Annex No.13
GIS User's Manual

THE STUDY
ON
COUNTERMEASURES FOR SEDIMENTATION
IN
THE WONOGIRI MULTIPURPOSE DAM RESERVOIR
IN
THE REPUBLIC OF INDONESIA

FINAL REPORT

SUPPORTING REPORT III

Annex No. 13: GIS User's Manual

Table of Contents

List of Tables

List of Figures

CHAPTER 1 INTRODUCTION

1.1 Objectives

GIS is one of powerful and useful tools to manipulate the supporting data for master plan formulation on sedimentation problem in the reservoir. Therefore, JICA Study has developed Wonogiri GIS database and utilized it in many fields regarding sedimentation in Wonogiri multipurpose dam reservoir and management of its watershed.

Main objectives of development of the GIS database are as follows:

- Map preparation for assisting field investigation by the Study team,
- Calculation of sedimentation volume in the reservoir,
- Calculation of sediment yield from the watershed, and
- Estimation of the effect of countermeasures conducted in the watershed.

This database shall be used not only in the Study but also in implementation stage as well as in monitoring and evaluation stage. And then, the master plan prepared in the Study will need to be modified if the situation of the sedimentation problem is drastically changed. Therefore, the database should be updated to conduct the above action. In addition, the steps to develop the GIS database are applicable in different places to formulate the plan on sedimentation problem in the reservoir and watershed management.

Based on the above, the objectives to prepare this GIS User's Manual are:

- To understand the steps of development of the Wonogiri GIS database theoretically, and
- To acquire technical skills on how to use GIS software.

1.2 Work Flow of GIS Database Development

Figure 1.2.1 shows the summary of the work flow of GIS database development. The detailed activities are mentioned in Chapter 2.

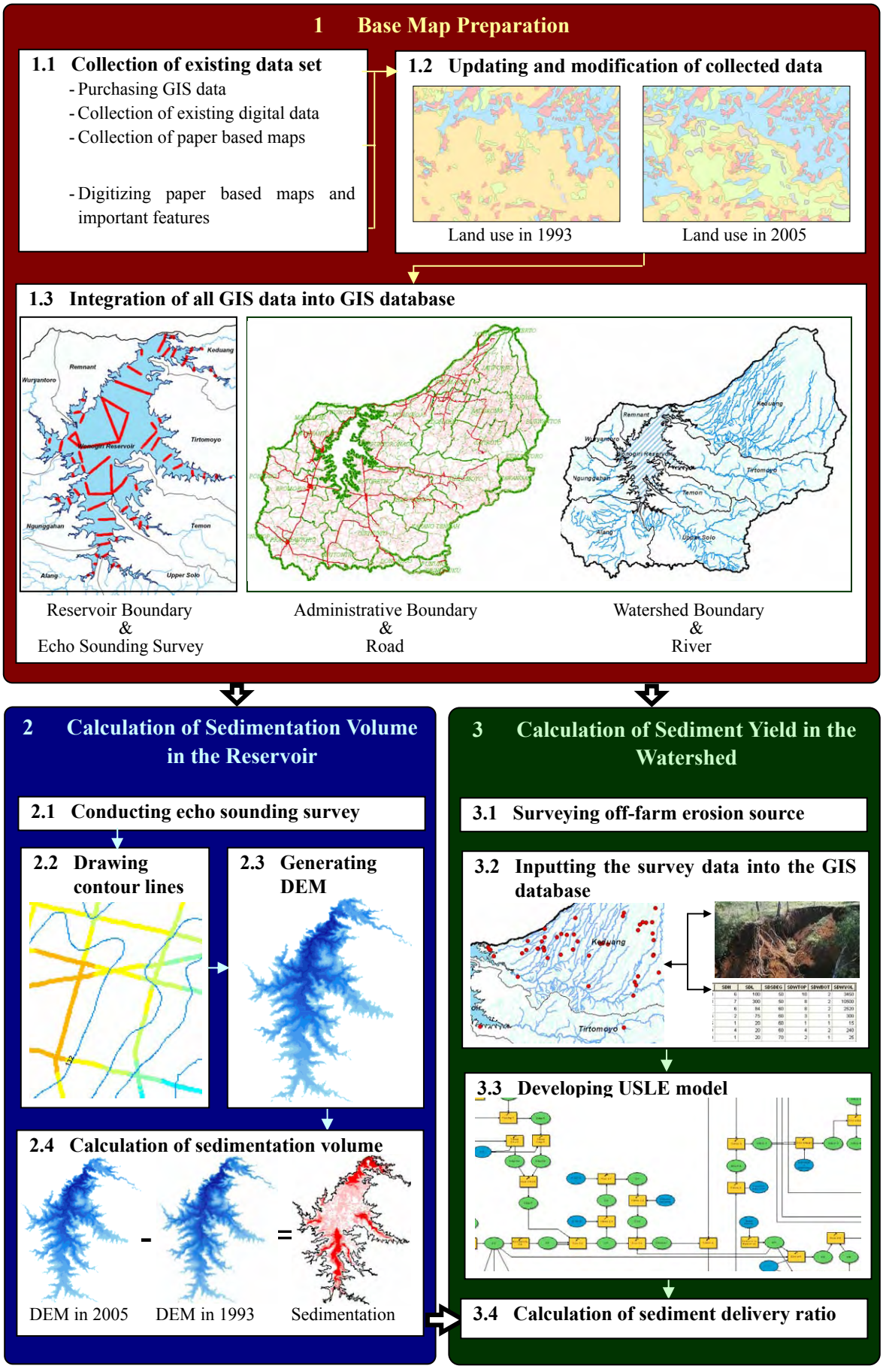


Figure 1.2.1 Procedure of GIS Database Development

CHAPTER 2 PROCEDURE OF GIS DATABASE DEVELOPMENT

This chapter introduces the procedure of the GIS database development using ArcView Ver.9.1 as fundamental GIS software and Spatial Analyst, which is one of the extensions to enhance analysis function of the GIS software.

2.1 Base Map Preparation

2.1.1 Collection of Existing Data Set

Table 2.1.1 shows the collected data from organizations concerned. Paper based data was scanned and digitized using GIS software for the analyses and the map preparation as described later.

Table 2.1.1 List of Collected Existing Data for GIS Database Development

	Data Type	Data Name	Data Source	Note
1	GIS Data	Administrative Boundary	BAKOSURTANAL	
			BAPEDA Wonogiri	Only in Kabupaten Wonogiri Latest Information
		Transportation	BAKOSURTANAL	
		River	BAKOSURTANAL	
		Contour Line	BAKOSURTANAL	
		Land Use in 1993	BAKOSURTANAL	
2	Other Digital Data	Echo Sounding Data in 1993	IPKPWSBS	
3	Paper Based Data	Watershed boundary	IPKPWSBS	
		Rainfall Gauging Station	CDMP** Project Document provided by IPKPWSBS	
			IBRD*** Project Document provided by BPDAS	
		Soil	IBRD*** Project Document provided by BPDAS	
		State Forest	BPDAS	
		Check Dam Map	IPKPWSBS	
4	Satellite Image	SPOT	RESTEC*	Data in 2003/8/1
		ASTER	RESTEC*	
		Landsat	RESTEC*	

* RESTEC: Remote Sensing Technical Center of Japan
** Comprehensive Development and Management Plan Study for Bengawan Solo River Basin under Solo River Improvement Project
*** The Upper Solo Watershed Protection Project

2.1.2 Updating and Modification of Collected Data

(1) Data Updating

1) Land Use Map

Land use map was produced by BAKOSURTANAL based on the interpretation of aerial photographs taken in 1993/1994. To understand the present land use and calculate the present sediment yield in the watershed the land use map was updated through field investigation. In parallel with the field investigation, terrace condition was also surveyed based on the old land use map and high resolution satellite image.

The result of the field investigation was reflected on the GIS data as land use map in 2005 and P factor map (terrace condition map).

2) Administrative Boundary

Administrative boundary had been changed since the preparation of the topographic maps by BAKOSURTANAL. Therefore, based on the topographic maps, BAPPEDA Wonogiri conducted the survey for identification of actual administrative boundary and prepared the latest information as GIS data. In the Study the latest information was utilized only in Kabupaten Wonogiri.

(2) Modification of Collected Data

The existing data should be verified before the utilization since the data might have errors. The following list shows the observed errors in the collected GIS data.

1) Attribute Error

GIS data is spatial information (feature) linked with tabular information (attribute). For example, when the land use map is displayed using GIS, the attribute data in each feature decides the color of the feature. Moreover, the generation of slope steepness map needs the accurate elevation data in each feature (refer to Figure 2.1.1). Therefore, the attribute table was verified and modified before conducting the analysis using GIS data.

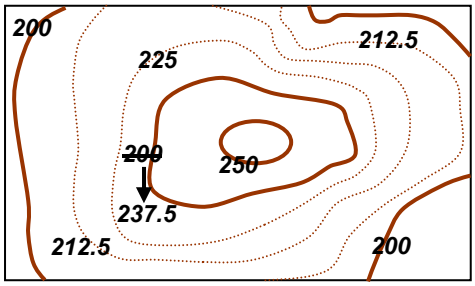


Figure 2.1.1 Attribute Error (In Case of Topographic Map)

2) Survey or Drawing Error

Survey or drawing error might be caused by the insufficient field investigation or drawer's careless mistakes. Especially the land use map in 1993 was seemed to have this error compared the information on the topographic maps with the impression on the field. Therefore, the data was modified based on the result of interview survey to the farmers. The reasons of the mistakes were thought that i) the land use map was created by interpretation of aerial photographs without enough field investigation, and ii) the lip of well managed terrace looked like the furrow in paddy field.

3) Topology Error

Topology error is the logical error in the features related to each other. Well observed examples in the existing GIS data were i) overlapping of the

administrative boundary features, ii) crossing contour lines etc. Since these errors would affect the accuracy of the calculation result or the flow of execution through a calculation model, the errors were solved by JICA Study Team.

Since the following error was observed in the collected data set through the data verification process, the data was modified based on the data of i) field survey, ii) paper based map, iii) interview survey to farmers, etc.

Table 2.1.2 List of Errors Observed in the Collected Data

Type of Error	Data Name	Observed problems	Referred information
Attribute	Contour line	-No attribute of elevation information -Difference from paper based map	Paper based map
	Land use	-No attribute information -Difference from paper based map	Paper based map
Survey/ drawing	Soil	-Difference between soil map and field investigation	Field investigation
	Land use	-Difference between land use map and interview survey to the farmers	Interview survey to the farmers Field investigation
Topology	Contour line	-Crossing contour line	-
	Administrative boundary	-Overlapping features -Gap between adjacent features	-
	Land use	-Overlapping features -Gap between adjacent features	-

2.1.3 Integration of All GIS Data into GIS Database

After the data modification and updating, the GIS data was input into the folder of Wonogiri GIS Database. The data contents are summarized in Figure 3.1.1 in Chapter 3.

2.2 Calculation of Sedimentation Volume in the Reservoir

2.2.1 Conducting Echo Sounding Survey

Echo sounding survey with GPS for the Wonogiri reservoir were conducted over two periods of October to November 2004 (before the wet season) and June to July 2005 (after the wet season) to clarify the current status of the sedimentation in the reservoir as well as incremental sediment deposit in the wet season in 2004/2005. The surveyed three dimensional data was converted GIS data and put in the above GIS database.

On the other hand, the past data surveyed by PTCita Mandala Agritans in 1993 was also utilized to clarify the long term trend of sedimentation.

2.2.2 Drawing Contour Lines

The point features of the surveyed data were colored on the screen by the elevation of each survey location. The numerical value of elevation in each survey location was also displayed as a label of the point. Based on i) the colored point, ii) the attached label, and iii) original topographic feature in the reservoir, the contour lines in the reservoir were drawn. The detailed steps are described in Clause 4.2.1.

