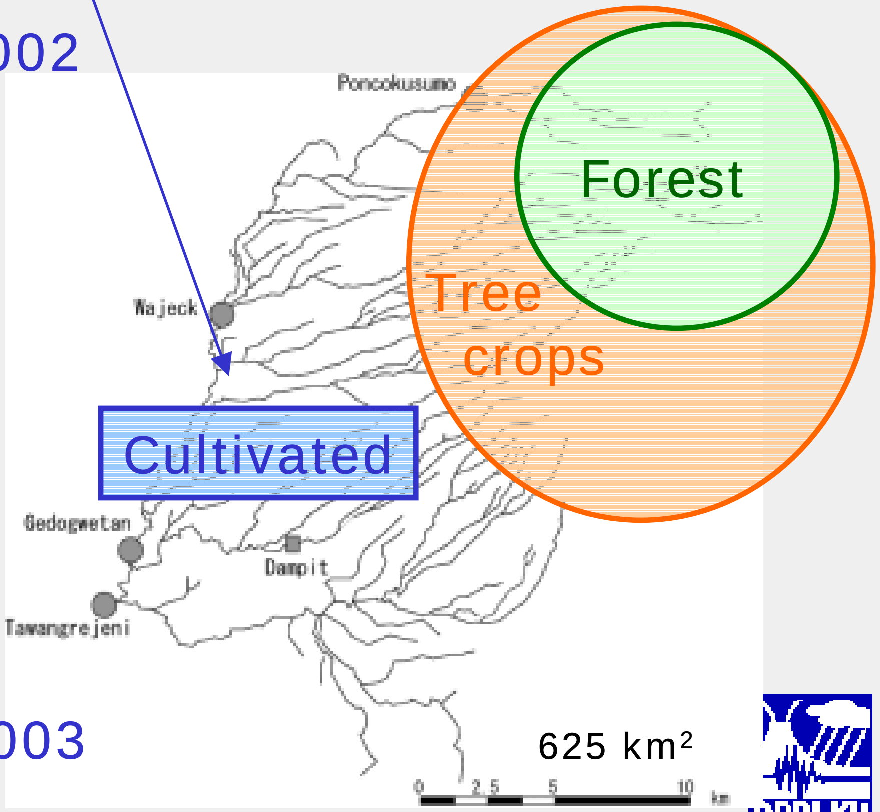
Sutami Dam

Senggruh Dam

Oct 2002

Flood, Nov 2003

Dec 2003



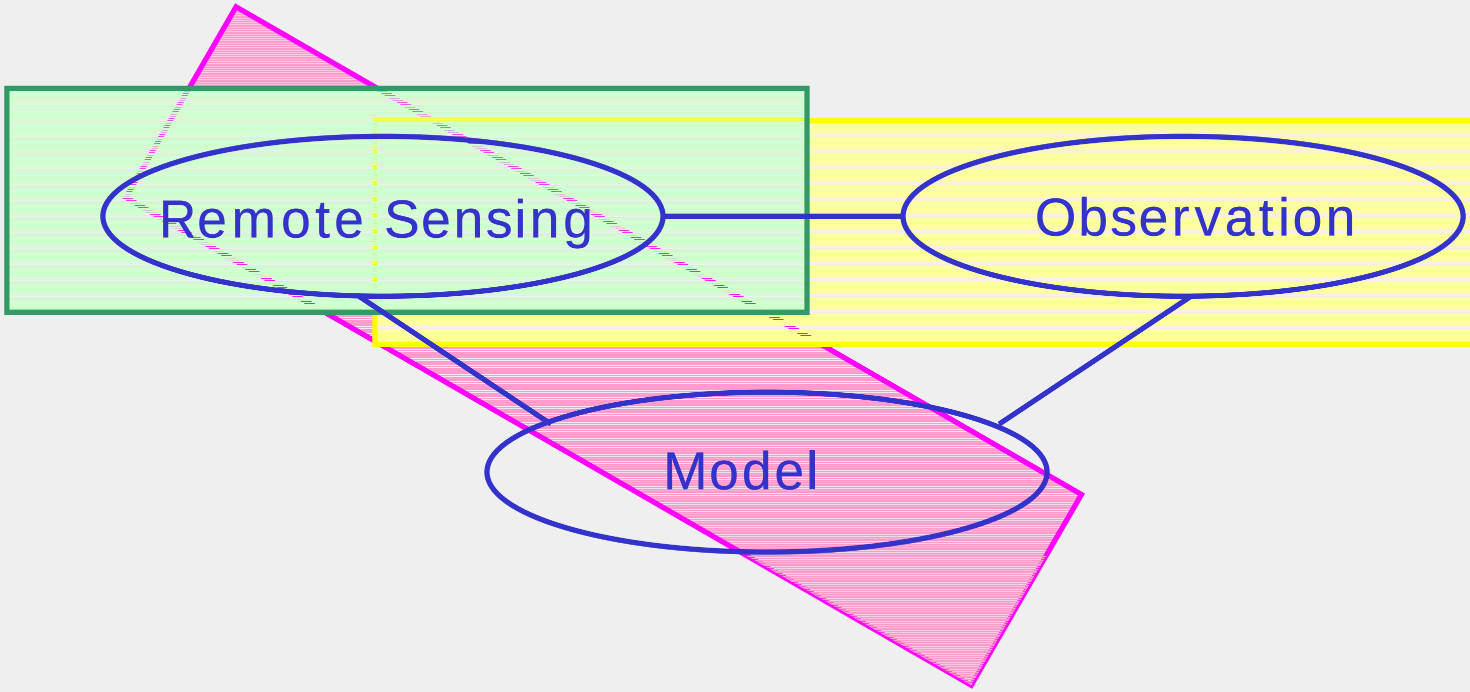
Background

- Large amount of yielded sediment causes severe sedimentation problems at the dam reservoir.
- What is the dominant sediment source ?

  Cultivated areas or deforested areas at Mt. Semeru?
- Has the deforestation increased sediment yield in the Lesti River basin ?
- Effect of inter and inner annual variability of land cover on sediment yield ?

--> Remote sensing technique and distributed rainfall-sediment-runoff model are useful tools for understanding sediment dynamics in time and space.

--> Field observation is necessary for the verification.

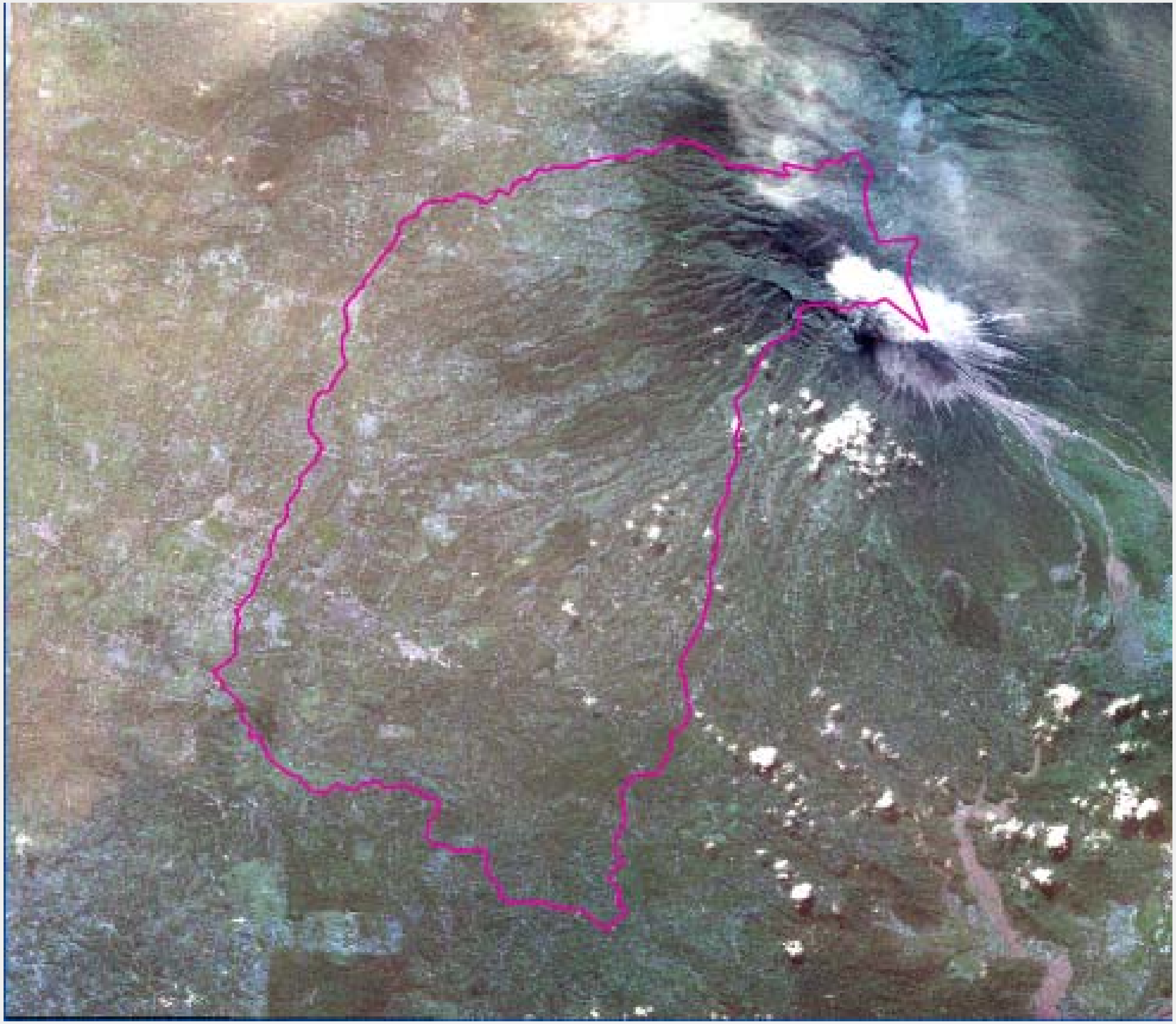


1. Deforestation in the last 5 years

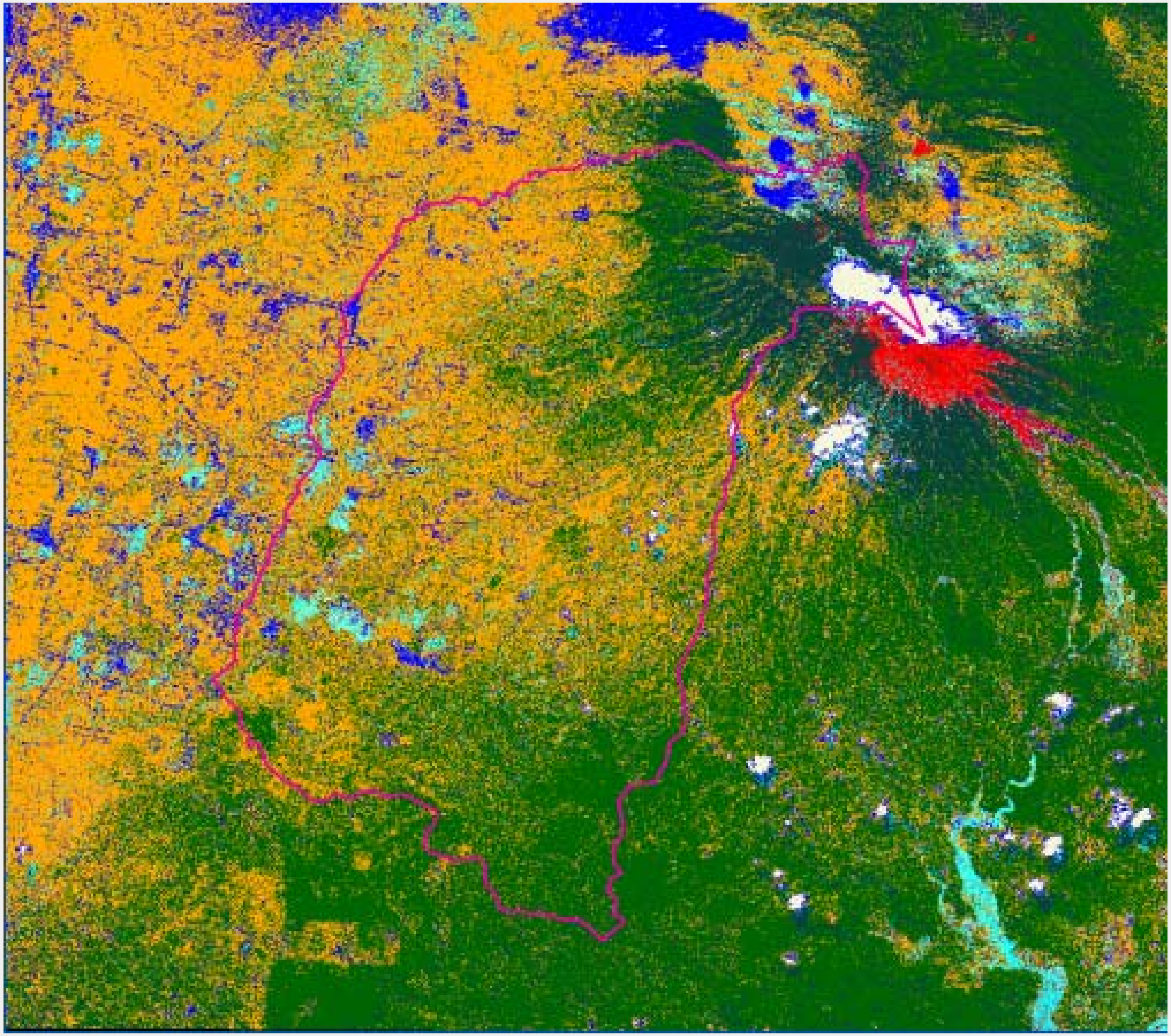
2. Seasonal variability of land cover and its effect on erosion

3. Effect of deforestation on sediment yield

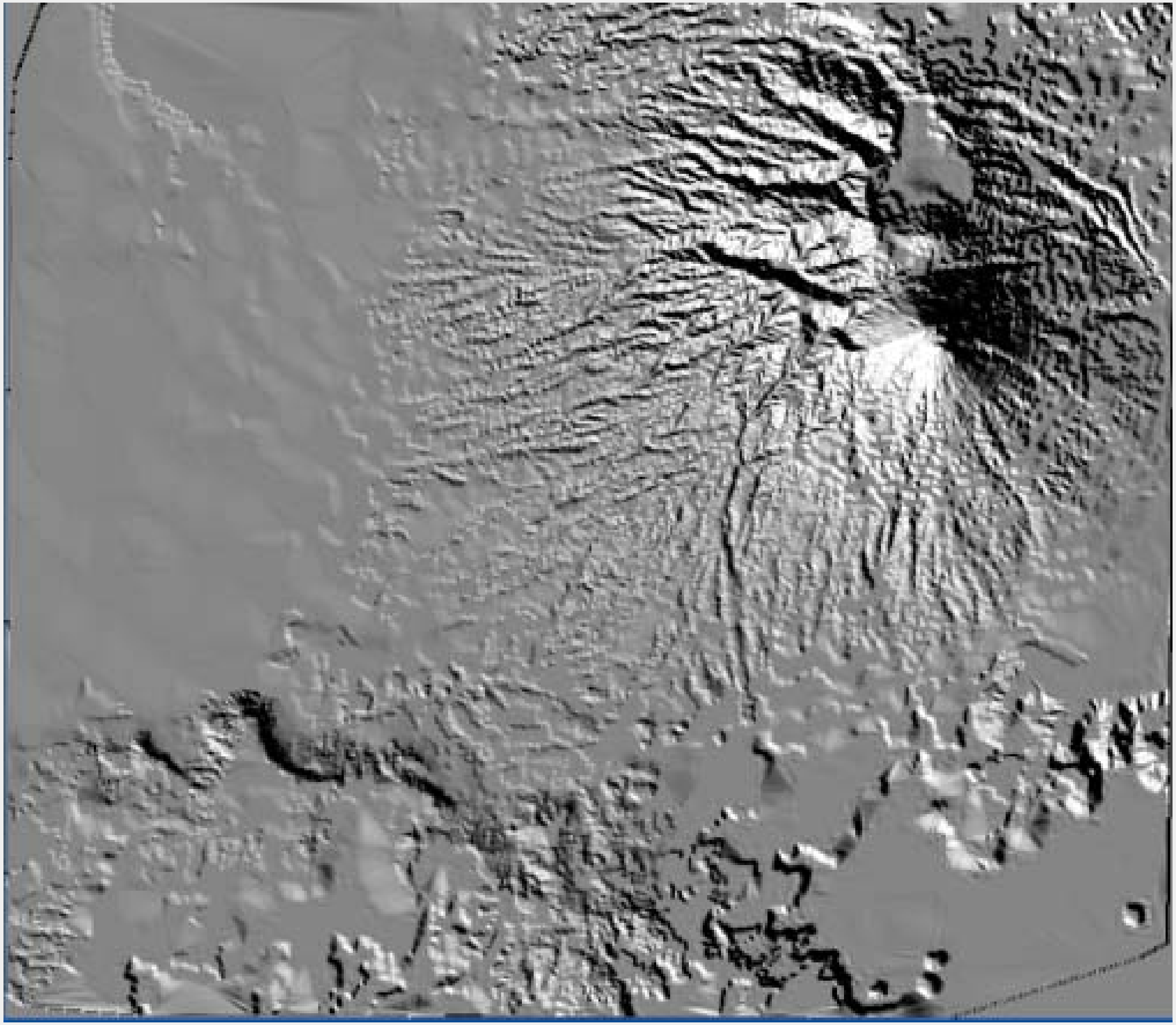
Land Use in Lesti River Basin, Indonesia



Land cover classification



Digital Elevation Model (250m)



Flow Direction Map Derived from DEM

1. Deforestation in the last 5 yeas ?

Outside the Lesti River Basin

June 1997 by ADEOS/AVNIR

May 2002 by LANDSAT7 ETM+

1. Deforestation in the last 5 yeas ?

Outside the Lesti River Basin

Forest

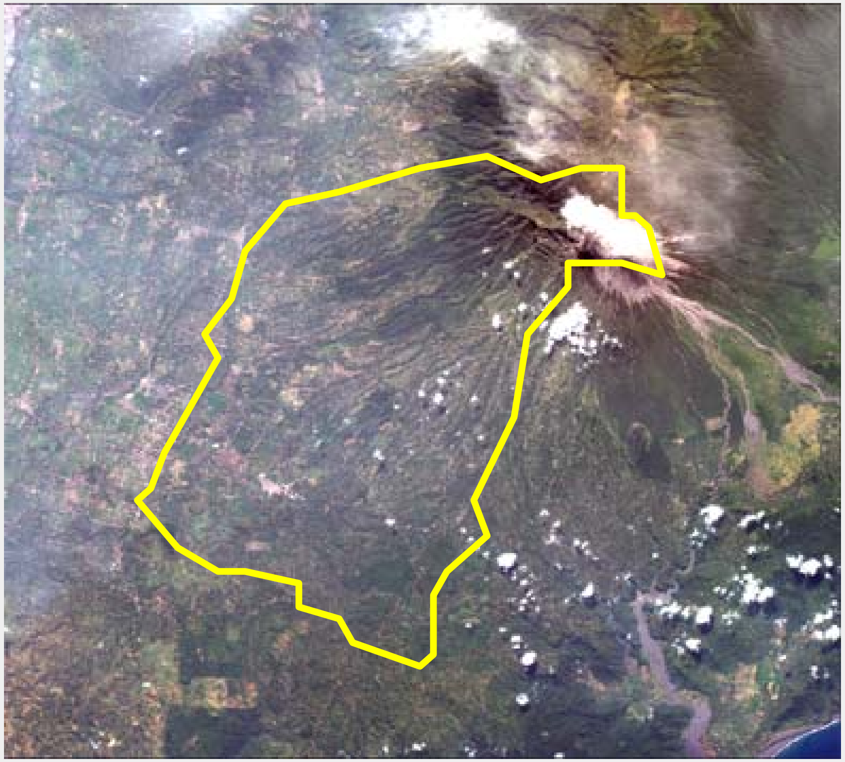
Cultivated

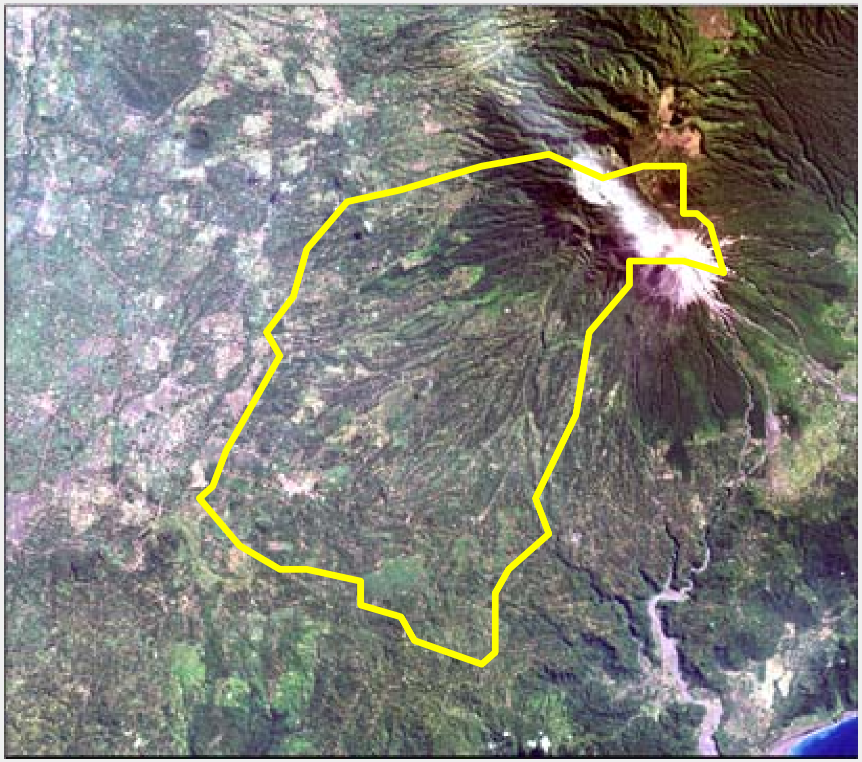
June 1997 by ADEOS/AVNIR

May 2002 by LANDSAT7 ETM+

1. Deforestation in the last 5 yeas ?

Lesti River Basin





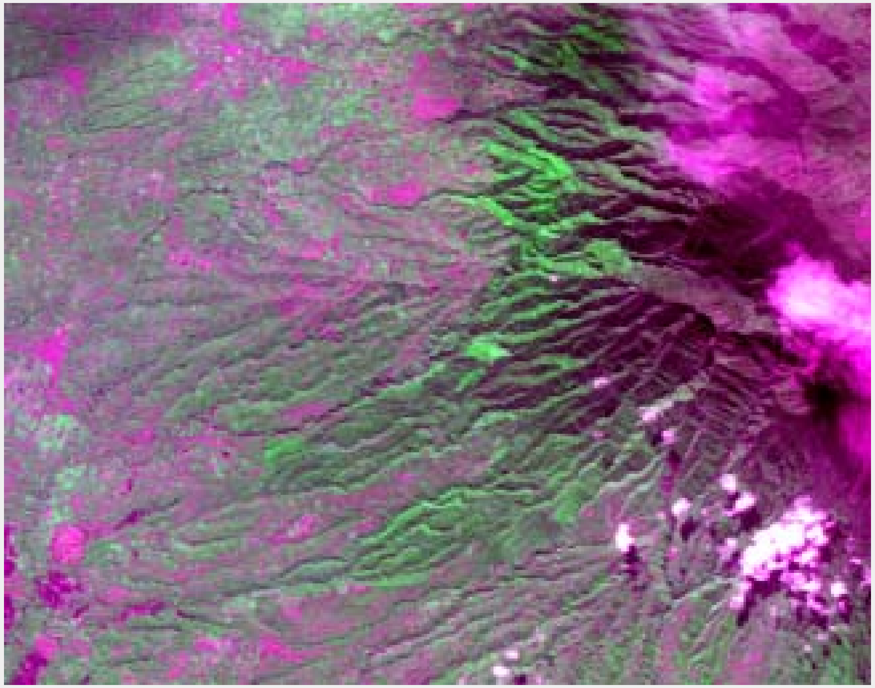
June 4, 1997 by ADEOS/AVNIR
Red : 3 (Red)
Green : 2 (nearIR)
Blue : 1 (Green)

May 19, 2002 by LANDSAT7+/ETM
Red : 3 (midIR)
Green : 2 (nearIR)
Blue : 1 (Green)

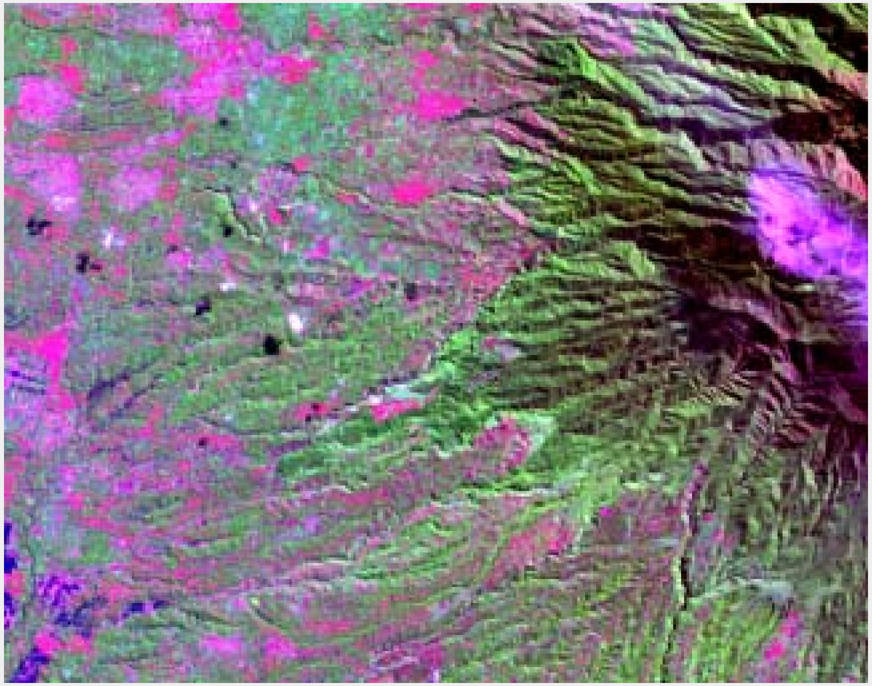
DPRI-KU

1. Deforestation in the last 5 yeas ?

Foot of Mt. Semeru in the Lesti River Basin



June 4, 1997 by ADEOS/AVNIR
Red : 3 (Red)
Green : 4 (nearIR)
Blue : 2 (Green)



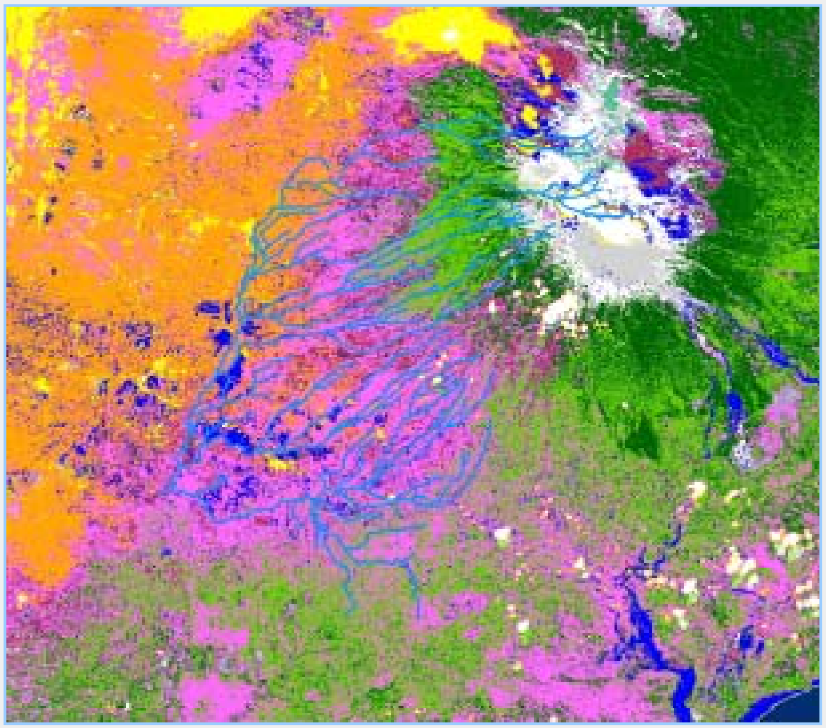
May 19, 2002 by LANDSAT7+/ETM
Red : 7 (midIR)
Green : 4 (nearIR)
Blue : 2 (Green)

DPRI-KU

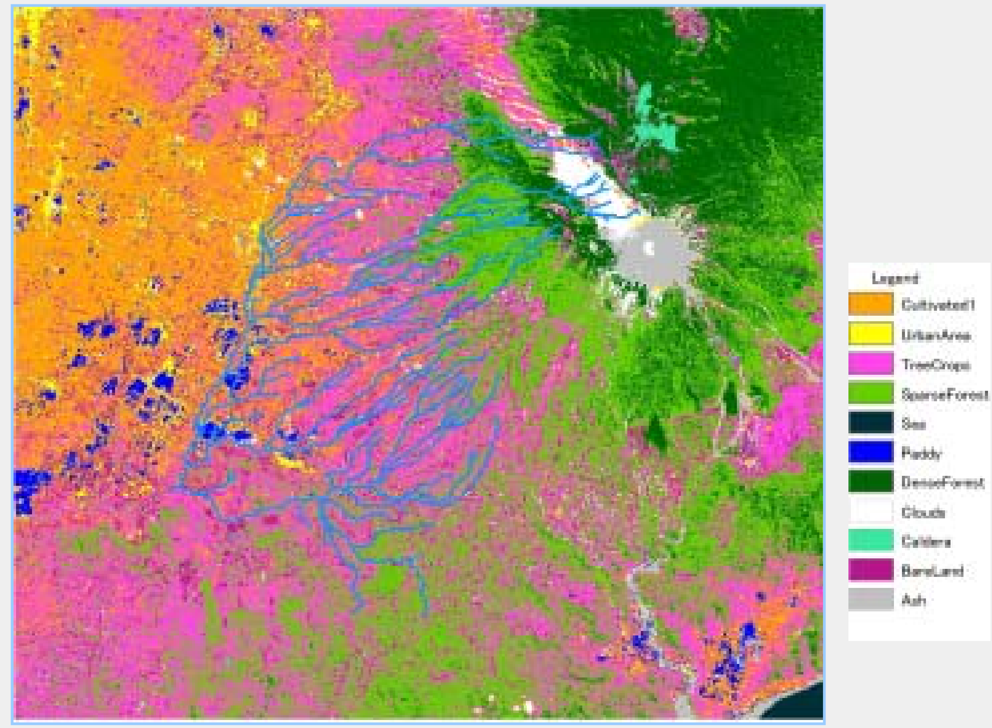
1. Deforestation in the last 5 yeas ?