In parallel with the above drawing, the contour lines in 1993 were redrawn based on the surveyed data in 1993 and the original topographic feature.

2.2.3 Generating Digital Elevation Model (DEM)

DEM in the reservoir area was produced from the drawn contour lines. The resolution of

the DEM was 10m/pixel and the calculated area was less than 150m of the elevation.

2.2.4 Calculation of Sedimentation Volume

The sedimentation volume was calculated from the difference between original reservoir capacity and the generated DEM data. Additionally increment of sedimentation was also calculated from the difference between two DEM generated by the survey data in different years.

2.3 Calculation of Sediment Yield in the Watershed

2.3.1 Surveying Off-farm Erosion Source

Source of sediment production can be classified into two, i.e. on-farm erosion and off-farm erosion. On-farm erosion is surface erosion from upland field, forest or bare ground and can be calculated by Universal Soil Loss Equation (USLE) as described in the following clause. However, i) the linear erosion source such as river, gully and road side, and ii) the accidental erosion source such as land slide or collapse cannot be included in the calculation result of USLE. Such erosion is called as off-farm erosion.

Field investigation was conducted in the watershed with a GIS receiver and a digital camera to detect the location of off-farm erosion source and the volume of the erosion.

2.3.2 Inputting the Survey Data into the GIS Database

The survey data was input into the GIS database to link among location (point feature), attribute (numerical information of erosion) and photo (visual information of erosion).

2.3.3 Developing USLE Model

(1) Universal Soil Loss Equation (USLE)

USLE is the method most widely used around the world to predict long term rates of sheet and rill erosion from field or farm size units subject to different management practices and was developed based on thousands of plot-years of data from experimental plots especially in United States.

The USLE is an empirical multiple-regression type equation which incorporates the parameters that influence erosion, and is expressed by the following equation:

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

Where,

A: Average annual soil loss (t/ha/year)

R: Rainfall erosivity factor

K: Soil erodibility factor

L: Slope length factor

S: Slope steepness factor

C: Cover and management factor

P: Support practice factor

Parameters list utilized for the calculation were summarized in Table 2.3.1.

The detailed explanation of each factor is described in the Interim Report of this Study (June 2006).

(2) Model Building for USLE Calculation

USLE is easily applicable equation for the estimation of the sediment yield in the watershed judged from the logical sequence of the calculation as explained above. However, it is also easily understandable that the work volume of the calculation depends on i) the size of grid and ii) the number of category in each factor. Calculation model for USLE was developed in this study as illustrated in Figure 4.2.1 and the details are described in Clause 4.2.2.

2.3.4 Calculation of Sediment Delivery Ratio (SDR)

Much eroded sediment from the distant source will typically encounter more opportunities for re-deposition before the watershed outlet. The ration between the erosion rate and sediment yield is the "Sediment Delivery Ratio (SDR)".

Under the Study, the SDR for soil erosion from land surface was estimated by using the measured sedimentation volume in the Wonogiri reservoir which was directly surveyed in the Study and the result of USLE calculation.

Table 2.3.1 Parameter List for USLE (1/2)

	Category	Parameter
1	General	
	Target area for the calculation	Watershed of Wonogiri reservoir (excluding inside of the reservoir: area of the elevation lower than 137.5 m)
	Grid size	20 m/pixel
2	Rainfall erosivity factor	
	$Re = 2.21 \times \Sigma Ri^{1.36}_{i=1}$ (12)	
	Where,	
	Re: Rain erosivity index	
	Ri: Monthly rainfall (cm)	
	i: Month (January to December)	
	Rainfall erosivity index "Re" and factor "R"	
	Rain erosivity index (Re)	Rainfall erosivity factor (R)
	1,000-1,100	1,050
	1,100-1,200	1,150
	1,200-1,300	1,250
	1,300-1400	1,350
	1,400-1,500	1,450
	1,500-1,600	1,550
	1,600-1,700	1,650
	1,700-1,800	1,750
	1,800-1,900	1,850
	1,900-2,000	1,950
	2,000-2,100	2,050
	2,100-2,200	2,150
	2,200-2,300	2,250
	2,300-2,400	2,350
	2,400-2,500	2,450
	2,500-2,600	2,550
3	Soil erodibility factor	
	Applied soil erodibility factor "K"	
	Kind of soils	Soil erodibility factor (K)
	Mediteran soils	0.31
	Grumsols	0.48
	Latosols	0.32
	Lithosols	0.015*
	* This figure is taken from rehabilitasi lahan dan konservasi tanah daerah tangkapan waduk serbaguna Wonogiri BukuII Lampiran teknik	
4	Topographic factor (Including slope length factor and slope steepness factor)	
	$LS = \sqrt{\lambda/22.1} \times (65.41 \sin^2\theta + 4.56 \sin\theta + 0.065)$	

Where,

LS: Topographic factor

λ: Slope length

θ: Steepness *

* The steepness value of 50% in gradient is applied for all the upland fields having a steepness of over 50%.

Slope length for classified land uses

Land use	Slope length (m)/slope(%)
(1) Upland field, paddy field, orchard and plantation area, dry farming land in home settlement area	
a) class-1	8 m / 0- 8%
b) class-2	8 m / 8-15%
c) class-3	4 m /15-25%
d) class-4	3 m /25-40%
e) class-5	2 m /over 40%
(2) Others	50 m

5 Cover and management factor

Cover and Management Factor "C"

Land use	Cover and management factor (C)
Paddy field	0.05
Home settlement areas	0.10
Home settlement area under upland field condition	0.70
Upland field*	
1-MT-I: average annual crop factor for mixed cultivation of maze and cassava	0.60
2-MT-II: average annual crop factor for mixed cultivation of beans and cassava	0.45
3-MT-III:average annual crop factor for mixed cultivation of beans and cassava	1.00
Grassland /Bush land	0.02
Forest	0.01
Orchard/Plantation	0.30
Bare lands	1.00
Water body	0

* An overall cover and management factor for upland areas is calculated as the following equation by using a cropping intensity data on the Kecamatan level.

C = (Ci・Ri+Cii・Rii+Ciii・Riii+・・・・+Cxii・Rxii)/Ri~xii

where,

C: Annual overall cover and management factor C

Ci: Average annual crop factor for mixed cultivation of cassava and maize and mixed cultivation of cassava and beans

Ri: Monthly rainfall erosivity factor for i_th month

Ri~xii: Annual rainfall erosivity factor (accumulated Jan. to Dec.)

6 Support practice factor

Support practice factor "P"

Erosion-control practice	P-factor value
No treatment of soil conservation	0.80
Ridge terrace	
Composite (land of composite of condition of ridge terrace and non-treatment)	
Traditional bench terrace	0.50
Bench terrace for upland field	
(1) Good quality	0.04
(2) Medium quality	0.20
(3) Fair to bad quality	0.40
Terrace of irrigated paddy field	0.02
Orchard/Plantation	0.40
Upland field in settlement area	0.65
State forest	1.00
Home settlement area	1.00
Grass land	1.00

CHAPTER 3 DATA CONTENTS OF WONOGIRI GIS DATABASE

3.1 Database Structure

Figure 3.1.1 shows the GIS database structure developed in the Study. The database is consisted from 7 data folders and two ESRI ArcMap Document files summarized as follows.

(1) General Description of Watershed

This folder contains the basic information for map making and GIS analysis, such as i) watershed boundary, ii) administrative boundary, iii) land use etc.

(2) Sedimentation in Reservoir

Sedimentation volume in the past and the present situation needs to be clarified to formulate the master plan. Utilized raw data and the output for the calculation are input into this folder.

(3) Sediment Production in Watershed

USLE was utilized for the calculation of the present sediment yield in the watershed and the estimation of the effect of the countermeasures through enhancement of watershed management. This folder contains i) GIS data of each index used to run USLE calculation model, ii) the calculation result, and iii) the calculation model..

(4) Miscellaneous Information of Erosion and Sedimentation

The volume of erosion from i) river bank, ii) gully, iii) road bank, land slide was estimated through the field survey. To be considered about trapped soil particle in check dams in the watershed, the occupancy of the check dams was also surveyed. Such surveyed data is put in this folder.

(5) Document

This folder includes this GIS manual and presentation material for GIS training.

(6) Photo Album

Photographs of the watershed and their location are stored in this folder.

(7) Training

Training contents used in Chapter 4 are stored in this folder.

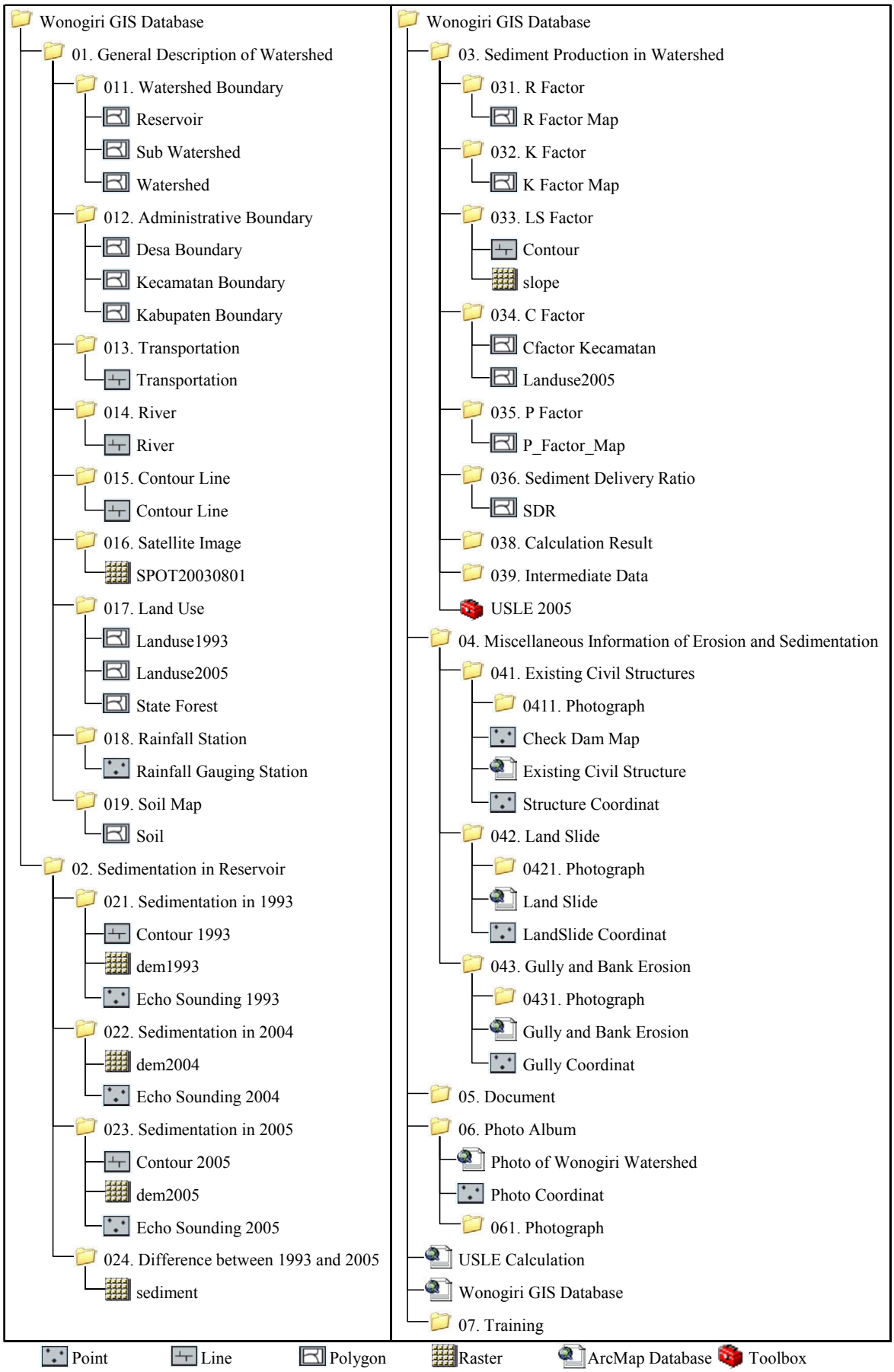


Figure 3.1.1 Wonogiri GIS Database Structure

(8) ESRI ArcMap Document File

There are two ArcMap Document files under Wonogiri GIS Database folder, i.e. Wonogiri GIS Database and USLE Calculation.