Land Cover Classification : Lesti River Basin

Inter – annual variability of land cover may not be significant !



June 4, 1997 by ADEOS/AVNIR
Maximum Likelihood



May 19, 2002 by LANDSAT7+/ETM
Maximum Likelihood

2. Seasonal variability of land cover and its effect on erosion

Inner – annual variability of land cover may be more significant !

Oct 2002

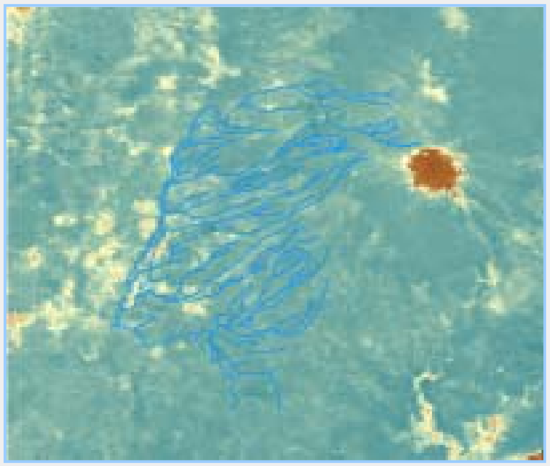
Feb 2003

Oct 2003

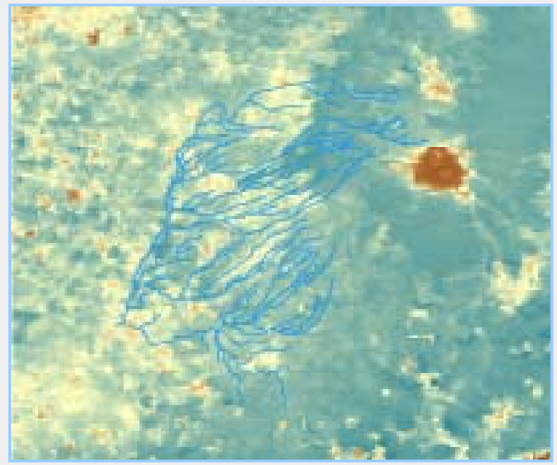
2. Seasonal variability of land cover and its effect on erosion

Dry season : May.- Aug.
Rainy season: Oct. – Mar.

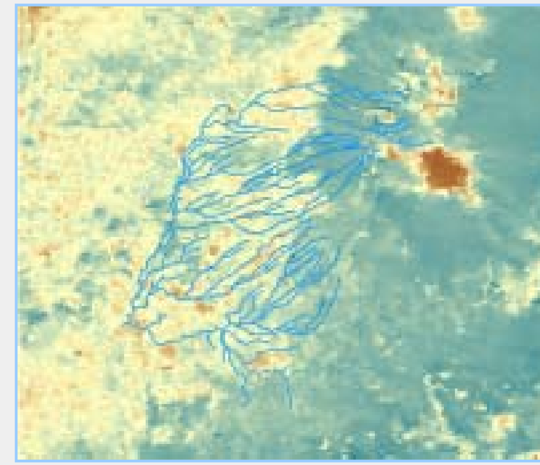
TERRA/MODIS



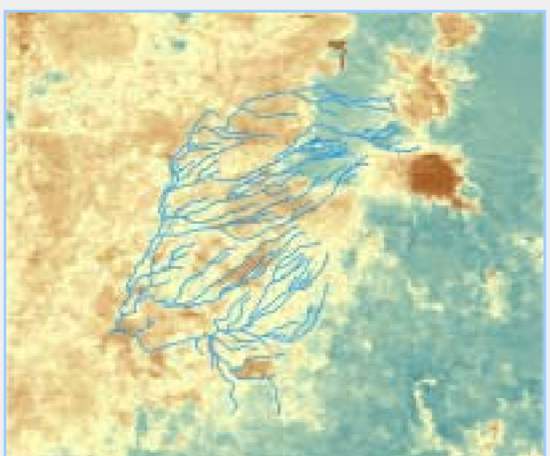
May, 2002



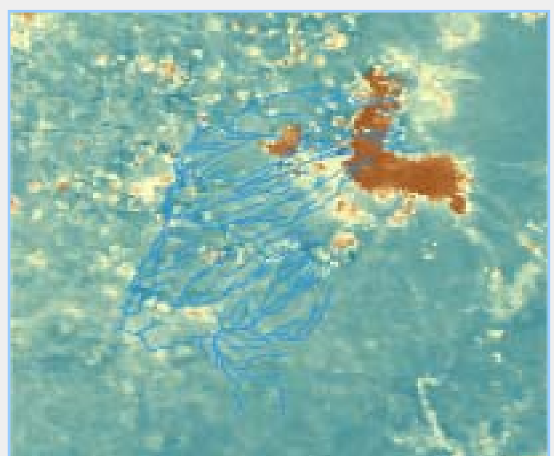
July, 2002



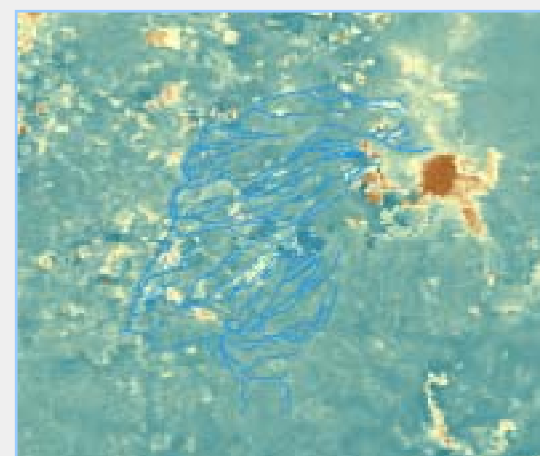
August, 2002



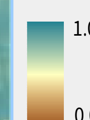
October, 2002



December, 2002

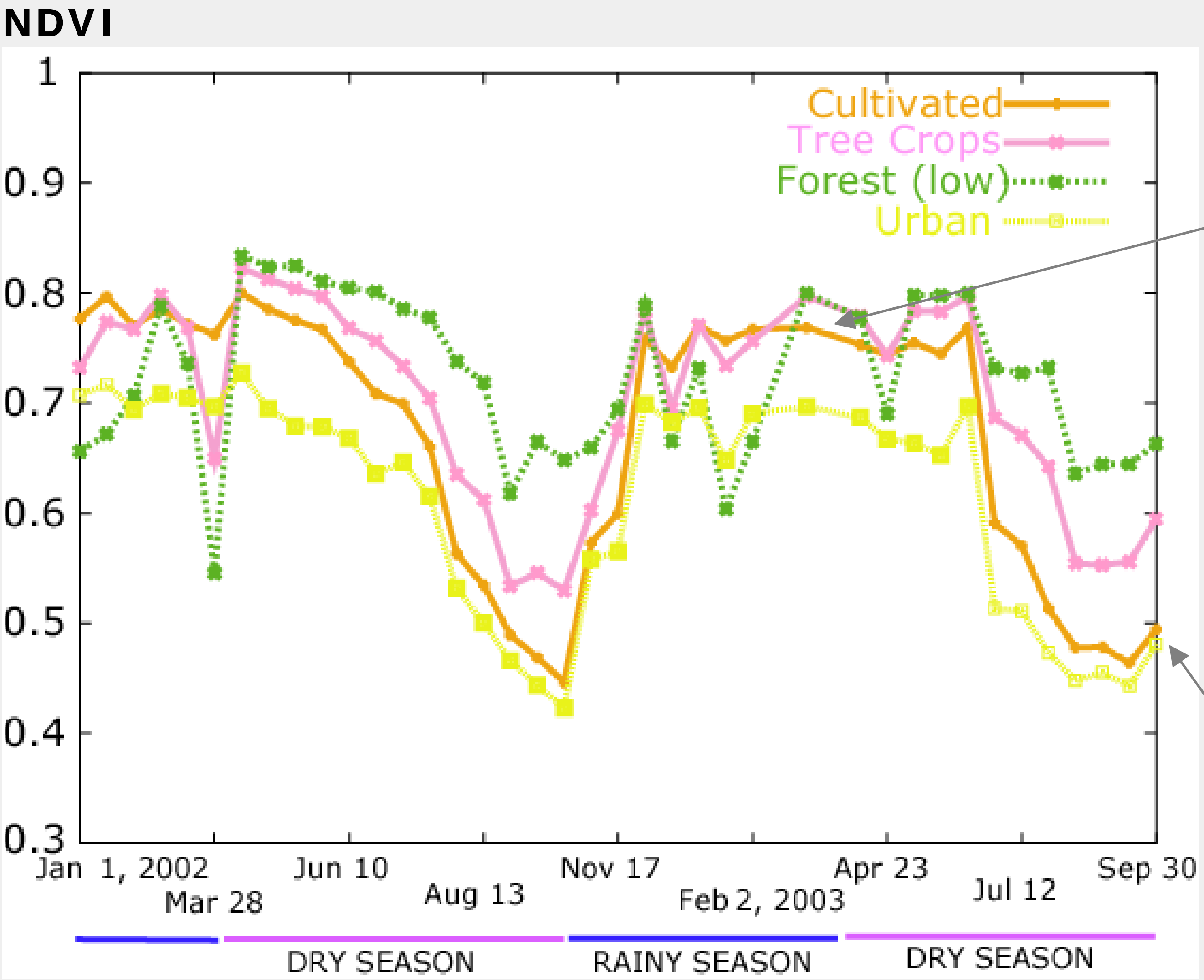


March, 2003



DPRI-KU

2. Seasonal variability of land cover and its effect on erosion

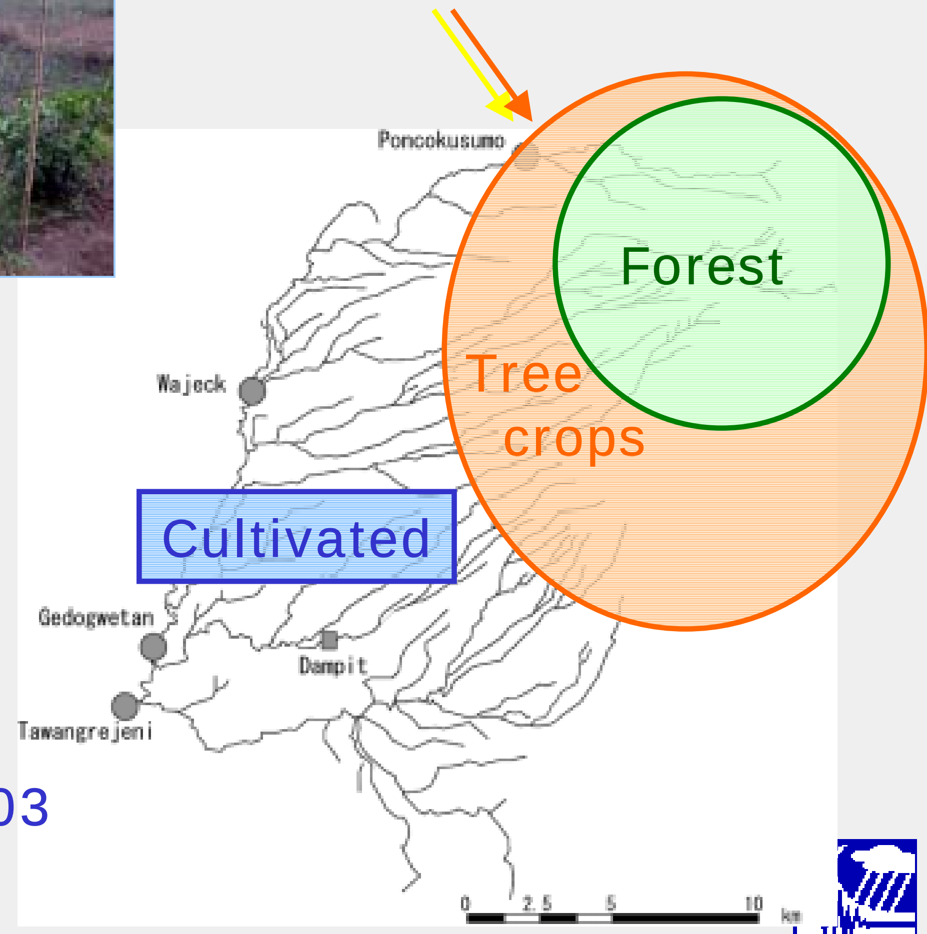


2. Seasonal variability of land cover and its effect on erosion

Tree crops (Apple trees)

Woods

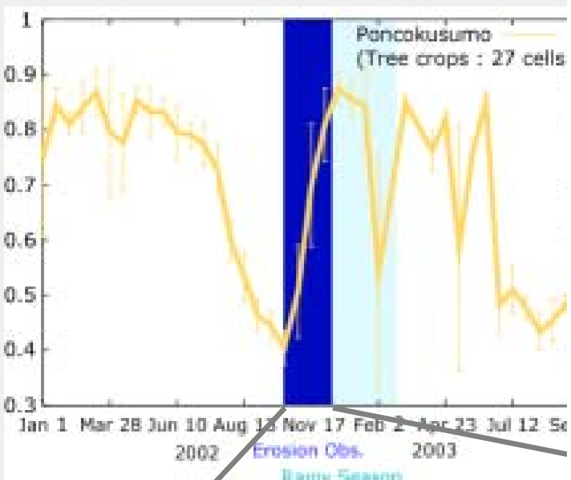
From Oct 2003

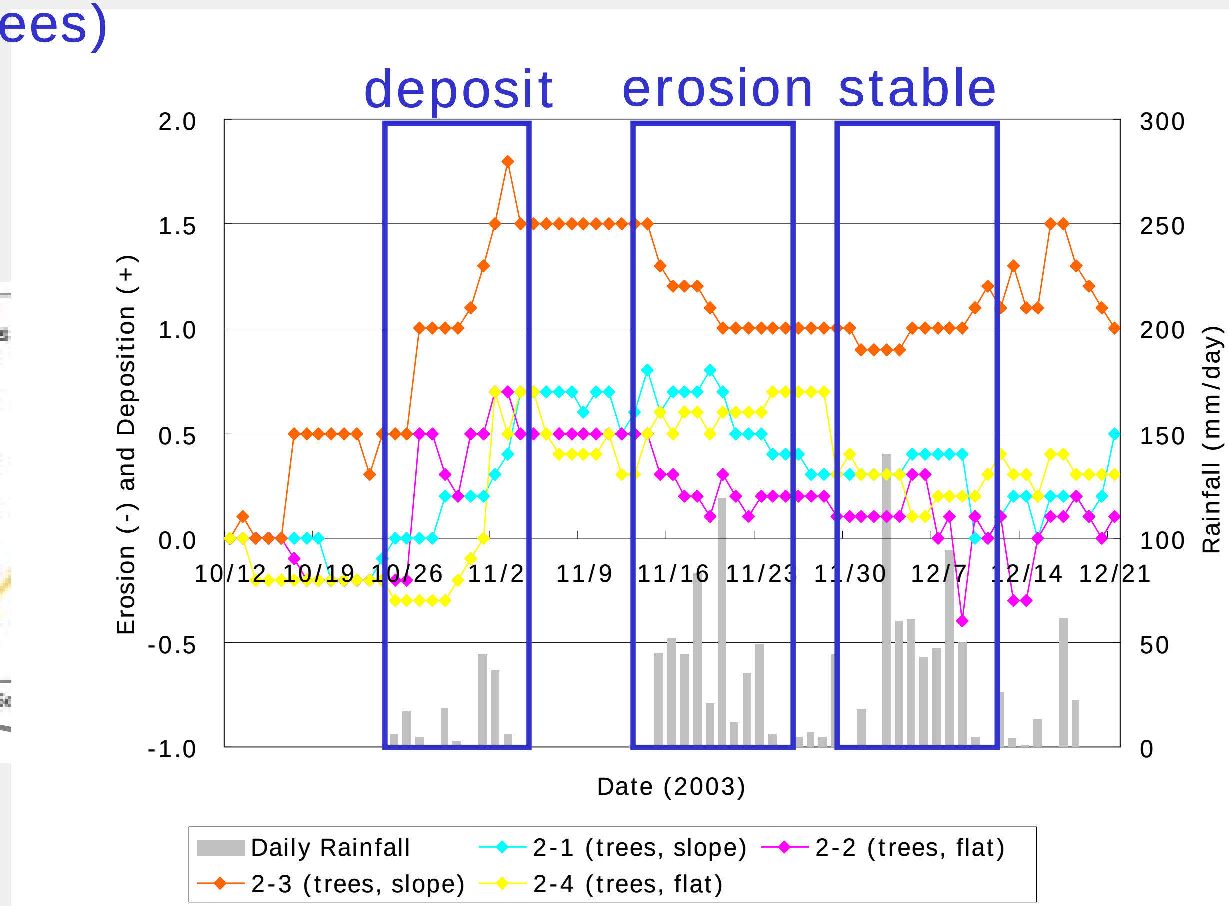


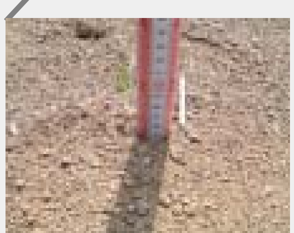
2. Seasonal variability of land cover and its effect on erosion

Tree crops (Apple trees)

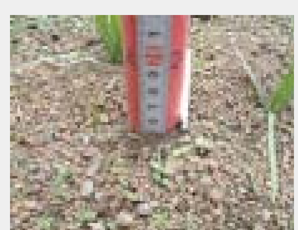
NDVI by MODIS






Oct 12


Nov 1


Nov 6


Nov 17


Nov 29

DPRI-KU

Deforestation increased the sediment yield in the Lesti River Basin ?

1. Deforestation in the last 5 years ?

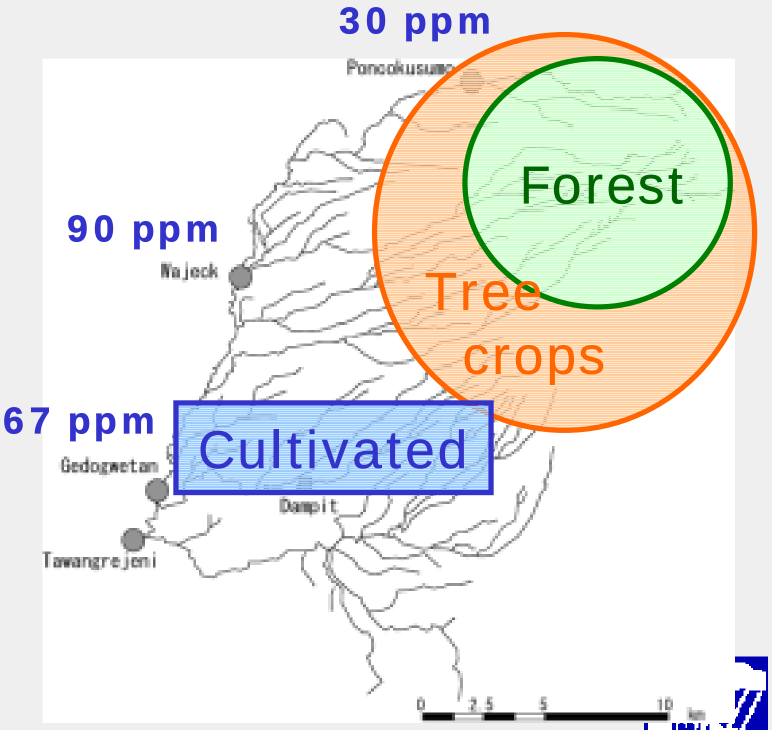
Not significantly.

2. Seasonal variability of land cover and its effect on erosion

Large amount of sediment may be yielded if severe rainfall events come at the beginning of the rainy season, when the cultivated and tree crops areas become like bare land.

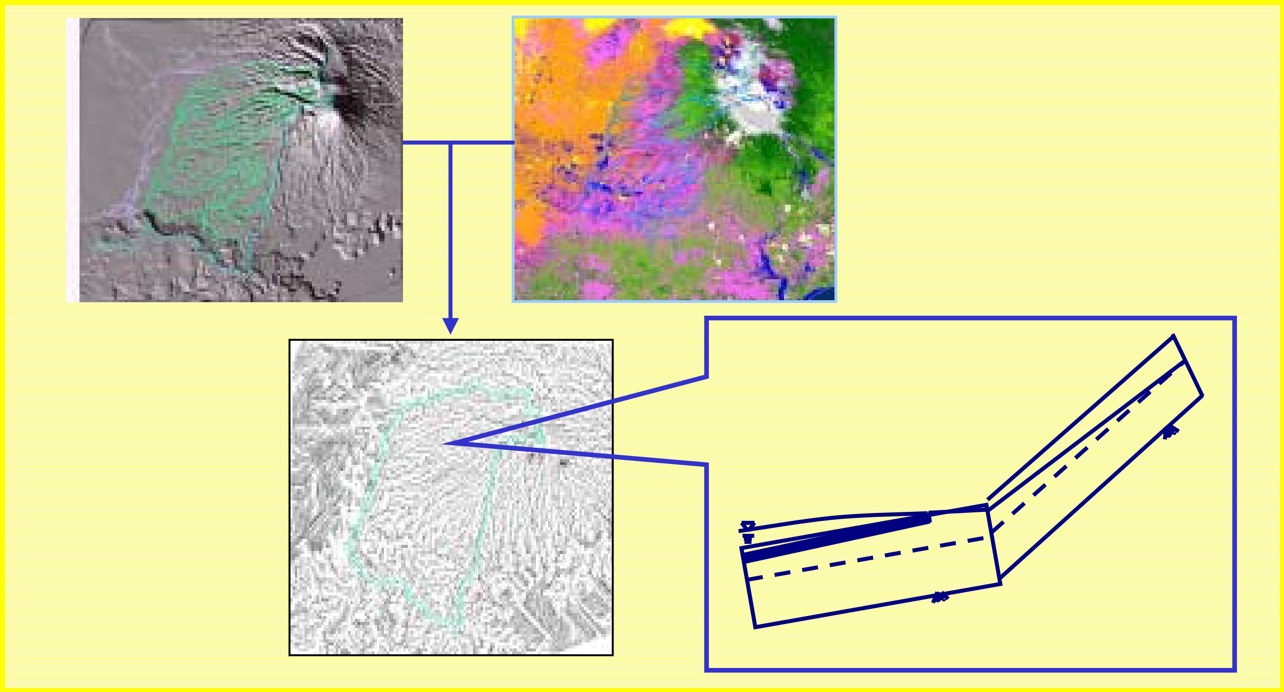
3. Sediment yield from forest areas ?

If the current forest areas is cultivated ?



DPRI-KU

3. Sediment yield from forest areas ?



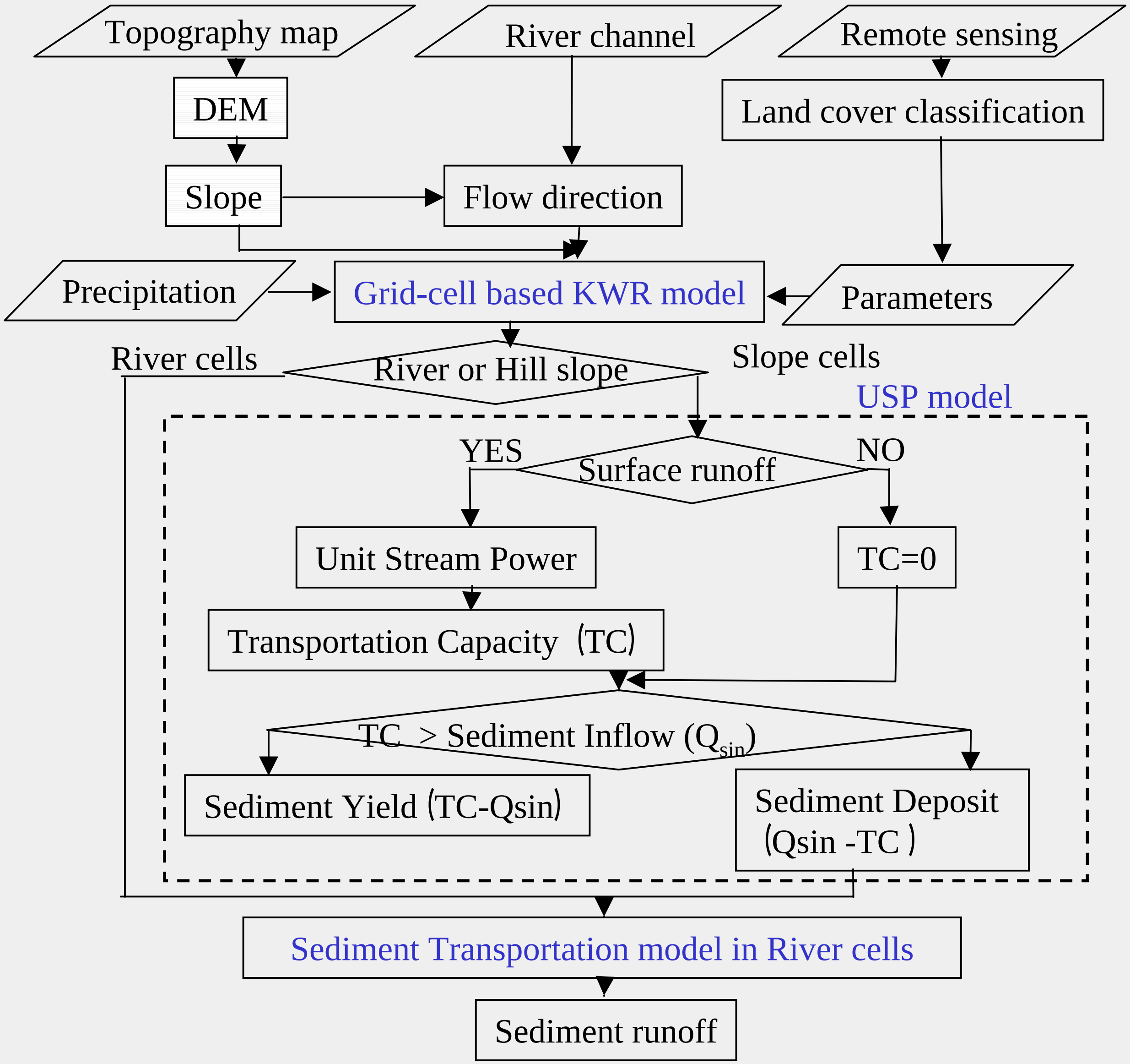
Sediment Transportation Capacity (TC) of surface flow

Erosion : TC > Inflow
Deposit : TC < Inflow

Assumptions : All forested areas are cultivated.
Forest : Saturated, unsaturated subsurface and surface flow
Cultivated : Surface flow

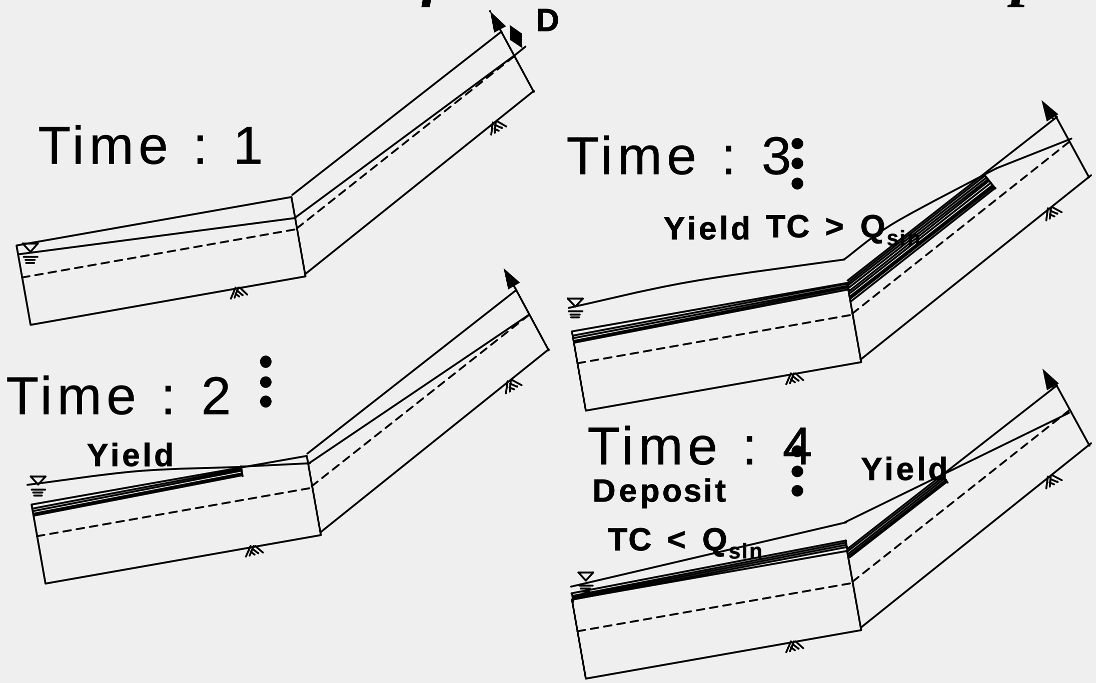
3. Sediment yield from forest areas ?