The former contains the data on the general information in the reservoir as well as the watershed and is available for i) looking around the reservoir and the watershed condition, ii) printing maps to support your field investigation. The latter is specially customized for USLE calculation and pre-stored the data set and the calculation model.

3.2 Data Contents

3.2.1 General Description of Watershed

(1) Watershed Boundary

Reservoir	
Storage	Wonogiri GIS Database/01. General Description of Watershed /011. Watershed Boundary
Data Source	Topographic map prepared by BAKOSURTANAL (1993)
	Attribute Name AREA_HA (Area in ha)
Sub Watershed	
Storage	Wonogiri GIS Database/01. General Description of Watershed /011. Watershed Boundary
Data Source	Topographic map prepared by BAKOSURTANAL (1993)
	Attribute Id SUBDAS (Name of sub watershed) AREA_HA (Area in ha in each sub watershed)
Watershed	
Storage	Wonogiri GIS Database/01. General Description of Watershed /011. Watershed Boundary
Data Source	Topographic map prepared by BAKOSURTANAL (1993)

	Attribute Name AREA_HA (Area in ha)

(2) Administrative Boundary

Desa Boundary	
Storage	Wonogiri GIS Database/01. General Description of Watershed /012. Administrative Boundary
Data Source	Topographic map prepared by BAKOSURTANAL (1993) Administrative map prepared by BAPEDA Wonogiri (2005)
	Attribute KECAMATAN KABUPATEN PROVINSI DESA AREA_HA (Area in ha in each village)
Kabupaten Boundary	
Storage	Wonogiri GIS Database/01. General Description of Watershed /012. Administrative Boundary
Data Source	Topographic map prepared by BAKOSURTANAL (1993) Administrative map prepared by BAPEDA Wonogiri (2005)
	Attribute KABUPATEN PROVINSI AREA_HA (Area in ha in each kabupaten)
Kecamatan Boundary	
Storage	Wonogiri GIS Database/01. General Description of Watershed /012. Administrative Boundary
Data Source	Topographic map prepared by BAKOSURTANAL (1993) Administrative map prepared by BAPEDA Wonogiri (2005)

	Attribute KECAMATAN KABUPATEN PROVINSI AREA_HA (Area in ha in each kabupaten)

(3) Transportation

Transportation	
Storage	Wonogiri GIS Database/01. General Description of Watershed /013. Transportation
Data Source	Topographic map prepared by BAKOSURTANAL (1993)

	Attribute KODE_UNSUR (Code number of type of road) NAMA_UNSUR (Type of road)

Relation between code number and type of road

KODE UNSUR	NAMA UNSUR	KODE UNSUR	NAMA UNSUR
2350	Road, Main	2510	Road, Other
2360	Bridge, Main	2511	Bridge, Road, Other
2361	Bridge, Main road, Road signature	2512	Bridge, Road, Other, Road signature
2370	Overpass, Main road	2513	Overpass, Road, Other
2371	Overpass, Main road, Road signature	2514	Overpass, Road, Other, Road signature
2410	Road, Local	2590	Road, Other (alternative symbol)
2420	Bridge, Local road	2610	Footpath
2421	Bridge Local road, Road signature	2620	Footbridge for single line river
2430	Overpass, Local road	2630	Footbridge for double line river
2431	Overpass, Local road, Road signature	2780	Overpass

(4) River

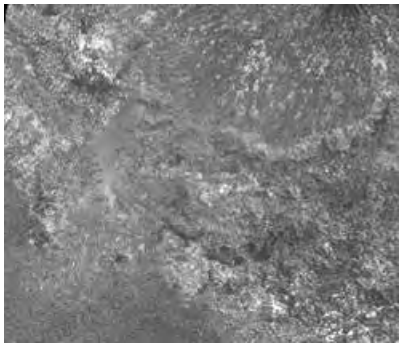
River	
Storage	Wonogiri GIS Database/01. General Description of Watershed /014. River
Data Source	Topographic map prepared by BAKOSURTANAL (1993)

	Attribute River_name main_river (1: Main river, 0: Tributary)

(5) Contour Line

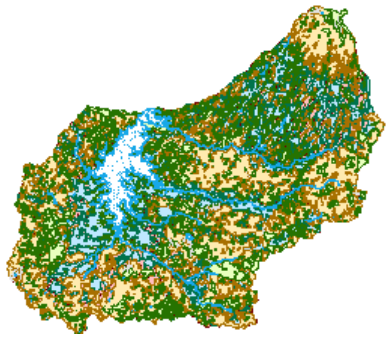
Contour	
Storage	Wonogiri GIS Database/01. General Description of Watershed /015. Contour Line
Data Source	Topographic map prepared by BAKOSURTANAL (1993)
	Attribute Elevasi (Elevation in meter)

(6) Satellite Image

SPOT20030801	
Storage	Wonogiri GIS Database/01. General Description of Watershed /016. Satellite Image
	Acquired Year: 2003 Prepared by: Remote Sensing Technology Center of Japan Size of grid: 10m/pixel

(7) Land Use

Landuse1993	
Storage	Wonogiri GIS Database/01. General Description of Watershed /017. Land Use
Data Source	Topographic map prepared by BAKOSURTANAL (1993)



Attribute
KODE_UNSUR
(Code number of land use)
NAMA_UNSUR
(Name of land use)
LABEL
(Abbreviation of name of land use)

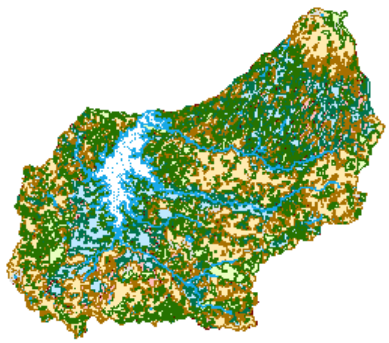
Relation between code number and land use

KODE UNSUR	NAMA UNSUR (LABEL)	KODE UNSUR	NAMA UNSUR
1214	Building (GD)	5254	Orchard/Plantation (KB)
1224	Settlement (P)	5264	Bush (B)
5214	Irrigated paddy field (S)	5274	Forest (H)
5224	Rainfed paddy field (SH)	5294	Rocky ground (BB)
5234	Upland field (T)	6264	Water body (AT)
5244	Grass land (R)	6314	Swamp (AR)

Landuse2005

Storage: Wonogiri GIS Database/01. General Description of Watershed /017. Land Use

Data Source: Topographic map prepared by BAKOSURTANAL (1993)



Attribute
KODE_UNSUR
(Code number of land use)
NAMA_UNSUR
(Name of land use)
LABEL
(Abbreviation of name of land use)

State Forest

Storage: Wonogiri GIS Database/01. General Description of Watershed /017. Land Use

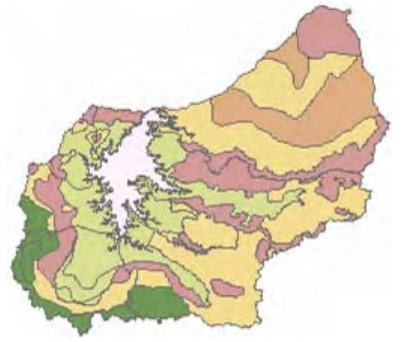
Data Source: Forest map prepared by BPDAS

Attribute
Name
ID (1: State forest, 2: Others)
AREA_HA
(Area in ha in each category)

(8) Rainfall Station

Rainfall Gauging Station	
Storage	Wonogiri GIS Database/01. General Description of Watershed /018. Rainfall Station
Data Source	Completion Report on Comprehensive Development and Management Plan (CDMP) Study for Bengawan Solo River Basin under Lower Solo River Improvement Project (2001)
	Attribute Station Name

(9) Soil Map

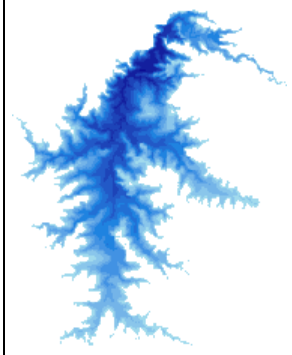
Soil	
Storage	Wonogiri GIS Database/01. General Description of Watershed /019. Soil Map
Data Source	Completion Report on The Upper Solo Watershed Protection Project (1998)
	Attribute Soil Type MED: Mediteran soil GRU: Grumsols LAT: Latosols LI: Lithosols LM: Lime stone Rec_KFact (Rectified soil factor based on the survey result of the JICA STUDY TEAM)

3.2.2 Sedimentation in Reservoir

(1) Sedimentation in 1993

Contour 1993	
Storage	Wonogiri GIS Database/02. Sedimentation in Reservoir /021. Sedimentation in 1993
Data Source	Drawn by JICA Study Team based on the Study result conducted by PT CMA (1993)

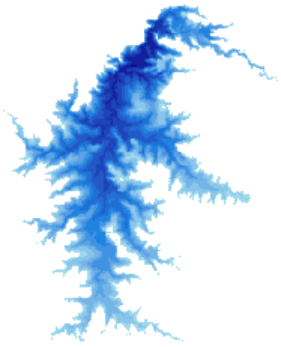
	Attribute Contour (Elevation of contour lines)

dem1993	
Storage	Wonogiri GIS Database/02. Sedimentation in Reservoir /021. Sedimentation in 1993
	Note 'dem1993' was generated from the contour lines drawn by JICA Study Team based on the result of echo sounding survey conducted in 1993. Size of grid: 10m/pixel

Echo Sounding 1993	
Storage	Wonogiri GIS Database/02. Sedimentation in Reservoir /021. Sedimentation in 1993
Data Source	Study result conducted by PT CMA (1993)
	Attribute X (Easting) Y (Northing) Z (Elevation of survey points)

(2) Sedimentation in 2004

dem2004	
Storage	Wonogiri GIS Database/02. Sedimentation in Reservoir /022. Sedimentation in 2004

	Note 'dem2004' was generated from the contour lines drawn by JICA Study Team based on the result of echo sounding survey conducted in 2004. Size of grid: 10m/pixel

Echo Sounding 2004	
Storage	Wonogiri GIS Database/02. Sedimentation in Reservoir /022. Sedimentation in 2004
Data Source	Survey result conducted by JICA Study Team (2004)
	Attribute X (Easting) Y (Northing) Z (Elevation of survey points)

(3) Sedimentation in 2005

Contour 2005	
Storage	Wonogiri GIS Database/02. Sedimentation in Reservoir /023. Sedimentation in 2005
Data Source	Survey result conducted by JICA Study Team (2005)
	Attribute Contour (Elevation of contour lines)

dem2005	
Storage	Wonogiri GIS Database/02. Sedimentation in Reservoir /023. Sedimentation in 2005

	Note 'dem2005' was generated from the contour lines drawn by JICA Study Team based on the result of echo sounding survey conducted in 2005. Size of grid: 10m/pixel

Echo Sounding 2005	
Storage	Wonogiri GIS Database/02. Sedimentation in Reservoir /021. Sedimentation in 2005
Data Source	Survey result conducted by JICA Study Team (2005)
	Attribute X (Easting) Y (Northing) Z (Elevation of survey points)

(4) Sedimentation in 2005

sediment	
Storage	Wonogiri GIS Database/02. Sedimentation in Reservoir /024. Difference between 1993 and 2005
	Note 'sediment' was generated from the difference between 'dem2005' and 'dem1993'. Size of grid: 10m/pixel