Distributed Rainfall-Sediment-Runoff model



3. Sediment yield from forest areas ?

USP Model for soil erosion and deposit



VS : Velocity * Slope (Unit Stream Power)

$$\log C_t = I + J\left(\frac{VS}{\omega} - \frac{V_{cr}S}{\omega}\right)$$

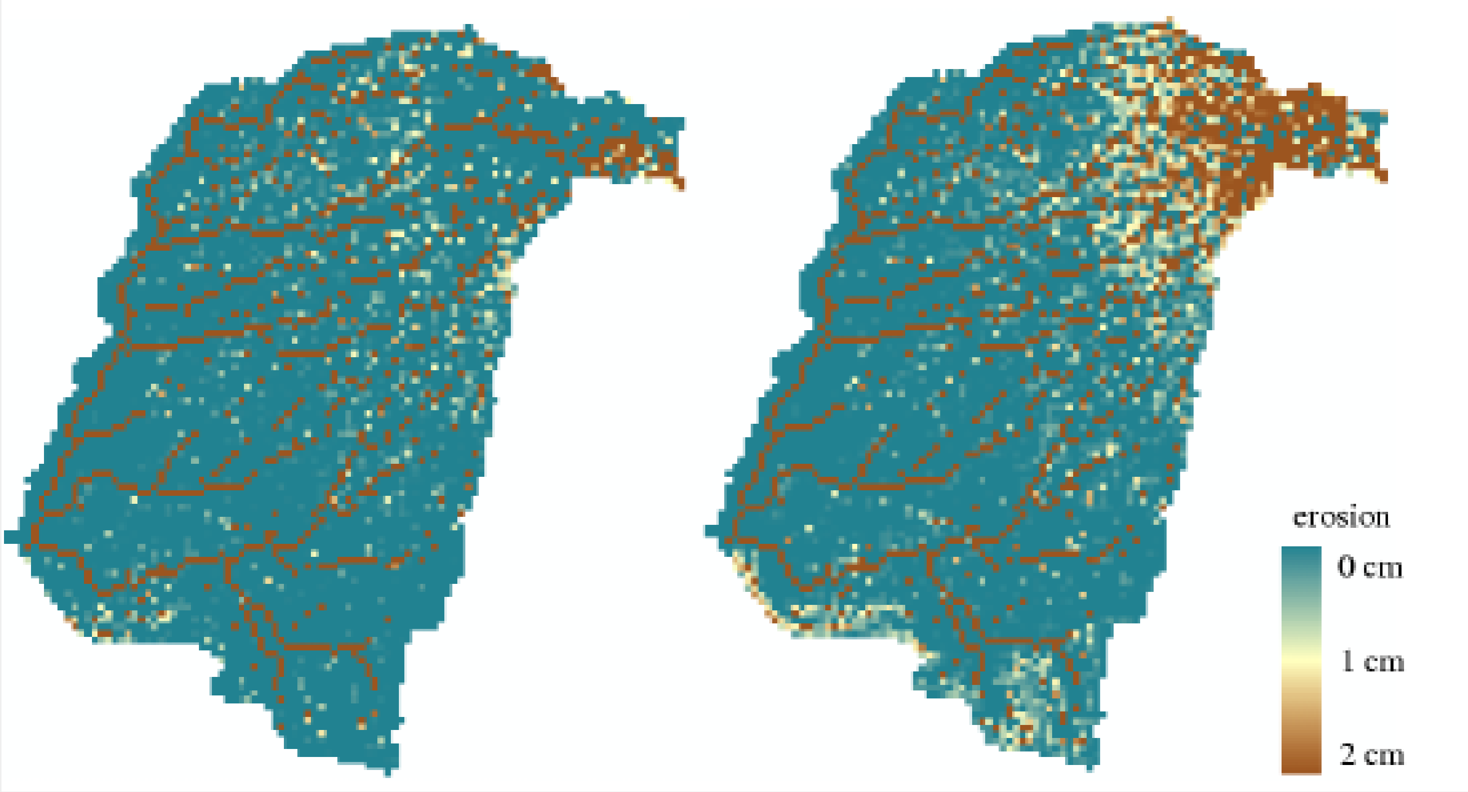
TC : Transportation capacity $TC = Q \times C_t$

Q_{sin} : Sediment Inflow

3. Sediment yield from forest areas ?

Simulated sediment erosion for a rainy season

from Nov 1995 – Apr 1996

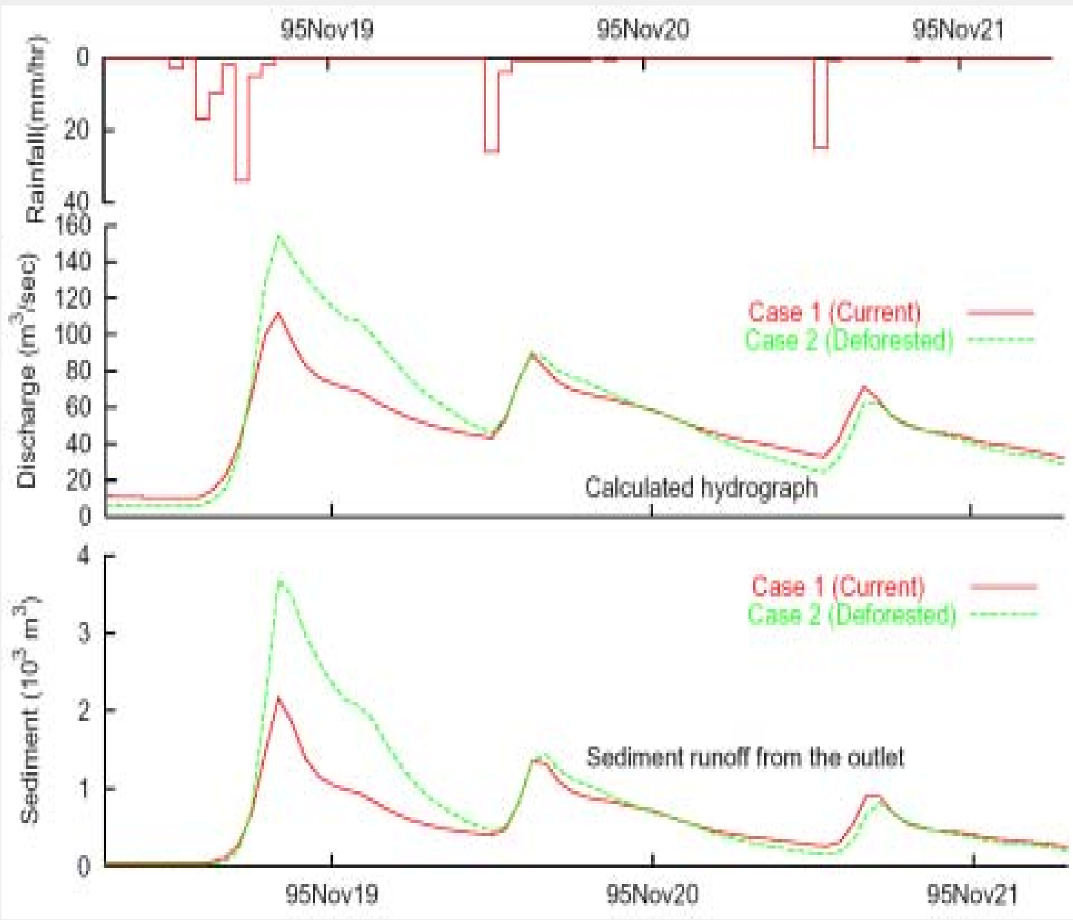


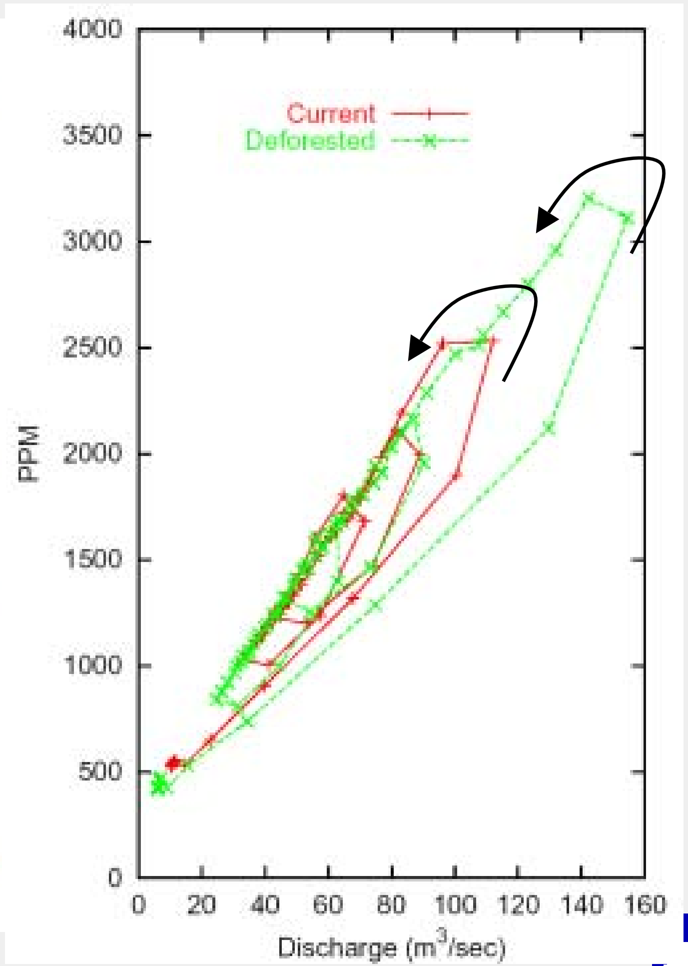
Current Deforested

3. Sediment yield from forest areas ?

For a moderate rainfall event

from Nov 18, 1995 – Nov 21, 1996

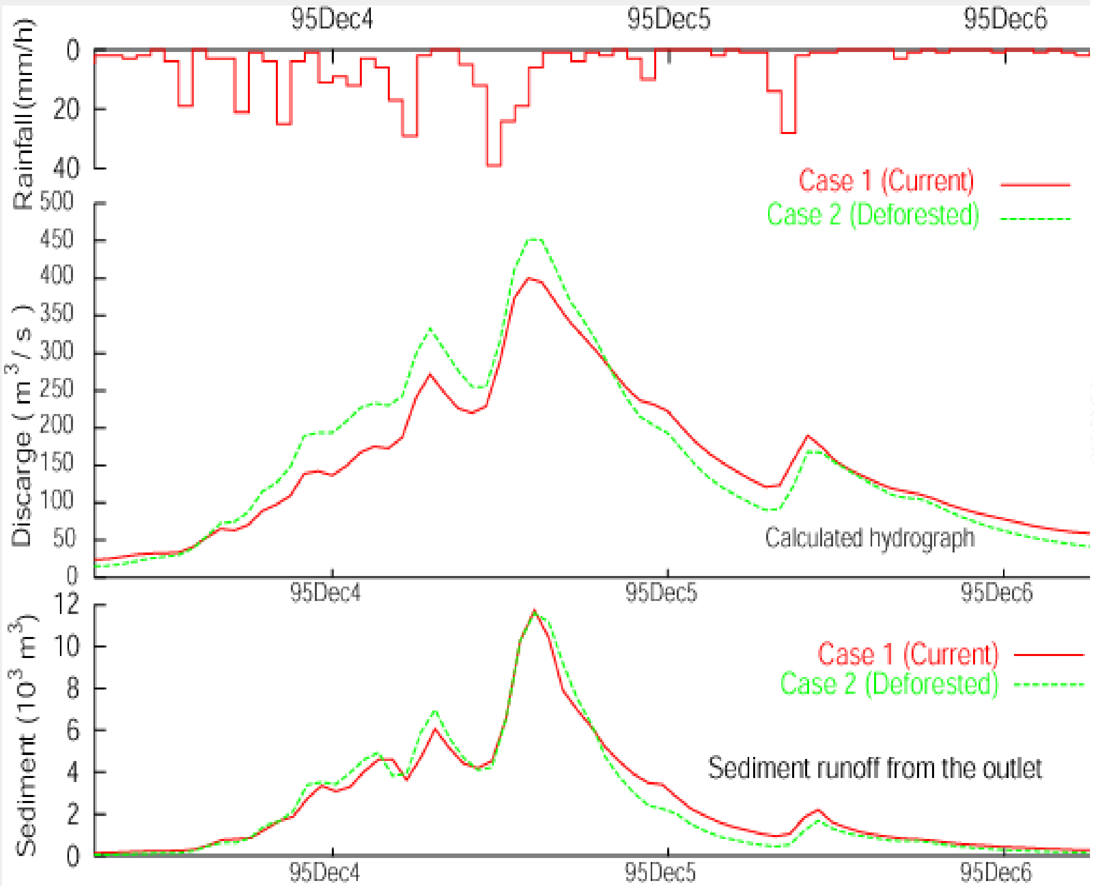


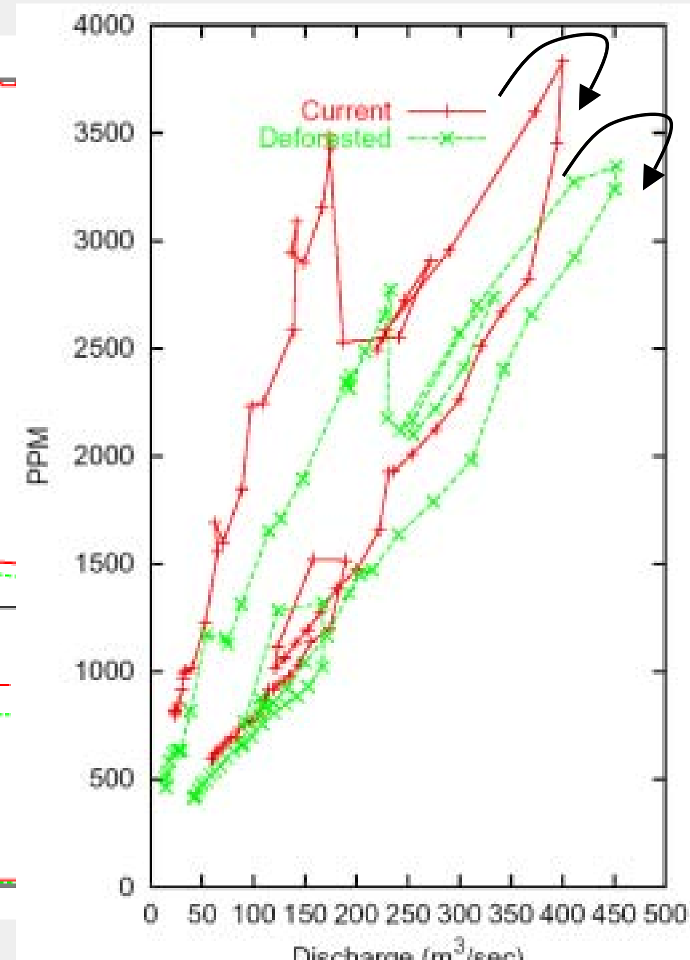


3. Sediment yield from forest areas ?

For a severe rainfall event

from Dec 3, 1995 – Dec 6, 1996

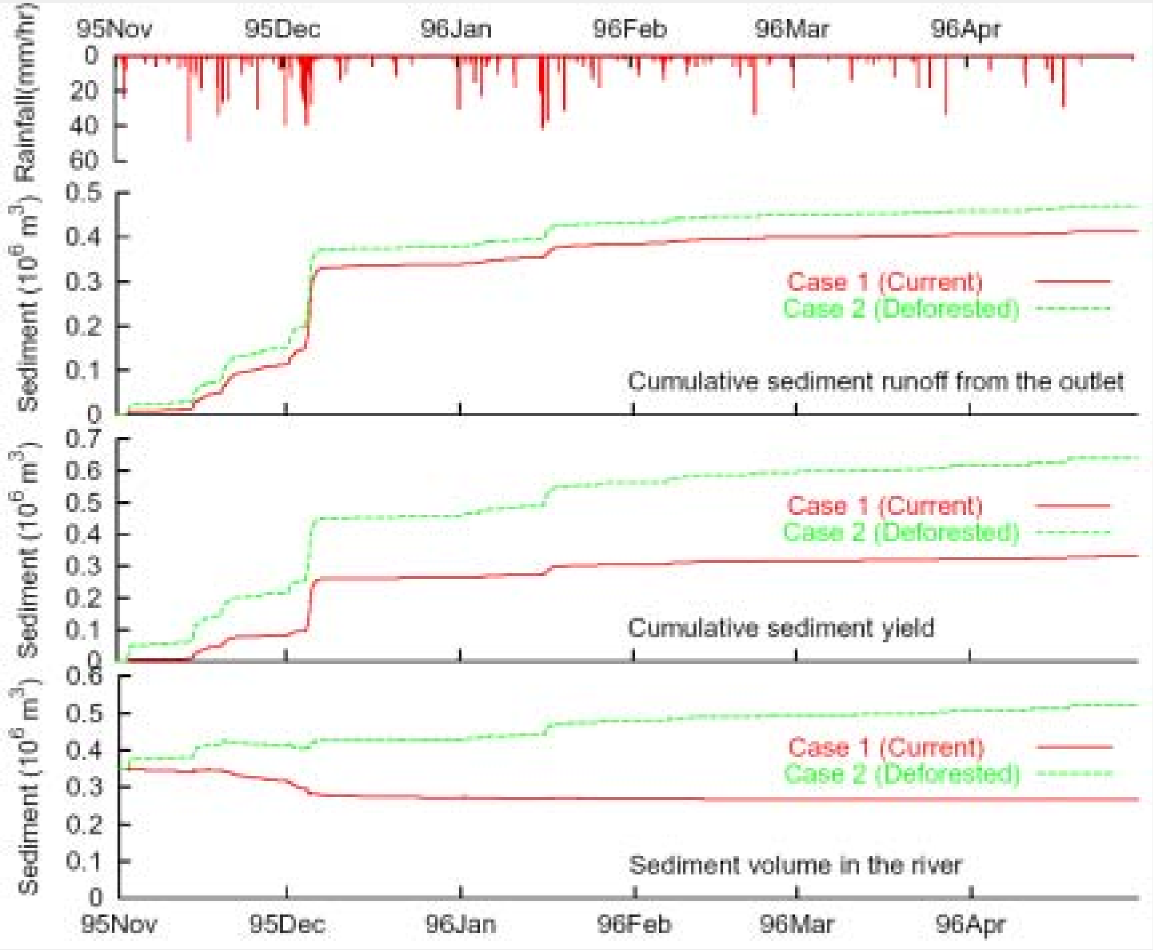


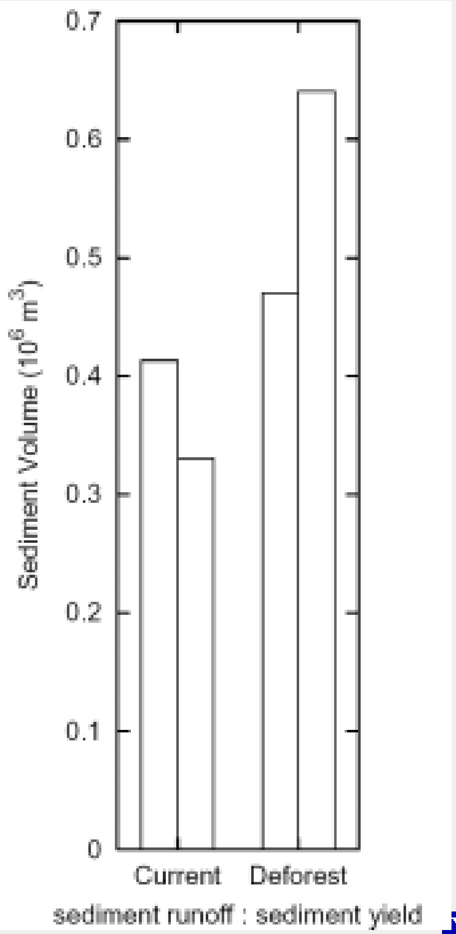


3. Sediment yield from forest areas ?

For a rainy season

from Nov 1995 – Apr 1996





Conclusions for the analysis

1. Deforestation in the last 5 years ?

- Comparison between ADEOS/AVNIR (1997) image and LANDSAT7/ETM+(2002) image did not show the massive deforestation inside the Lesti River basin.

2. Seasonal variability of land cover and its effect on erosion

- Multi temporal TERRA/MODIS NDVI succeed to show the seasonal variability of vegetation activity, which affect erosion rate.

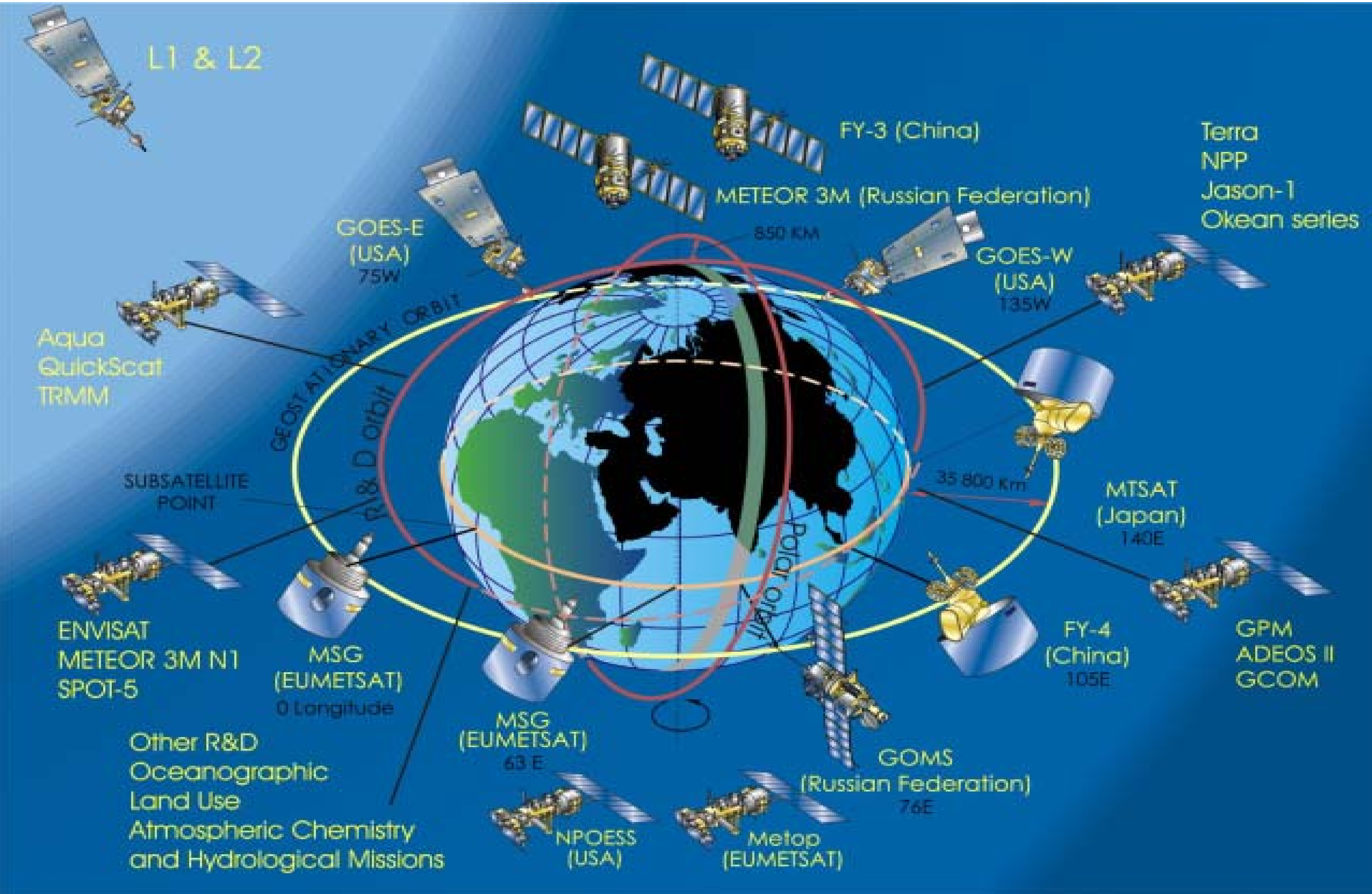
- Land cover in the cultivated areas become like bare land at the beginning of a rainy season, and sediment movement becomes active at the same time.

3. Sediment yield from forest areas ?

- Model study indicated large-scale deforestation increases sediment yield, but not as much of sediment load, especially for a severe rainfall event.

DPRI-KU

DURING THE NEXT DECADE THERE WILL BE AN UNPRECEDENTED NUMBER OF SATELLITES OBSERVING THE EARTH. THEY ALSO HAVE THE POTENTIAL TO ALTER THE WAY IN WHICH SOCIETY MANAGES WATER.



IGBP
http://www.igbp.kva.se/

CEOS
http://www.ceos.org

IGFA
IGFA@forskningsradet.no

GCOS
http://www.wmo.ch/web/gcos/

IGOS-Partners

the major satellite and ground-based systems for global environmental observations of the atmosphere, oceans and land in a framework that delivers maximum benefit and effectiveness in their final use

WCRP
http://www.wmo.ch

GOOS
http://www.ioc.unesco.org/goos/

WMO
http://www.wmo.ch

GTOS
http://www.fao.org/gtos/

UNESCO
http://www.unesco.org

FAO
http://www.fao.org

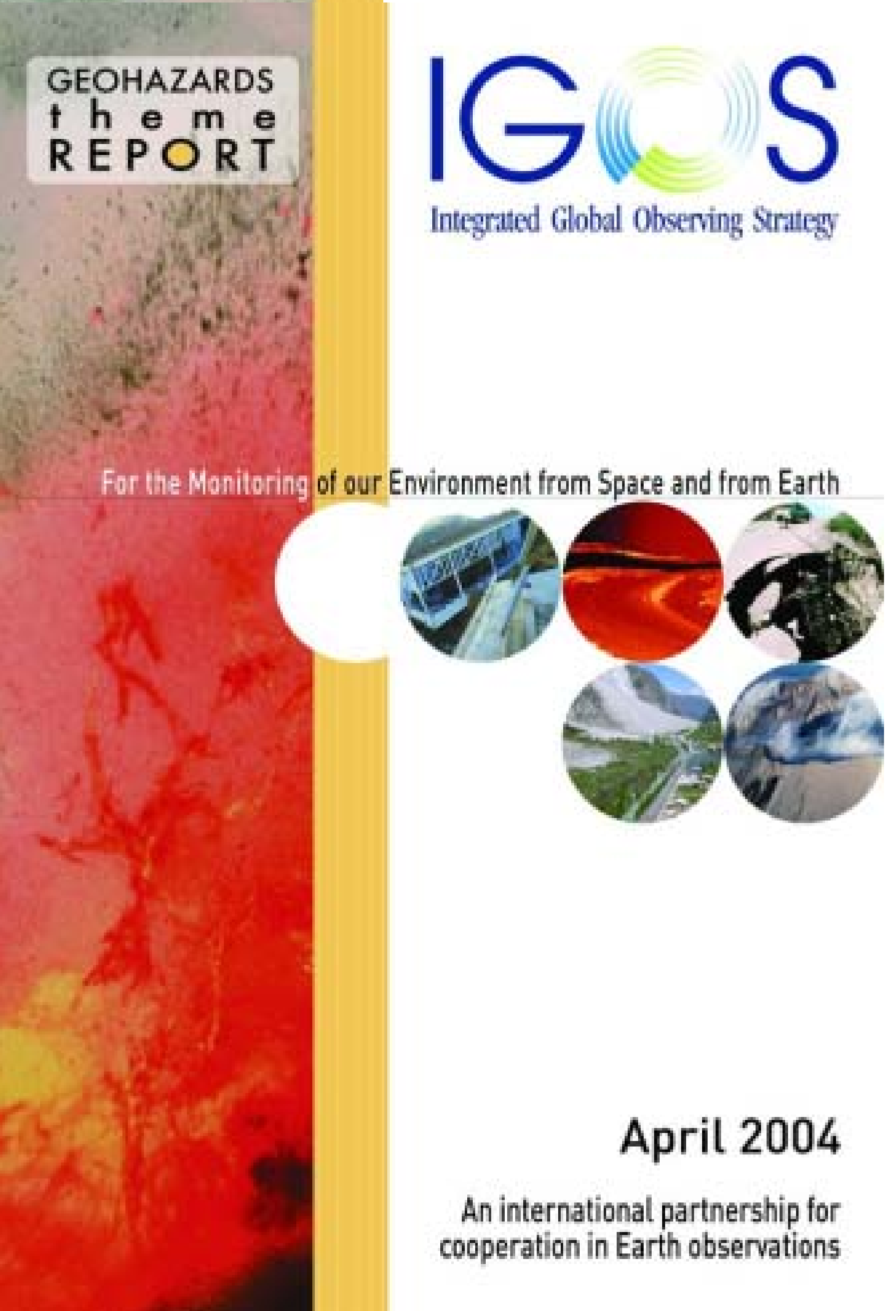
Integrated Global Observing Strategy

UNEP
http://www.unep.org

ICSU
http://www.icsu.org

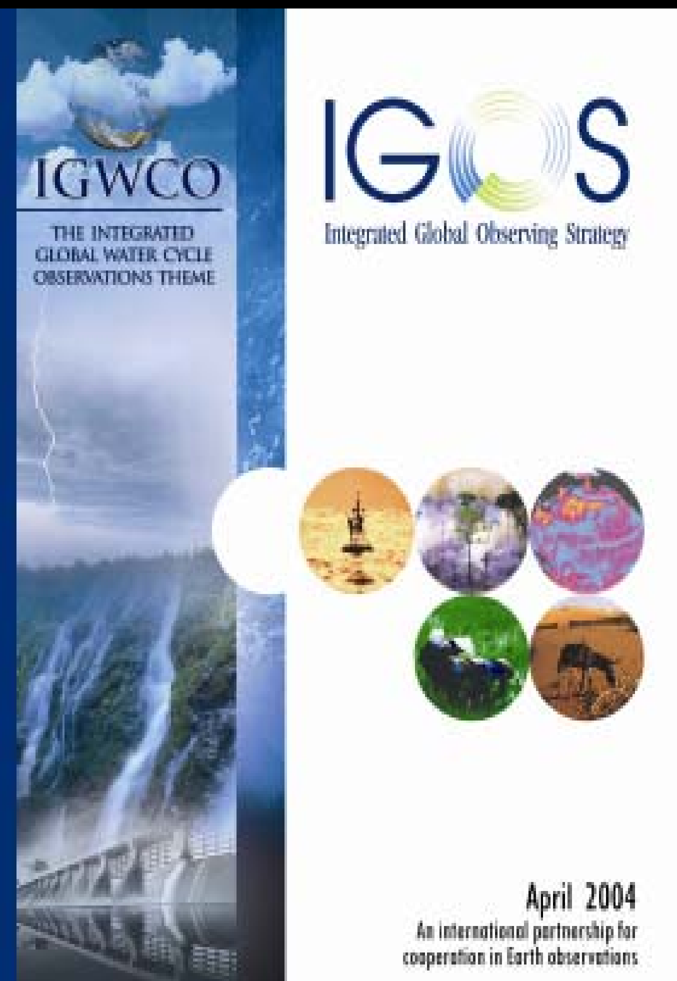
IOC
http://www.ioc.unesco.org/iocweb/

The IGOS Geohazards theme report



- Context, scope and strategic objectives
- Beneficiaires, stakeholders and user needs
- Required observations and key systems
- Integration issues
- Filling the gaps
- Implementation plan and commitments to act

IGOS-P PREPARED A BACKGROUND DOCUMENT ON WATER
IGWCO: Integrated Global Water Cycle Observation theme



OBJECTIVES:

1) Provide a framework for guiding decisions on priorities and strategies regarding water cycle observations for:
   - Monitoring climate variability and change,
   - Effective water management and sustainable development of the world's water resources,
   - Societal applications for resource development and environmental management,
   - Specification of initial conditions for weather and climate forecasts,
   - Research directed at priority water cycle issues.
2) Promote strategies that facilitate the processing, archiving and distribution of IGWCO data products.