3.2.3 Sediment Production in Watershed

(1) R Factor

R Factor Map	
Storage	Wonogiri GIS Database/03. Sediment Production in Watershed /031. R Factor
Data Source	'Rainfall Gauging Station' map based on Completion Report on CDMP Study (2001)

	Attribute R_factor (R factor in total) R factor by month (Monthly average of R factor from January to December)

(2) K Factor

K Factor Map	
Storage	Wonogiri GIS Database/03. Sediment Production in Watershed /032. K Factor
Data Source	'Soil' map based on Completion Report on The Upper Solo Watershed Protection Project (1998)
	Attribute Soil Type MED: Mediteran soil GRU: Grumsols LAT: Latosols LI: Lithosols LM: Lime stone Rec_KFact (Rectified soil factor based on the survey result of the JICA STUDY TEAM) K10000 (Rec_KFact*10,000)

(3) LS Factor

Slope	
Storage	Wonogiri GIS Database/03. Sediment Production in Watershed /033. LS Factor
	Note 'Slope' was generated from three types of data, i.e. 'Watershed' as boundary, 'River' as depression and 'Contour' as elevation information. Size of grid: 20m/pixel

(4) C Factor

CFactor Kecamatan	
Storage	Wonogiri GIS Database/03. Sediment Production in Watershed /034. C Factor
Data Source	'Kecamatan Boundary' map and data surveyed by JICA Study Team

	Attribute KECAMATAN C_FACTOR (C factor in upland field by kecamatan)

(5) P Factor

P_Factor_Map	
Storage	Wonogiri GIS Database/03. Sediment Production in Watershed /035. P Factor
Data Source	'Landuse2006' map and data surveyed by JICA Study Team
	Attribute NAMA_UNSUR (Name of land use) P_terrace (P factor in each category) Terrace_co (Type of terrace)

Relation between P factor and type of terrace		
Terrace_co	(English)	P_terrace
Air Tawar Sungai	(Water body)	1.00
Bangunan/Gedung	(Building)	1.00
Bukit Batuan	(Rocky ground)	1.00
Hutan	(Forest)	1.00
Padang Rumput	(Grass land)	1.00
Pemukiman	(Settlement)	1.00
Perkebunan/Kebun	(Orchard/Plantation)	0.40
Sawah	(Irrigated paddy field)	0.02
Sawah Tadah Hujan	(Rainfed paddy field)	0.02
Semak Belukar	(Bush)	1.00
In Upland Field		
No Treatment of soil conservation		0.80
Composite of ridge terrace		0.80
Ridge terrace		0.80
Traditional bench terrace		0.50
Fair to bad bench terrace		0.40
Medium bench terrace		0.20
Good bench terrace		0.04

(6) Sediment Delivery Ratio

SDR	
Storage	Wonogiri GIS Database/03. Sediment Production in Watershed

	/036. Sediment Delivery Ratio
Data Source	'Sub Watershed' map and 'Sediment' map prepared by JICA Study Team
	Attribute Id Name (Name of sub watershed) Area_km2 (Area in ha in each sub watershed) SDR (Sediment delivery ratio in each sub watershed)

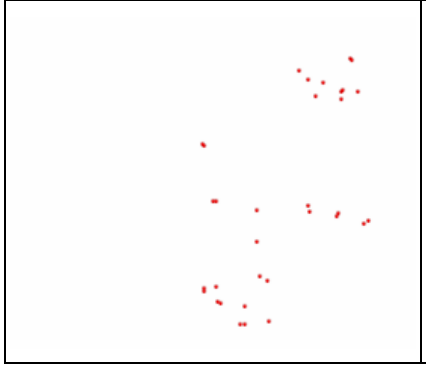
3.2.4 Miscellaneous Information of Erosion and Sedimentation

(1) Existing Civil Structures

Check Dam Map	
Storage	Wonogiri GIS Database/04. Miscellaneous Information of Erosion and Sedimentation/041. Existing Civil Structures
Data Source	Structure data list provided by PBS
	Attribute Legend (Existing or proposed check dam by management agency) Construc_Y (Construction year) Height Length Capacity (in cubic meter) Remark
Structure Coordinat	
Storage	Wonogiri GIS Database/04. Miscellaneous Information of Erosion and Sedimentation/041. Existing Civil Structures
Data Source	Surveyed by JICA Study Team
	Attribute Refer to Table 3.2.1

(2) Land Slide

LandSlide Coordinat	
Storage	Wonogiri GIS Database/04. Miscellaneous Information of Erosion and Sedimentation/042. Land Slide

Data Source	Surveyed by JICA Study Team
	Attribute Refer to Table 3.2.2

(3) Gully and Bank Erosion

Gully Coordinat	
Storage	Wonogiri GIS Database/04. Miscellaneous Information of Erosion and Sedimentation/043. Gully and Bank Erosion
Data Source	Surveyed by JICA Study Team
	Attribute Refer to Table 3.2.3

3.2.5 Photo Album

Photo Coordinat	
Storage	Wonogiri GIS Database/04. Miscellaneous Information of Erosion and Sedimentation/043. Gully and Bank Erosion
Data Source	Surveyed by JICA Study Team
	Attribute X (Easting of site of photographs) Y (Northing of site of photographs) REMARK Photo1 (File name of each photograph)