Towards a Global Observing System Architecture

IGOS IS DEVELOPING THE <u>STRATEGY</u> FOR INTEGRATING OBSERVATIONAL SYSTEMS

EOSs AND GEO ARE DEVELOPING A PLAN FOR AN INTEGRATED OBSERVATIONAL SYSTEM OF SYSTEMS (GEOSS)

ESSP (INCLUDING GEWEX) IS CARRYING OUT THE RESEARCH NEEDED TO DEVELOP A PREDICTION SYSTEM TO SUPPORT WATER MANAGEMENT

ESSP

(DIVERSITAS, IGBP, IHDP, WCRP)

QuickTimeý Ç²
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Ç™Ç±ÇÃÉsÉNÉ`ÉÉÇ¾å©ÇÈÇžÇ½Ç…ÇÕïKóvÇ-Ç ÅB

THROUGHOUT HISTORY THE ABILITY TO OBSERVE HAS HAD PROFOUND EFFECTS ON WATER MANAGEMENT

EPOCH #1: WATER: NATURE'S GIFT TO MANKIND (DAWN OF CIVILIZATION TO LAST CENTURY)

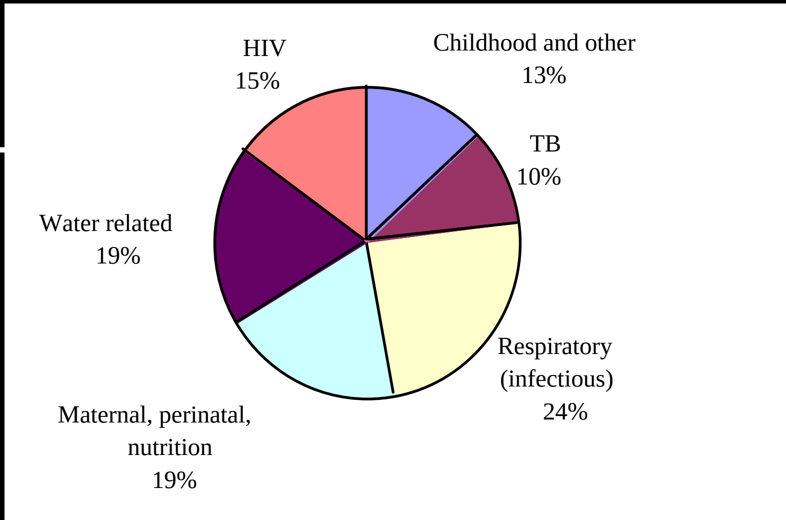
WATER IS ESSENTIAL FOR LIFE

EPOCH #2: WATER AND DEVELOPMENT (LATE 1800'S TO PRESENT)

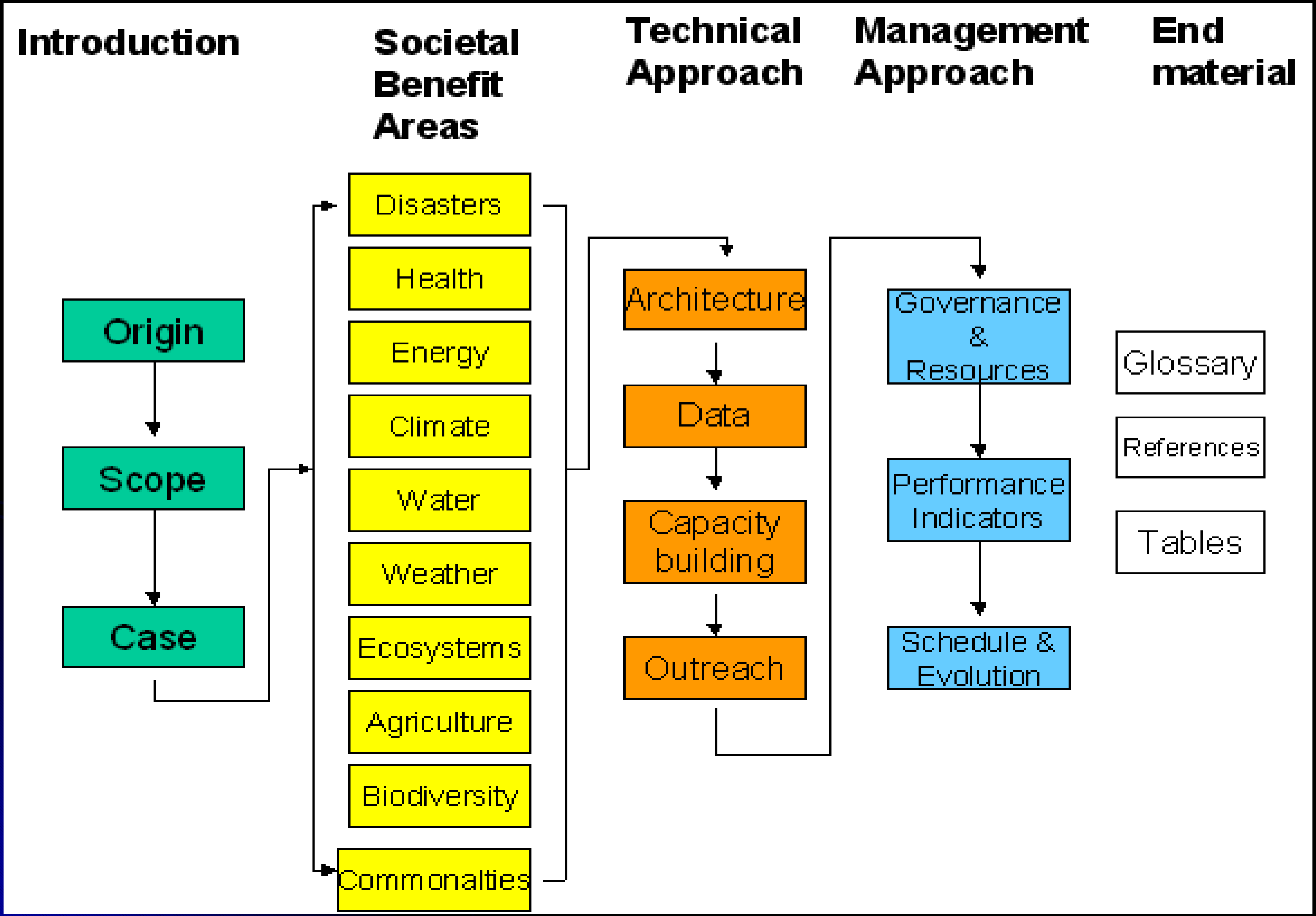
WATER IS ESSENTIAL FOR PROSPERITY

EPOCH #3: WATER AND THE ENVIRONMENT (APPROX. MID-1960'S TO THE PRESENT)

WATER IS ESSENTIAL FOR HEALTH (FOR HUMANS AND ECOSYSTEMS)

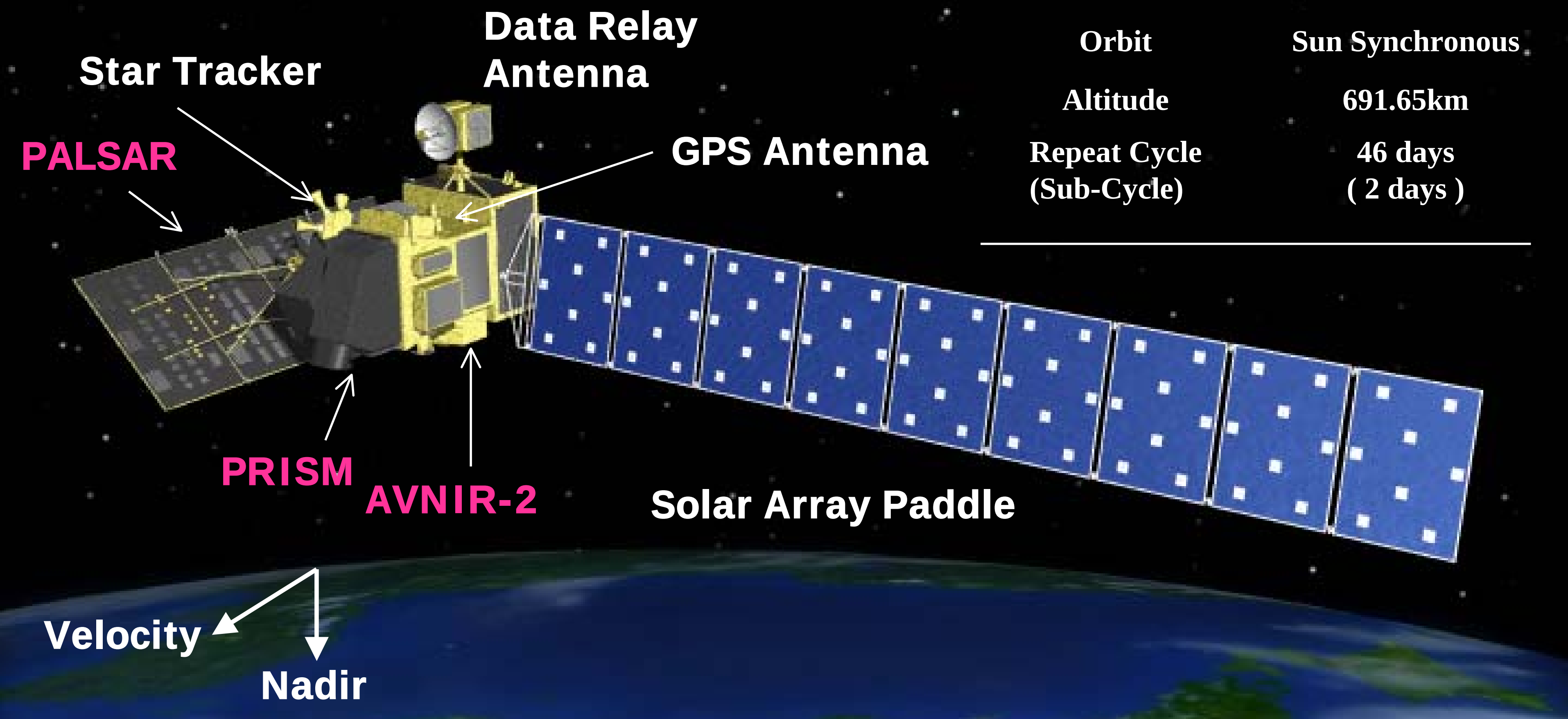


GEOSS 10-year PLANS DEVELOPED ON A HIGH PRIORITY BASIS



ALOS Satellite System

Launch Date	JFY 2004
Launch Vehicle	H-IIA
Spacecraft Mass	about 4,000kg
Generated Elec. Power	about 7kW at EOL
Orbit	Sun Synchronous
Altitude	691.65km
Repeat Cycle (Sub-Cycle)	46 days (2 days)



PRISM : Panchromatic Remote-sensing Instrument for Stereo Mapping
AVNIR-2 : Advanced Visible and Near Infrared Radiometer type 2
PALSAR : Phased Array type L-band Synthetic Aperture Radar

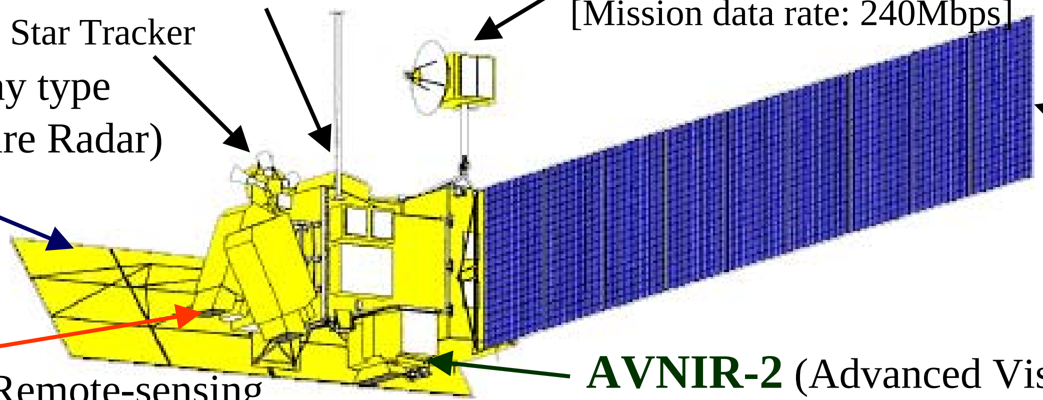
ALOS Features for Each Mission

- **Cartography**
  - **3 to 5m accuracy Digital Elevation Model (DEM) for 1/25,000 scale map**
  - **High resolution (2.5m) and wide swath width (35 or 70km)**
  - **Mapping without any Ground Control Points**
- **Regional Observation**
  - **Multi-Spectral & Multi-Polarization Observation**
  - **ALOS realizes first-ever simultaneous observation by Optical Sensor and SAR.**
  - **Wide Swath Width and Frequent Observation (Seasonal Changes)**
- **Disaster Monitoring**
  - **Observation within 48 hours (on the equator) or 24 hours (at 60deg latitude)**
  - **All weather, day-and-night observation by SAR.**
- **Earth Resources Survey**
  - **JERS-1 Successor**

ALOS Mission Objectives and Sensors

Mission Objectives	PRISM	AVNIR-2	PALSAR
Cartography	◎	○	○
Regional Environmental Monitoring	◎	◎	◎
Disaster Monitoring	○	◎	◎
Earth Resource Survey	○	○	◎

Advanced Land Observing Satellite (ALOS)



ALOS mission objectives are to;

(1) Provide and update maps for Japan and other countries including those in the Asian-Pacific region (Cartography),

(2) Perform regional observation for "sustainable development," harmonization between Earth environment and development (Regional Observation),

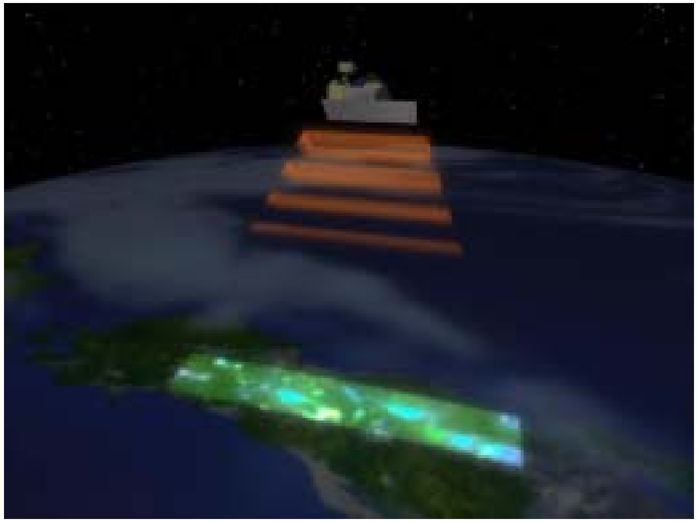
(3) Conduct disaster monitoring around the world (Disaster Monitoring),

(4) Survey natural resources (Resources Surveying), and

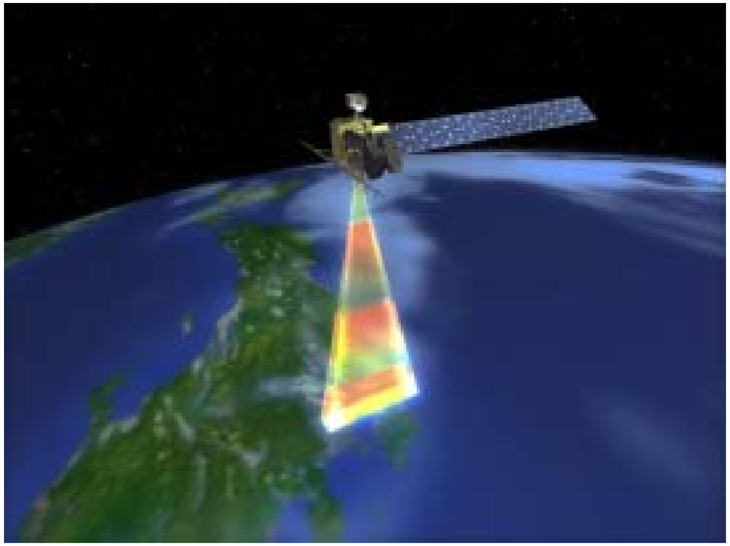
(5) Develop technology necessary for future Earth observing satellites (Technology Development).

ALOS Overview

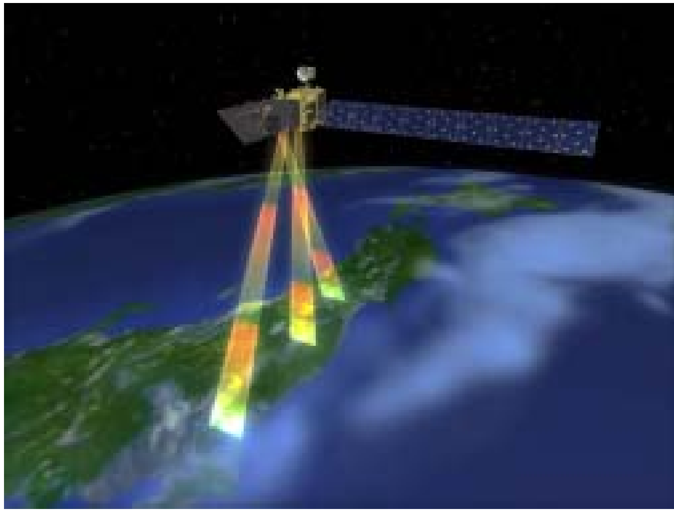
- Launch Vehicle: H-IIA Rocket
- Launch Site: Tanegashima Space Center, Japan
- Satellite Mass: Approx. 4000kg at lift-off
- Generated Power: Approx. 7 kW at EOL
- Design Life: 3 to 5 years
- Orbit: Sun-Synchronous Sub-Recurrent
- Repeat Cycle: 46 days, Sub Cycle: 2 days
- Altitude: 691.65 km at equator
- Inclination angle: 98.16 deg.



PALSAR (Phased Array type L-band Synthetic Aperture Radar)
1.27GHz, HH/VV/HH+HV/VV+VH/HH+HV+VH+VV,
10-100m, 70-350km



AVNIR-II
(Advanced Visible and Near Infrared Radiometer-II)
4ch, 10m, 70km



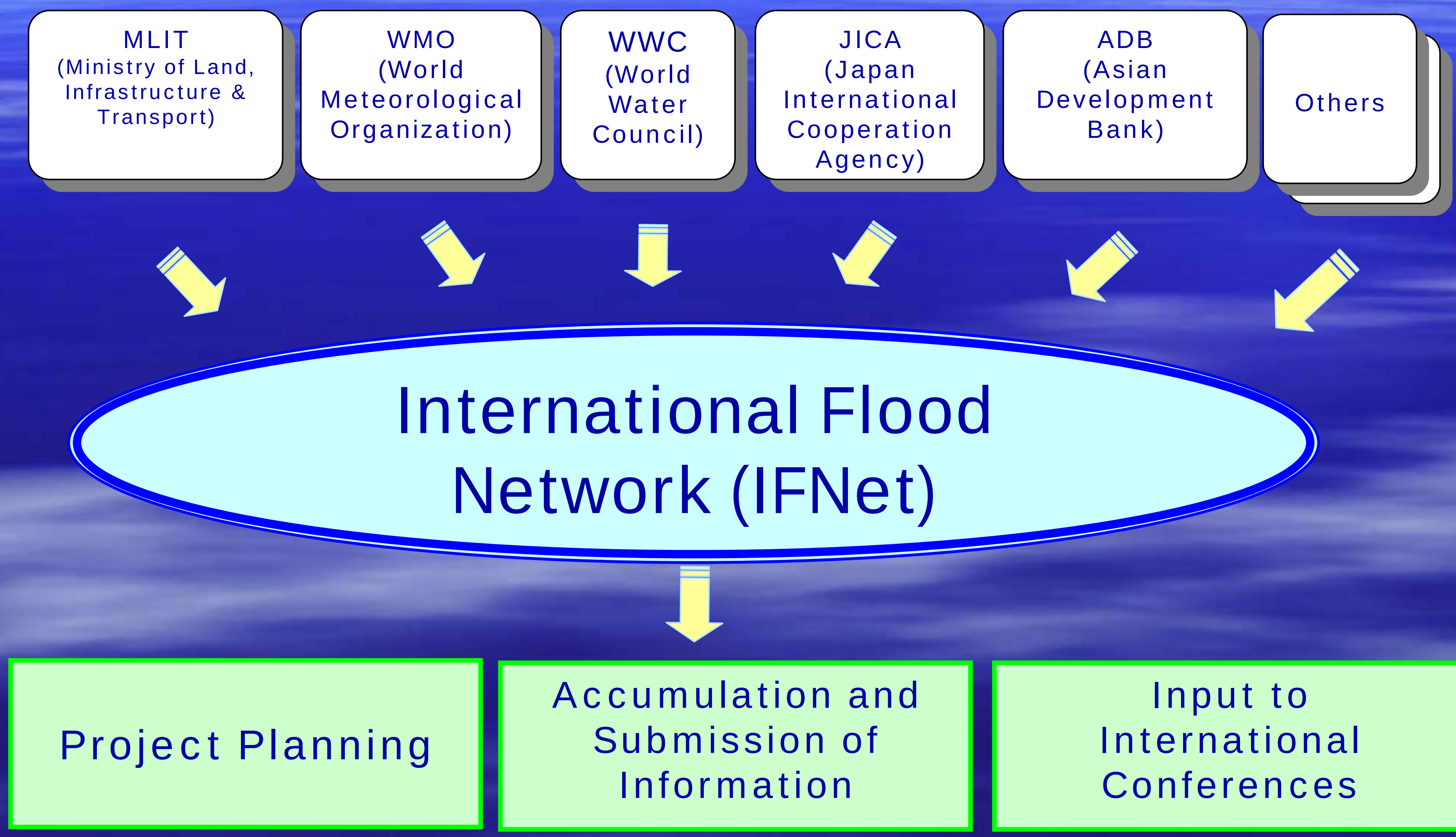
PRISM
(Panchromatic Remote-sensing Instrument for Stereo Mapping)
1ch, 2.5m, 35/70km×3 optics

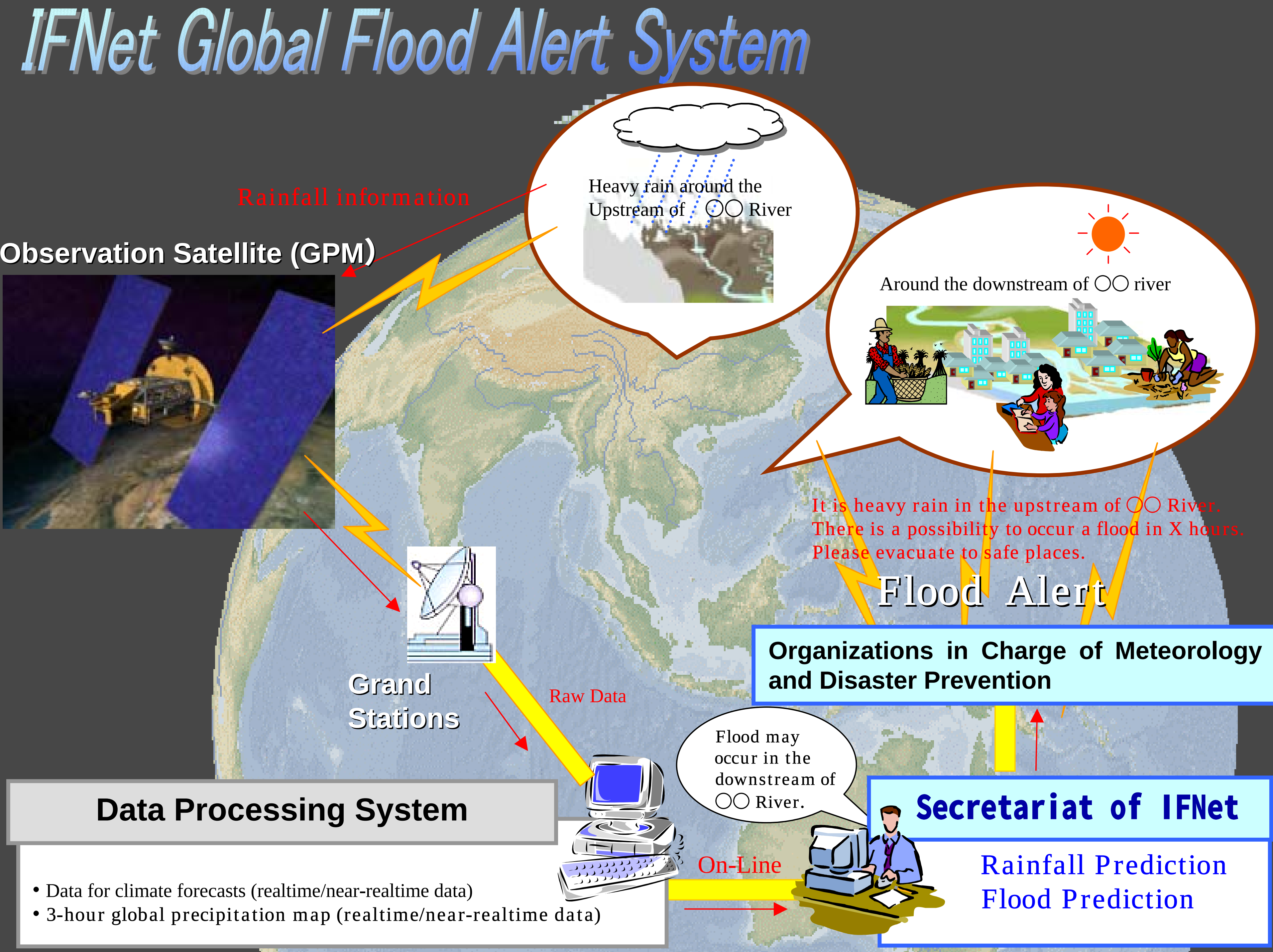
International Flood Network
- IFNet -

<Establishment>

International Flood Network (IFNet) was officially established during the WWF3 in Kyoto March 2003

International Flood Network Image




IFNet Global Flood Alert System
Rainfall information
Observation Satellite (GPM)
Heavy rain around the Upstream of 〇〇 River
Around the downstream of 〇〇 river
It is heavy rain in the upstream of 〇〇 River.
There is a possibility to occur a flood in X hours.
Please evacuate to safe places.
Flood Alert
Organizations in Charge of Meteorology and Disaster Prevention
Grand Stations
Raw Data
Flood may occur in the downstream of 〇〇 River.
Secretariat of IFNet
Rainfall Prediction
Flood Prediction
On-Line
Data Processing System
• Data for climate forecasts (realtime/near-realtime data)
• 3-hour global precipitation map (realtime/near-realtime data)

Outline of Global Precipitation Measurement (GPM)

- Scheme of establishment in observing global precipitation every 3 hours with the main satellite and 8 supportive satellites
- Japan's contribution: Development of dual precipitation data and launch of HLA Rocket

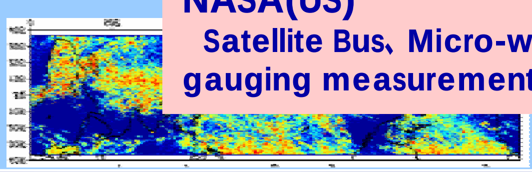
Main Satellite

Dual Precipitation Data

✧Observation of rainfall with more accurate and higher resolution

✧Adjustment of data from supportive satellites

JAXA (Japan)
Dual precipitation Radar、Rocket
NASA(US)
Satellite Bus、Micro-wave gauging measurement

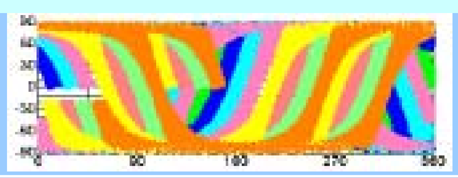


Supportive Satellite

Satellites with Micro-wave gauging Measurement

✧More frequent Observation

Cooperation：NOAA(US)、NASA(US)、ESA（EU)、China, Korea and others



- –Earth heating Phenomena
- –Study of Climate Change
- –Improvement of forecasting system

Global Observation every 3 hours

- •IWRM
- •Flood Forecasting
- •Forecasting of crop productivity

Other International Programs

- UNESCO's International Hydrological Programme (IHP)
- International Flood Initiative/Programme (IFI/P)
- International Sediment Initiative (ISI)

  - UNESCO-WMO joint projects

  - See **http://www.unesco.org/water**

- International Programme on Landslides (IPL)

  - Coordinated by International Consortium on Landslides (ICL) with support of UNESCO, WMO, FAO, ISDR, etc.

  - See **http://icl.dpri.kyoto-u.ac.jp**

DPRI-KU

Possible proposals for future collaboration in terms of RS and GIS and International Programs

- Land use/cover monitoring by RS
- Hazard risk mapping for floods, sedimentation, debris flows, as well as volcanic eruption
- Demonstration project for GEOSS
- Application to JAXA EORC's RA for ADEOS-II
  http://sharaku.eorc.jaxa.jp/ADEOS2/ra/ra.html
- ALOS-related research
- IFNet's Global Flood Alert System (GFAS)
- International Flood Initiative/Programme (IFI/P)
- International Sediment Initiative (ISI)

DPRI-KU