Table 3.2.1 Ovservation Sheet of Countermeasure Structure

No.	Type[1]	Date	Time	River System[2]	Kecamatan	Desa	Dusun	Name[3]	Coordinates (by Handy GPS) X	Y	Sediment Condition[4]	Soil Type	D(cm)	)max (cm)	Dam/Weir H (m)	Lc (m)	Reservoir W_top (m)	W_b (m)	L (m)	D (m)	V (m³)	W_w (m)	W_l (m)	W_d (m)	W_v (m³)	W_s (m²)	Spillway H (m)	W (m)	Water Drainage (L/min)[5] Spillway	Intake	Sediment Year	Photos	
1	C	2005/11/23	8:43	K	Sidoharjo	Jatimon	Sudimoro		49,509,527	9,134,023	F	cley			8	66	42	5	186	6	8,742					8,742	3.1	5	20	0	12	PB230001	PB230006
2	C	2005/11/23	10:00	K		Doho	Karangnongko	Seren	49,509,149	9,134,603	F	cley			7	71	71	5	284	5	17,987					17,987	2	8	100	0	4	PB230007	PB230019
3	C	2005/11/23	11:12	K		Girimarto	Geneng		49,508,376	9,139,191	F	sand/grave	10	150	2	20	20	20	130	2	1,733					1,733						PB230025	PB230027
4	W	2005/11/23	12:52	K					49,511,597	9,143,051	F	sand/grave		15	3	21	21	21	188	3	3,948					3,948		1	20	100		PB230037	PB230042
5	W	2005/11/24	9:11	K		Kerjo lor		Tare	49,503,304	9,135,879	F	sand/cley			4	6.5	6.5	6.5	46	3.5	349					349		1	0	0		PB240061	PB240064
6	W	2005/11/24	9:33	K		Kerjo lor	Karang kidul		49,504,551	9,135,281	M	sand/cley		3	2	16	16	16	107	1.5	856					856		1	2	30		PB240065	PB240068
7	C	2005/11/24	11:11	K		Mojopuro		Kepek	49,505,370	9,133,888	F	sand/grave	3	10	1.5	36	36	36	100	1.5	1,800					1,800						PB240087	PB240089
8	W	2005/11/24	11:52	K		Mojopuro			49,507,137	9,125,431	F	sand/grave			2	6	6	6	15	2	60					60						PB240090	PB240090
9	W	2005/11/24	12:40	K		Mojopuro			49,506,841	9,126,043	F	sand/grave	10	60	4	10	10	6	85	4	907					907		1	0	0		PB240096	PB240097
10	W	2005/11/25	9:04	K		Giriyoso	Tulakan	Watugajah	49,512,266	9,137,640	F	sand/grave	10		5.5	21	21	10	65	5	1,679					1,679		1	5	150		PB250098	PB250099
11	W	2005/11/25	9:30	K		Kopen	Kedong		49,512,553	9,137,330	F	sand/cley			4	4	4	3	50	4	233					233				20		PB250100	PB250101
12	Dr	2005/11/25	10:00	K		Mangunharjo	Godang		49,513,687	9,140,261		cley			1		1.5	0.5			0					0						PB250105	PB205107
13	W	2005/11/25	11:13	K		Jeporo	Tamansari		49,514,060	9,139,942	F	sand/grave	10	30	3	12	12	3	40	3	300					300				100		PB250113	PB250115
14	W	2005/11/25	11:24	K		Jeporo	Tamansari		49,514,288	9,139,913	F	sand/grave	10	40	3	8	8	5	40	3	260					260		1	0	100		PB250116	PB250117
15	C	2005/11/25	15:45	K		Kerjo Kidul	Klepu	Klepu	49,502,662	9,130,368	F	sand/grave	5		5	22	22	10	143	4.5	3,432					3,432			200		1984/1	PB250150	PB250152
16	C	2005/11/28	9:30	T		Genengharjo	Tenggar	Ngurul	49,513,027	9,122,996	F	sand/grave	10	200	2	35	35	35	100	1.5	1,750					1,750			100		1987	PB280002	
17	C	2005/11/28	12:33	T	JAWA Timur				49,520,416	9,119,244	M	cley			8	29	26	5	90	6	2,790					2,790	1.7	5	0			PB280019	PB280024
18	C	2005/11/28	13:06	T		Penggung			49,519,964	9,120,011	M	cley			8	43	43	5	140	6	6,720					6,720	1	5	50	5	10	PB280025	PB280028
19	C	2005/11/28	13:50	T		Penggung			49,517,808	9,119,207	M	cley			8	53	37	5	166	6	6,972					6,972	1.5	6	50	0	13	PB280030	PB280031
20	C	2005/11/28	14:26	T		Pakisbaru		Jabak	49,520,343	9,121,052	M/E	sand/cley			8	50	45	5	140	6	7,000					7,000	2	5	0	0	15	PB280032	PB280036
21	C	2005/11/28	15:16	T		Pakisbaru			49,520,800	9,121,711	F	sand/cley			8	70	70	5	280	6	21,000					21,000	3	5			9	PB280037	
22	C	2005/11/28	15:54	T		Penggung			49,520,468	9,119,371	M	sand/cley			8	40	40	5	120	6	5,400					5,400	1.5	5	40		6	PB280038	PB280039
23	W	2005/11/29	9:23	K		Jatirejo			49,508,352	9,130,390	F	cley			2	13	7	5	10	2	40					40				10	0.5	PB290045	
24	C	2005/11/29	9:35	K		Jatirejo			49,508,247	9,130,233	F	sand/cley			8	63	58	5	150	6	9,450					9,450	2	5	0	0	5	PB290046	PB290051
25	C	2005/11/29	10:36	K		Pesido			49,508,106	9,127,700	F	cley			8	96	89	7	198	5.5	17,424					17,424	2.5	7	0	0	18	PB290052	PB290062
26	W	2005/11/29	13:01	K		Boto			49,518,385	9,129,071	F	sand/grave			3	24	24	24	95	2.5	1,900					1,900		1	50	300		PB290067	PB290069
27	SD1	2005/12/2	14:00	K		Ngadipiro			49,497,675	9,129,865	M	sand/grave	3		2.5	63	50	20	120	2	2,800					2,800						PB020112	PB020119
28	SD2	2005/12/2	14:30	K		Ngadipiro			49,500,963	9,128,813	M	sand/grave			4	65	55	20	150	3	5,625					5,625						PB020121	PB020125
29	C	2005/6/23	8:44	K	Ngadirojo	Kerjo Lor			49,501,884	9,134,295	M	cley			8	55	55	5	140	6	8,400	55	70	2	2,178	6,222	2	3	0	0		P7180027	
30	C	2005/6/23	9:10	K	Ngadirojo	Kerjo Lor			49,501,884	9,134,123	F	cley			8	80	80	30	220	6	24,200					24,200	2	5	50	5		P7180036	
31	C	2005/6/23	10:10	K	Sidoharjo	Kelurahan Kayuloko			49,501,165	9,134,450	F	cley			3	23	23	5	150	3	2,100					2,100							
32	C	2005/6/23		K		Jatinom			49,509,402	9,135,832	E				8	123					0					0							
33	W	2005/6/25	11:51	K		Bubakan		Candimuru	49,516,275	9,146,950	F	sand/grave		200							0					0						P6250021	
34	W	2005/6/25	14:54	K		Sanan	Konpan		49,509,272	9,142,116	F	sandy/cley			3	10	10	10	15	3	150					150						P6250054	P6250057
35	W	2005/6/25	15:54	K		Selorejo	Kuniran	Geneng	49,508,679	9,139,764	F	sand/grave		30	4	20	20	20	50	4	1,333					1,333						P6250070	P6250076
36	W	2005/6/25	16:37	K		Doho	Doho lor		49,505,775	9,137,150	F	sand/cley			3	15	15	15	40	3	600					1,100						P6250082	
37	C	2005/6/27	13:20	K		Kedunggupit		Balaikamb	49,504,788	9,133,824	F	sand/cley			8	56	51	30	150	6	12,150					12,150	2	5	20	10		P6270107	P6270111
38	W	2005/6/27	13:43	K		Kedunggupit		Naruan	49,504,603	9,133,501	F	sand/grave	5	30	4	30	30	10	200	4	5,333					5,333			100	30		P6270112	P6270123
39	C	2005/6/27	14:26	K		Kerjo Lor		Kerjo	49,502,814	9,132,417	F	sand/cley			8	82	80	5	110	6	9,350					9,350	2	5	20	20		P6270125	P6270127
40	C	2005/6/28	9:30	W	Wuryantoro	Pijiharjo			48,480,698	9,130,131	M	sand/cley			8	77	70	5	150	6	11,250					11,250						P6280003	P6280006
41	C	2005/6/29	10:09	T	Nguntoronadi	Kelurahan Beji	Pandan		49,497,610	9,126,720	M	sand/cley			8	85	80	5	163	6	13,855	80	67	2	3,015	10,840	2	5	0	50		P6290036	P6290038
42	C	2005/6/29	11:55	T	Nguntoronadi	Kelurahan Beji	Bodeh Lor		49,498,625	9,127,750	M	sand/cley			8	88	50	5	130	6	7,150	50	50	2	1,417	5,733	2	5	0	10		P6290041	P6290044
43	C	2005/6/29	12:43	K		Nguntoronadi	Semin		49,500,309	9,126,323	M	sandy/cley			6	67	62	5	100	4	4,467	62	35	2	1,114	3,353	2	5	10	0		P6290050	P6290059
44	C	2005/6/29	14:53	K		Nguntoronadi	Semin		49,500,500	9,126,200	F	sandy/cley			7	80	80	5	100	5	7,083					7,083	2	5	50	100		P6290061	P6290075
45	W	2005/6/30	8:10	K		Pondok	Pondok Kulon		49,498,300	9,133,623	M	cley			3	19	19	19	30	3	570					570			40	40		P6300085	P6300087
46	W	2005/6/30	8:40	K		Pondok	Pondok Kulon		49,499,102	9,134,048	F	sand/cley			3	16	16	16	20	3	320					320						P6300088	P6300091
47	W	2005/6/30	9:02	K		Pondok	Pondok Kulon		49,498,666	9,134,033	M	sand/cley			1.5	13	13	13	20	1.5	130					130						P6300092	P6300094
48	W	2005/6/30	9:20	K		Pondok	Pondok Kulon		49,498,308	9,134,014	M	sand/cley			2	7.6	7.6	7.6	20	2	101					101						P6300096	
49	W	2005/6/30	9:52	K		Pondok	Ngadirojo Wetan		49,500,082	9,133,889	F	sand/cley			3	15	13	13	20	3	260					260		2	100			P6300097	P6300098
50	C	2005/6/30	10:38	K		Pondok	Semin Wetan		49,497,261	9,132,109	M	sand/cley			8	50	45	5	180	6	9,000	45	45	2	1,150	7,850	2	5	0	0		P6300100	P6300105
51	W	2005/6/30	13:05	K		Kerjo Kidul	Ketel	Ketel	49,501,179	9,132,472	M	sand/grave	1		2	10	10	10	20	2	133					133			50			P6300123	P630 126
52	W	2005/6/30	14:31	K					49,502,282	9,133,003	M	sand/cley			1.5	6	6	6	40	1.5	120					120			0			P6300152	
53	W	2005/6/30	15:12	K					49,502,244	9,134,351	F	sand/cley			1.5	10	10	10	40	1.5	200					200				20		P6300158	
54	W	2005/7/1	8:22	K					49,510,192	9,134,326	M	sand/grave	3		5	14	14	14	40	4	747					747			100			P6300004	
55	W	2005/7/1	9:10	K					49,510,341	9,134,477	F	sand/grave	3		3	12	12	12	40	3	480					480			5	100		P6300009	
56	W	2005/7/1	9:31	K					49,508,383	9,133,522	M/E				2	26	26	26	40	2	693	26	40	2	693	0		1	50	100		P7010013	
57	C	2005/7/1	10:00	K					49,510,966	9,133,856	F	cley			8	83	63	5	75	6	5,100					5,100	2	5	10	0		P7010015	P7010016
58	W	2005/7/1	10:49	K					49,510,990	9,132,267	F	sand/grave	10	200	4	18	18	18	40	3	720					720						P7010029	P7010031
59	W	2005/7/1	11:04	K					49,510,544	9,132,270	F	sand/grave	10	200	1.6	15	15	15	40	1.5	300					300			10	10		P7010035	
60	W	2005/7/1	11:58	K					49,510,537	9,131,009	F	sand/grave	5	200	4	26	26	26	100	4	3,467					3,467			100	100		P7010039	P7010047
61	W	2005/7/1	12:33	K					49,510,353	9,131,825	F	sand			2	10	10	10	20	2	133					133			0	0		P7010049	
62	C	2005/7/1	14:00	K					49,512,471	9,130,774	F	sand/cley			8	50	45	5	75	6	3,750					3,750	2	5	0	0		P7010052	P7010054
63	W	2005/7/1	14:25	K					49,513,245	9,131,235	E				1	14	14	14	20	1	93	14	20	1	93	0			30	30		P7010058	
64	C	2005/7/1	14:53	K					49,513,000	9,131,150	F	sand/cley			8	72	48	5	133	6	7,049	48	52	1	770	6,279			0	0		P7010065	P7010067
65	C	2005/7/2	9:12	K					49,520,958	9,139,555	F	sand/cley			8	61	55	5	70	6	4,200					4,200	2	5	0	0		P7020071	P7020073
66	C	2005/7/2	9:45	K					49,520,503	9,139,326	F	sand/cley			8	40	35	5	50	6	2,000					2,000	2	5	0	0		P7020081	P7020082
67	W	2005/7/2	10:29	K					49,520,245	9,136,346	F	sand/grave			2	6	6	6	20	2	80					80				20		P7020092	
68	C	2005/7/2	10:45	K					49,520,547	9,136,576	F	sand/cley			8	70	60	5	100	6	6,500					6,500	2	10	10	10		P7020097	P7020100
69	W	2005/7/2	11:13	K					49,520,825	9,136,000	F	sand			3	8	8	8	40	3	320					320				50		P7020108	P7020110
70	W	2005/7/2	11:38	K					49,521,579	9,133,275	F	cley			1.5	7	7	7	20	1.5	70					70			5	0		P7020114	P7020115
71	W	2005/7/2	11:40	K					49,521,643	9,133,324	F	cley			2.6	8	8	8	20	2.5	133	8	40	1.15	123	11			0	0		P7020116	
72	W	2005/7/2	12:09	K					49,522,121	9,132,921	F	sand/grave	10		5	6	6	6	20	5	200					200			50				
73	C	2005/7/4	9:20	K					49,515,030	9,129,501	F	sand/cley			5	58	50	5	150	3	4,125					4,125	8	2	0	0		P7040129	P7040135
74	W	2005/7/4	10:36	K					49,514,350	9,126,100	F	sand/cley			2	10	10	10	15	2	100					100						BP7040146	
75	C	2005/7/4	11:06	K					49,513,817	9,126,633	F	sand/cley			8	63	56	5	100	6	6,100					6,100	2	7	0	10		P7040151	P7040147
76	C	2005/7/4	12:04	K					49,514,143	9,129,454	F	sand/cley			8	48	43	5	91	6	4,368					4,368	2	5	0	0		P7040166	P7040168
77	C	2005/7/4	13:31	K					49,518,311	9,131,364	F	cley			6	57	50	5	195	6	10,725	50	52	2	1,473	9,252						P7040176	P7040179
78	W	2005/7/4	13:58	K					49,519,798	9,131,021	F	sand/grave			3	8	8	8	20	3	160					160				10		P7040185	
79	W	2005/7/4	14:37	K					49,520,143	9,129,731	E				1.5	9	9	9	30	1.5	135	9	30	1.3	117	18						P7040187	
80	W	2005/7/4	15:00	K					49,520,676	9,130,357	F				2	12	12	12	20	2	160					160			20	20		P7040192	
81	W	2005/7/5	10:12	K					49,517,325	9,142,375	F	sand/grave	10	50	2	15	15	15	20	2	200					200						P7050025	
82	W	2005/7/7	11:05	K					49,513,100	9,134,925	F	sand/grave			4	15	15	15	40	4	800					800			200	100		P7070020	
83	W	2005/7/7	11:50	K					49,520,200	9,134,900	F				2	10					0					0							
84	W	2005/7/7	12:38	K					49,519,200	9,136,000	F	sand/cley			2	8	8	8	30	2	160					160						P7070061	
85	W	2005/7/7	12:58	K					49,516,575	9,137,950	F	sand/cley			2	8	8	8	20	2	107					107			50			P7070079	
86	W	2005/7/8	10:02	T					49,515,450	9,120,925	F	sand/grave	5	10	4	5	5	5	20	4	133					133			0			P7080145	
87	W	2005/7/8	10:28	T					49,515,100	9,120,375	F	sand/grave	10	200	1	3	3	3	10	1	10					10			10			P7080153	
88	SD	2005/7/8	10:57	T					49,501,300	9,121,550	F	sand/grave	5	45	1	66	66	66	50	1	1,100					1,100						P7080157	
89	W	2005/7/8	11:10	T					49,503,750	9,121,225	F	sand/grave	5		3	46	46	46	50	3	2,300					2,300						P7080165	
90	W	2005/7/8	11:35	T					49,503,725	9,119,825	F	sand/grave	5		4	16	16	16	30	4	640					640			100			P7080168	
91	C	2005/7/8	11:59	T					49,502,900	9,119,100	F	sandy/cley			8	52	36	5	50	6	2,050					2,050	2	6	5	10		P7080183	
92	W	2005/7/8	14:03	Te					49,494,000	9,122,850	M	sand/grave	3		3	4	4	4	12	3	48	4	12	1	16	32			10	10		P7080201	

Note 1. C: Check Dam, W: Irrigation Weir, B: Big Gully Plug, P: Pond or Small Reservoir
2. K: Keduang, Ti: Tirtomoyo, Te: Temon, S: Solo Hulu, A: Alang, N: Nguranggahan, W: Wuryantoro, R: Remnant area
3. Name of structure, if any

Note 4. F: Full, M: Medium, E: Empty
5. Diameter of observed maximum particle at site
6. Discharge at the time of observation

Legend for measurement

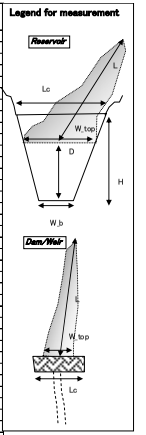


Table 3.2.2 Observation Sheet of Landslide and Collapse

No.	Type[1]	Date	Time	River System[2]	Coordinates (by Handy GPS)		Sediment Discharge						Possible Sediment Discharge (m^3)	Soil		Water[6] Discharge (L/min)	Condition[7]	Counter[8] measures	Start year	Photos	
					X	Y	L (m)	W (m)	D (m)	V (m^3)	V_r (m^3)	V_d (m^3)		Type	Thickness (m)						
1	L	2005/7/7	13:38	K	49,515,916	9,137,925	5	10	2	33	27	6	30	latosol	5		A			P7070076	
2	L	2005/7/7	13:02	K	49,516,200	9,138,100	3	20	1	20		20	20	latosol	3	0	A			P7070072	
3	L	2005/7/7	14:02	K	49,513,500	9,139,050	2	50	1	33		33	30	latosol	2		M			P7070080	
4	L	2005/7/7	14:19	K	49,511,450	9,139,550	3	10	2	20		20	20	latosol	3		A				
5	L	2005/6/25	10:12	K	49,510,201	9,140,681	8	30	2	160		160	160	latosol	8	0	A			P6250003	P7070097
6	L	2005/7/8	9:39	T	49,515,500	9,121,175	6	100	1	200		200	200	meditera	6	0	A			P7080129	
7	L	2005/7/8	10:00	T	49,515,450	9,120,925	6	6	1	12		12	50	meditera	6	0	A			P7080144	
8	L	2005/7/11	10:25	T	49,511,550	9,122,250	20	20	3	400		400	400	meditera	12	0	A			P7110235	
9	L	2005/7/12	10:45	K	49,504,400	9,117,375	20	15	2	200	67	133	150	latosol	3	0	A			P7120008	
10	L	2005/7/8	15:37	T	49,511,700	9,121,575	81	53	5	7,155		7,155	300	meditera	5	0	A				
11	L	2005/7/12	12:55	T	49,506,000	9,112,000	5	5	1	8		8	10	meditera	5	0	M			P7120043	
12	L	2005/7/12	13:00	T	49,505,000	9,112,650	5	5	1	8		8	10	meditera	5	0	M				
13	L	2005/7/12	13:52	S	49,497,375	9,111,000	7	5	2	23		23	20	meditera	5	0	A			P7130112	
14	R	2005/7/13	14:15	S	49,499,050	9,111,325	3	125	1	125		125	100	meditera	3	R	A				
15	R	2005/7/13	14:14	S	49,499,250	9,109,250	3	100	1	100		100	100	meditera	3	R	A			P7130115	
16	R	2005/7/13	14:24	S	49,499,600	9,108,875	2	100	1	67		67	100	meditera	2	R	A			P7130119	
17	R	2005/7/13	15:30	S	49,497,350	9,110,550	3	100	1	100		100	100	meditera	3	R	A			P7130130	
18	L	2005/7/14	10:40	S	49,502,800	9,106,200	3	20	1	20		20	20	meditera	3	0	A			P7140149	
19	L	2005/7/14	10:50	S	49,502,325	9,106,200	3	20	1	20		20	20	meditera	3	0	A			P7140154	
20	L	2005/7/14	12:10	S	49,506,175	9,106,475	4	10	1	13		13	10	meditera	4	0	A				
21	L	2005/7/14	14:09	S	49,502,800	9,108,600	15	15	3	225		225	200	meditera	5	0	A			P7140200	
22	L	2005/7/15	9:10	K	49,515,950	9,136,875	2	5	2	7		7	10	latosol	3	0	M			P7150233	
23	L	2005/7/5	10:00	K	49,517,250	9,142,300	6	30	4	240		240		latosol	5	0	M			P7050018	
24	L	2005/7/5	10:00	K	49,517,500	9,142,250	20	10	2	133		133		latosol	3	0	M			P7050020	
25	L	2005/11/25	9:37	K	49,512,553	9,137,330	50	30	5	2,500	1,333	1,167		latosol	5	0	M	W		PB250100	
26	L	2005/7/15	9:43	K	49,518,175	9,137,850	10	10	2	67		67	200	latosol	5	R	A			P7150241	
27	L	2005/11/24	10:20	K			4	30	1	40		40	100	latosol	4	0	A			PB240075	
28	R	2005/11/26	9:11	T	49,498,450	9,122,850	3	270	1	270		270		grumosol	3	R	N	BP		PB260157	
29	R	2005/11/26	9:33	T	49,504,575	9,121,600	2	230	1	153		153	200	grumosol	2	R	A			PB260163	
30	R	2005/11/26	13:20	T	49,499,000	9,122,850	3	200	1	200		200		grumosol	3		N	BP		PB260187	
31	L	2005/11/28	12:13	T	49,519,600	9,120,180	10	10	2	67		67	100	latosol	5		A			PB280018	
32	L	2005/11/28	13:38	T	49,519,025	9,119,820	5	20	3	100		100	100	latosol	5		A			PB280029	
33	R	2005/12/1	8:48	K	49,497,250	9,130,450	2	80	1	53		53		latosol	2		M			PB010005	
34	R	2005/12/1	9:02	K	49,497,025	9,130,700	1.5	20	1	10		10		latosol	1.5		M			PB010009	

Table 3.2.3 Observation Sheet of Gully and River Bank Erosion

No.	Type[1]	Date	Time	River System[2]	Kecamatan	Desa	Dusun	Name[3]	Coordinates (by Handy GPS)		Sediment Discharge						Possible Sediment Discharge (m^3)	Soil		Water[6] Discharge (L/min)	Condition[7]	Counter[8] measures	Start year	Photos	
									X	Y	H (m)	L (m)	Slope[4] (degree)	W_top[5] (m)	W_b[5] (m)	V (m^3)		Type	Thickness (m)						
1	G	2005/11/23	10:44	K		Sidokarto	Gambiran		49,506,537	9,137,480	6	100	50	10	1.5	3,450		latosol	4	0	M	S	2003	PB250021	24
2	G	2005/11/24	8:32	K	Ngadirojo	Kerjo lor			49,502,338	9,135,988	7	300	50	8	2	10,500		latosol	4	0	M	S		PB250057	60
3	G	2005/11/24	10:04	K		Kedunggupit			49,504,561	9,135,291	6	84	60	8	2	2,520	30	latosol	6	0	A	S		PB250069	70
6	G	2005/11/25	9:40	K		Kopen	Tandan		49,513,000	9,137,725	2	75	60	3	1	300	75	latosol	3	0	M				
7	G	2005/11/25	9:48	K		Kopen	Salanan		49,513,100	9,138,175	1	20	60	1	0.5	15		latosol	1	0	M			PB250102	107
8	G	2005/11/25	10:18	K		Mongunharjo	Pule		49,513,985	9,141,060	4	20	60	4	2	240		meditera	2	0	M/N			PB250110	
9	G	2005/11/25	10:45	K		Mongunharjo	Pule		49,513,900	9,140,120	1	20	70	2	0.5	25		meditera	2	0	M/N				
10	G	2005/11/25	16:21	K		Gedong	Puncungan		49,499,812	9,133,077	1	40	70	5	2	140		latosol	1	0	M/N	S		PB250154	
13	G	2005/11/26	9:53	T		Banyakprodo	Padalangan		49,505,677	9,119,747	2	40	70	2	0.5	100		latosol	1	0	M/N			PB260169	169
15	G	2005/11/28	9:40	T		Genengharjo	Tenggar		49,513,125	9,122,500	1	8	80	1	1	8		meditera	1	0	M/N				
18	G	2005/11/29	9:03	K		Widoro	Sembeng		49,508,355	9,132,309	2	50	60	5	2	350		latosol	2	0	N	B		PB290040	PB290043
19	G	2005/11/29	10:30	K		Jatirejo			49,508,325	9,128,125	3	50	60	4	1	375		latosol	3	0	N/M	S			
20	G	2005/11/29	14:00	K		Norompak	Negompok		49,517,850	9,130,000	2	40	60	1	0.5	60		latosol	2	0	N/M				
21	G	2005/11/29	14:15	K	Jatisrono	Sidorejo			49,517,155	9,132,432	3	10	60	6	0.5	98	100	latosol	2	0	A			PB290079	PB290084
22	G	2005/11/29	14:15	K	Jatisrono	Sidorejo			49,517,100	9,132,300	4	30	60	15	2	1,020		latosol	2		N/M				
25	G	2005/12/1	11:25	K		Pokoh Kidul	Pule		49,495,400	9,132,225	1	20	70	1	0.5	15		latosol	1	0	N/M			PB010041	PB010042
26	G	2005/12/1	11:52	K		Pokoh Kidul	Sidorejo		49,494,950	9,133,075	1	30	70	1	0.5	23		latosol	1	0	M			PB010053	PB010054
27	G	2005/12/1	12:14	K		Pokoh Kidul	Sidorejo		49,494,633	9,133,460	5	50	60	10	5	1,875	50	latosol	0.5	0	M	S		PB010060	PB010062
28	G	2005/12/1	12:07	K		Pokoh Kidul	Sidorejo		49,494,773	9,133,240	4	20	60	6	4	400		latosol	1	0	M	S		PB010056	
29	G	2005/12/2	10:00	A		Kelurahan Puloharjo			49,481,831	9,118,407	4	25	80	25	15	2,000	1000	grumosol	5	0	A			PB020095	PB020097
30	G	2005/12/2	10:03	A		Kelurahan Puloharjo			49,481,888	9,118,344	2	70	60	60	40	7,000	1000	grumosol	5	0	A			PB020098	PB020108
31	G	2005/6/23	8:35	K					49,500,000	9,134,280	1.5	20	60	5	2	105		latosol	1.5	0	N/M	S			
32	G	2005/6/23	9:49	K		Kedunggupit	Kedunggupit		49,506,324	9,135,176	4	30	60	5	2	420		latosol	4	50	N	B, H			
34	G	2005/6/23	12:00	K		Tanggulangin	Jaten		49,517,016	9,135,354	5	250	60	15	2	10,625		latosol	5	0	A	B, H		P6280019	
36	G	2005/6/25	11:45	K		Bubakan			49,516,175	9,146,950	5	60		30		4,500		rock			M			P6250016	
37	G	2005/6/25	12:43	K		Bubakan	Kutukan		49,514,767	9,145,676	6	53	60	15	2	2,703	200	latosol	5	50	A			P6250037	P6250042
38	G	2005/6/27	11:03	K		Kulurahan Kayuloko	Kayuloko		49,506,850	9,134,225	5	20	70	6	3	450		latosol	5	0	M			P6270088	
39	G	2005/6/27	11:10	K		Mojoreno			49,506,200	9,133,150	2	20	70	3	1	80		latosol	2	0	M				
40	G	2005/6/27	11:38	K		Ngabeyan	Ngasem Kidul		40,504,525	9,132,450	1.5	20	60	5	1	90		latosol	4	0	M/N	S		P6270094	P6270096
41	G	2005/6/27	12:00	K		Kedunggupit	PolosoWetan		49,505,350	9,135,125	2	50	60	3	1	200		latosol	2	0	M				
42	G	2005/6/27	14:38	K		kerjo Kidul			49,502,746	9,132,003	2	10	60	4	2	60	100	latosol	2	0	A			P6270128	
43	G	2005/6/30	13:51	K					49,502,173	9,133,392	6	20	70	12	10	1,320	100	latosol	3	0	M			P6300139	P6300145
44	G	2005/6/30	14:06	K					49,502,163	9,133,316	4	200	60	4	2	2,400	400	latosol	3	0	M			P6300147	
45	G	2005/6/30	14:31	K					49,502,282	9,133,003	1.5	20	70	6	4	150		latosol	1.5	50	M			P6300148	P6300149
46	G	2005/6/30	13:20	K					49,501,450	9,133,300	3	50	70	3	2	375	100	latosol	2	0	A			P6300127	P6300128
47	G	2005/6/30	13:20	K					49,501,350	9,133,300	3	100	70	1	2	450		latosol	3	0	M/N			P6300136	P6300137
48	G	2005/7/1	8:10	K					49,509,925	9,133,950	2	30	70	4	3	210	50	latosol	2	0	A			P7010001	
49	G	2005/7/1	10:00	K					49,510,966	9,133,856	3	40	70	5	4.5	570	100	latosol	2	10	A			P701024	
50	G	2005/7/1	10:00	K					49,510,250	9,134,000	2	100	70	2	2	400		latosol	2	0	M				
51	G	2005/7/2	10:30	K					49,520,245	9,136,346	2	20	60	3	2	100		latosol	2	0	M/N			P7020091	
52	G	2005/7/2	11:08	K					49,520,700	9,136,490	2	10	70	2	2	40		latosol	2	0	M			P7020107	
53	G	2005/7/2	11:20	K					49,521,125	9,135,625	3	50	70	1	1	150		latosol	3	0	M				
54	G	2005/7/2	11:25	K					49,521,675	9,134,900	3	50	70	1	1	150		latosol	3	0	M				
55	G	2005/7/4	9:40	K					49,514,600	9,128,700	2	200	70	2	2	800	200	latosol	2	0	A	H		P7040137	P7040139
56	G	2005/7/4	9:40	K					49,514,800	9,128,300	2	50	70	2	2	200	100	latosol	2	0	A				
57	G	2005/7/4	9:50	K					49,514,425	9,126,850	4	50	70	1	1	200		latosol	4	0	M/N			P7040143	P7040144
58	G	2005/7/4	14:52	K					49,520,450	9,130,125	3	50	70	2	1.5	263	50	latosol	3	0	A			P7040190	
59	G	2005/7/5	8:42	K					49,515,050	9,135,800	3	30	60	3	2	225	50	latosol	3	0	A			P7050001	P7050002
60	G	2005/7/5	8:58	K					49,515,327	9,136,585	8	90	60	19	2	7,560	100	latosol	5	0	M			P7050009	P7050008
61	G	2005/7/5	8:58	K					49,515,325	9,136,585	3	40	50	3	2	300		latosol	2	0	M			P7050005	
62	G	2005/7/5	9:00	K					49,515,675	9,136,900	3	50	60	3	2	375		latosol	3	0	M				
65	G	2005/7/5	15:40	K					49,517,400	9,138,800	2	50	90	1	1	100		meditera	2	0	M/N			P7050040	
66	G	2005/7/5	14:08	K					49,521,950	9,138,000	3	20	70	4	2	180		latosol	3	0	M/N	H		P7050057	
67	G	2005/7/5	14:15	K					49,521,400	9,136,600	2	20	60	3	2	100		latosol	2	0	M/N			P7050061	
68	G	2005/7/5	14:20	K					49,521,000	9,135,700	2	20	60	2	1.5	70		latosol	2	0	M			P7050064	
69	G	2005/7/5	14:30	K					49,520,650	9,134,900	3	50	60	1	1	150		latosol	3	0	M				
70	G	2005/7/5	11:40	K					49,517,000	9,136,850	1.5	20	60	1	1	30		latosol	1	0	M/N				
71	G	2005/7/7	12:40	K					49,519,175	9,136,250	2	50	60	1	1	100		latosol	2	0	M/N				
72	G	2005/7/7	15:00	K					49,511,300	9,141,600	8	10	60	10	2	480		latosol	8	30	M/N	H		P7070100	
73	G	2005/7/8	13:50	Te					49,493,500	9,122,600	1	30	70	1	1	30		latosol	2	30	A			P7070198	
74	G	2005/7/12	9:40	K					49,505,500	9,117,000	2	40	70	1.5	1	100	50	latosol	1	0	A			P7120006	
75	G	2005/7/12	10:10	S					49,503,000	9,105,400	3	30	50	5	1	270	50	meditera	1	5	M			P7140143	
76	G	2005/7/4	8:50	K					49,515,030	9,129,501	4	20	50	5	1	240		latosol	4	0	M/N	H		P7040125	
77	G	2005/7/15	9:11	K					49,516,125	9,136,825	2	20	70	2	1	60		latosol	2	0	M			P7150236	
78	G	2005/7/15	10:45	K					49,519,600	9,141,900	2	10	70	1	1	20		latosol	2	0	M			P7150282	
79	G	2005/7/15	12:54	K					49,517,201	9,134,458	6	240	50	15	2	12,240		latosol	6		M			P7150286	
80	G	2005/7/18	8:13	K					49,499,225	9,132,650	2	10	70	1	1	20		meditera	2	0	M	S		P7180001	

Note
1. *G: Gully Erosion, R: River Bank Erosion*
2. *K: Keduang, Ti: Tirtomoyo, Te: Temon, S: Solo Hulu, A: Alang, N: Ngunggahan, W: Wuryantoro, R: Remnant area*
3. *Name of structure or location, if any*
4. *Slope inclination*
5. *If Type is G (Gully), fill the column*
6. *Discharge at the time of observation*
7. *A: Active, M: mediteranium, N: Non-active*
8. *Type of countermeasures, if any*
   H: Gully Head Structure, B: Big Gully Plug, S: Small Gully Plug, G: Slope Grassing, O: Others (Write the detailed information in remarks)

CHAPTER 4 HOW TO USE ARCGIS

ArcGIS is the most popular GIS software all over the world including Indonesia and the Wonogiri GIS database was also developed by using it. If you can operate it, it will show you all GIS data developed by JICA Study as well as support you to make your original GIS database by yourself. On the other hand, the GIS data cannot be open, show you any information and be printed on the paper without using such GIS software even if you have a high spec PC or an expensive printer. Therefore, it is strongly recommended that not only GIS expert but also all the person related to GIS should understand how to operate GIS software.

This chapter can be classified into two components which are i) introduction of ArcGIS utilization using Wonogiri GIS database, and ii) advanced operation of ArcGIS for calculation of sedimentation volume and sediment yield by USLE. JICA Study Team hopes that this manual supports you to develop your knowledge and skills on GIS.

4.1 Introduction of ArcGIS

4.1.1 Applications in ArcGIS

ArcGIS includes a suite of integrated applications: ArcMap, ArcCatalog, and ArcToolbox. Using these three applications together, you can perform tasks such as:

- Creating and printing maps,
- Capturing new data,
- Managing geographic and tabular data, and
- Performing geographic analysis, data editing and geoprocessing.

In addition, ArcGIS Spatial Analyst, which is an extension of ArcGIS and was utilized in the Study, is introduced as follows.

(1) ArcMap

ArcMap is the most fundamental desktop GIS and mapping. ArcMap launches the following function:

- Visualization and printing of existing GIS data,
- Capturing new GIS data, and
- Performing geographic analysis, data editing.

Figure 4.1.1 shows the interface and the main component of ArcMap.

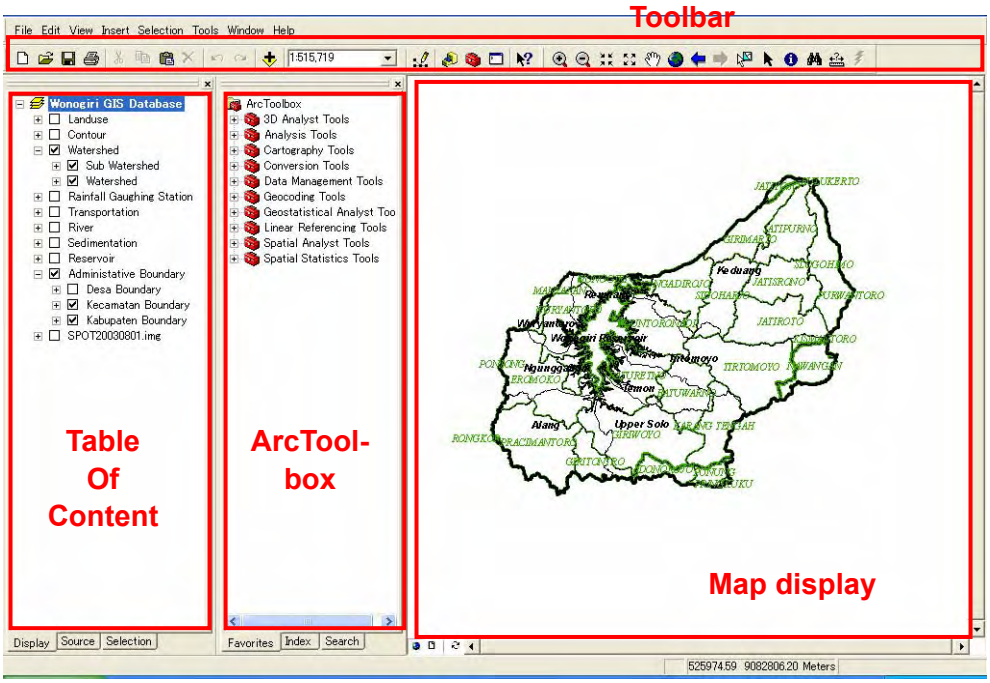


Figure 4.1.1 Interface of ArcMap

(2) ArcCatalog

ArcCatalog looks similar to "Windows Explorer" to provide the following function normally used for data management:

- Browsing and exploring maps and data,
- Creating new GIS data form to capture new GIS data, and
- Managing data sources.

Figure 4.1.2 shows the interface and the main component of ArcCatalog.

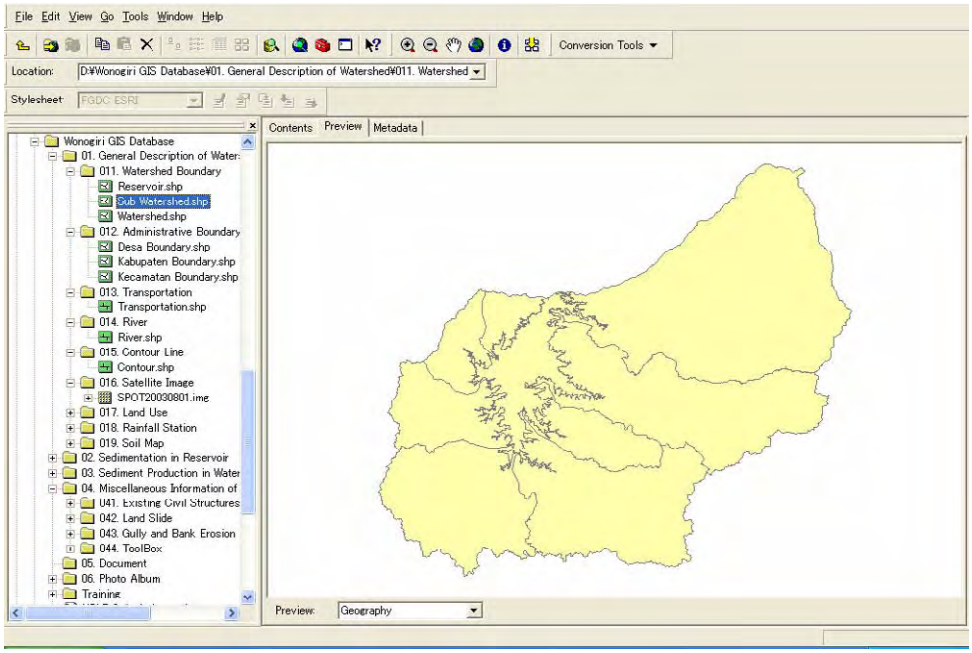


Figure 4.1.2 Interface of ArcCatalog

(3) ArcToolbox

ArcToolbox is specialized for spatial data analysis and can be launched on ArcMap as well as ArcCatalog. The detailed information and functions in ArcToolbox are introduced step by step in the following clauses.

(4) ArcGIS Spatial Analyst

This extension is used to enhance the analysis function of raster data such as satellite images, aerial photographs and grid data produced from vector data. This is inevitable for calculation of sedimentation volume in the reservoir as well as estimation of sediment production in the watershed.

4.1.2 Overview of ArcMap

ArcMap is the main application utilized in the process to develop Wonogiri GIS Database and the other applications and the extension can be recognized as supporting applications. Therefore, ArcMap is overviewed in this clause for the first step to be a GIS user.

(1) Loading of Wonogiri GIS Database

Steps	Action
1	Double-click the Map icon on the Windows Desktop or Click start the Windows Taskbar, point to Programs, then ArcGIS and click ArcMap.
2	A dialog box opens that asks whether you want to start ArcMap with 'A new empty map', 'A template' or 'An existing map'.
3	Select 'An existing map' and click Browse for maps.
4	Search the file of "*Wonogiri GIS Database.mxd*" and click Open. Following ArcMap window open.

(2) Icon and Function List in ArcMap

Following list summarizes the useful icons and their functions. Try using the functions after the ArcMap starts.

Main Menu

Button	Function
File	
New	Open new ArcMap file.
Open	Open existing ArcMap file. (Not add existing GIS data such as shapefile or grid file in the active map display)
Button	Function
Save	Save the active ArcMap file.
Save As	Save the active ArcMap file as a different name.
Add Data	Add existing GIS data on the active map display.
Page and Print Setup	Change the page size and orientation (Portrait or Landscape)
Print Preview	Look print preview.

Print	Print.
Export Map	Export the image on the active map display as different format such as JPEG, GIF, TIFF, etc.
View	
Data View	Change map display from 'Layout View' to 'Data View'. (Normal display except finalization of printing material)
Layout View	Change map display from 'Data View' to 'Layout View'. (Special display for finalization of printing material)
Toolbars	Add new toolbar on ArcMap.
Insert (used in 'Layout View')	
Data Frame	Make new data frame to show two or more maps.
Title	Add title label.
Text	Add text label.
Legend	Add legend.
North Arrow	Add north arrow.
Scale Bar	Add scale bar. (ex.)
Scale Text	Add scale as text. (ex. 1:50,000)
Selection	
Select By Attribute	Select features by attribute. (ex. Select only paddy field in land use layer.)
Select By Location	Select features by location. (ex. Select rivers in Alang sub watershed)
Tools	
Add XY Data	Change XY table data (ex. dbf file) to point feature.

Tools Toolbar

Button	Function
Zoom In/Out	Zoom In/Out. (Click once: zooming around the selected point Click and drag a rectangle: zooming selected area)
Pan	Moving the image. (Click and drag the pointer)
Full Extent	Zooming to the full extent of the data.
Back Forward	Moving back or forward one display.
Identity	Check the attribute of the feature you select.
Measure	Measure the distance.
Hyperlink	Access photos related to features. (In case hyperlinks are applied in the layers shown on map display)

Other Frequent Used Toolbars

Toolbar	Function
Editor	Draw new features and edit existing features launched on 'Table of Contents'.
Georeferencing	Give the exact location data to selected raster data.
Layout	Edit the printing layout. (using in 'Layout View')
Topology	Checking topology of selected layer.

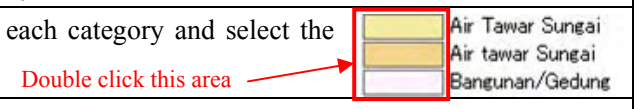
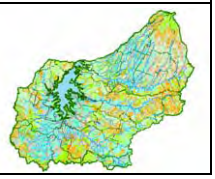
4.1.3 Introductory Utilization of ArcMap

(1) Setting Map

Steps	Action
1	Open ArcMap and select 'An existing map'.
2	Browse for "*Training for GIS.mxd*" file. (Name of data folder is "*Training*"under "*Wonogiri GIS Database*" folder.)
3	Click'Add Data' and add the following GIS data in "*Training*" folder. Kabupaten Boundary.shp Kecamatan Boundary.shp Desa Boundary.shp River.shp Landuse1993.shp
4	Change the order of layers in 'Table of Contents' as follows. (Drag and drop the layer in 'Table of Contents' to change the order.) River Kabupaten Boundary Kecamatan Boundary Desa Boundary.shp Reservoir Sub Watershed Landuse1993.shp
Steps	Action
5	Select following three layers in 'Table of Contents' and right-click to select Group. Kabupaten Boundary Kecamatan Boundary Desa Boundary.shp And then, change the group layer name as "*Administrative Boundary*"
6	Save the map by clicking in 'Standard' toolbar.

(2) Symbology

Steps	Action
Changing single symbol	
1	Right click on "*River*" layer and select 'Properties'.
2	Select 'Symbology' tag and click symbol button.
3	Select 'River' symbol in 'Symbol Selector' dialog box and click 'OK'.
4	Click 'OK' again of 'Layer Properties' window.
Importing layer file to change symbol	
5	Double click "*Kabupaten Boundary*" layer and select 'Symbology' tag.
6	Click 'Import' and click the ' Open Folder' icon.
7	Search "*Kabupaten Boundary.lyr*" file and click 'Add'.
8	Click 'OK' twice.
9	Change the symbol of "*Kecamatan Boundary*" layer and "*Desa Boundary*" layer same as the above steps.
Changing symbol by category	
10	Double click "Landuse1993" layer and select 'Symbology' tag.
11	Select 'Unique Value' in 'Categories'.
12	Click inside of 'Value Field' drop down box and select 'NAMA_UNSUR'.

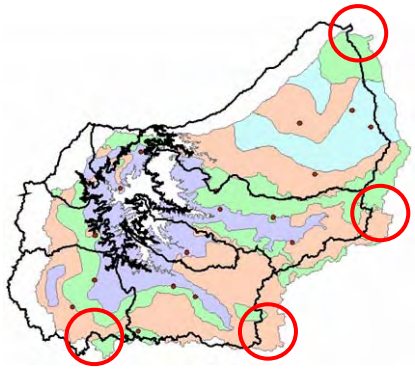
13	Click '**Add All Values**' button.
14	Double click the symbol in each category and select the symbol you like. 
15	Click '**OK**'.
16	Change the symbol of '**River**' same as the above steps using field of "*main_river*". The condition of the symbol is as follows. 0: Color – Light blue, Width – 0.50 1: Color – Deep blue, Width – 1.00
17	Final output will be similar as the right figure. 

(3) Georeferencing (To give specific coordinate on image file)

When existing paper based map needs to be converted to GIS raster data, the scanned maps does not have spatial information. Therefore, the scanned image cannot be overlaid on the existing GIS data. Even if satellite images with spatial information is utilized, the location of the images do not fit to existing GIS data completely because the images have an error of spatial location.

Function of georeferencing in ArcMap provides the exact location information to such images to consolidate new data with existing ones.

Four or more control points are necessary to do georeferencing. The right figure shows two maps, i.e. i) Scanned soil map (color image) without spatial information and ii) Watershed boundary (black line) with exact spatial information. The red circle in the right figure shows the potential control points to fit the location data of the color image to the watershed boundary.

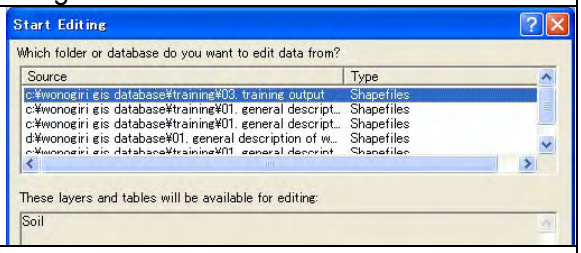


Steps	Action
1	Right-click on map display and select '**Turn All Layers Off**'.
2	Turn on "*Sub Watershed*" layer in '**Table of Contents**'.
3	Click '**Full Extent**' icon in 'Tool' toolbar.
4	Add "*Soil Map.jpg*" data stored in "*Training*" folder. (Even if a message is popped up, click '**OK**'.)
5	Click '**View**' and select '**Toolbars**' – '**Georeferencing**'. (Check '**Layer**' drop down box in '**Georeferencing**' toolbar. It should be "*Soil Map.jpg*")
6	Click '**Georeferencing**' button and click '**Fit To Display**'
7	Decide more than four control points from map viewer.
7	Click '**Add Control**' icon.
8	Click a control point of "*Soil Map.jpg*" and click the control point of "*Sub Watershed*".
9	Repeat step 8 to obtain 4 points or more control points. (*When you obtain incorrect control points, open '**Link Table**' and delete the points.)
10	Click '**Rectify**' in '**Georeferencing**' toolbar as following condition. Cell Size: default

	Resample Type: Nearest Naibor Output Raster: Wonogiri GIS database/Training/03. Training Output/rectifysoil map.tif
11	Delete "*Soil Map.jpg*" layer and add "*rectifysoil map.tif*" layer.

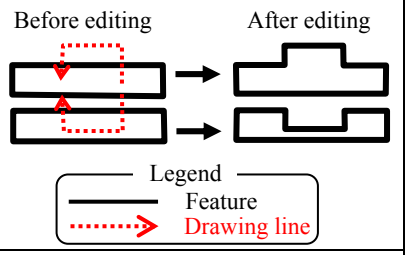
(4) Creating New GIS Data from Scanned Image

When new GIS data is created, topology should be taken care. For example, following steps you will create new "*Soil Map.shp*" file by yourself based on the georeferenced image. However, if the soil map is digitized only based on the image, the outer frame of digitized soil map might not fit the watershed boundary. Therefore, in the following step, "*Soil.shp*" file generated from the watershed boundary file is prepared for digitizing the image.

Steps	Action
1	Open ArcCatalog.
2	Copy "*Watershed.shp*" file stored in "*011. Watershed Boundary*" folder to "*03. Training*" folder.
3	Change the name of the copied file as "*Soil.shp*".
4	Add "*Soil.shp*" layer on ArcMap and change the layer order. ("*Soil.shp*" layer should be put on the top of all layers.)
5	Change the symbol of "*Soil.shp*" layer as follows Fill Color: Empty color Outline Width: 2 Outline Color: Red
6	Click 'View' and select 'Toolbars' – 'Editor'.
7	Click 'Editor' and Select 'Start Editing'.
8	Select 'Source' to edit "*Soil*" ("*Soil*" should be written in the column of 'These layers and tables will be available for editing:' shown as the right figure.) 
9	Check the name of file in the drop down box of 'Target' in 'Edit' toolbar. ("Soil" should be written in the box.)
10	Click ' Edit Tool' icon in 'Editor' toolbar and the feature of "*Soil*" layer in map display. (The feature's boundary will change from red to light blue, which show the feature is selected.)
11	Change task of editing in 'Task' drop down box to 'Cut Polygon Feature'.
12	Click ' Sketch Tool' icon and draw the line to cut the selected feature based on "*rectifysoil map.tif*" image.
13	After completion of digitizing soil map, click 'Editor' and select 'Stop Editing'.
14	Click 'Yes' if the pop up window appears to confirm to save your edit.
15	Delete "Soil

Function of Frequent Used Task in Editing Toolbar

Task	Function
Create New Feature	Drawing for new feature. (This task should be utilized in case of unnecessary consideration of topology.)

Reshape Feature	Reshape the selected feature as shown in the right figure. (Normally used for modification of shape of existing features.) 
Cut Polygon Features	Cut selected feature. (ex. When new layer needs to be prepared based on the existing GIS data, this is strongly recommended to use.)
Modify Feature	Modify vertex of selected feature.

Other Function in Editing Toolbar

Item	Function
Start Editing	Start editing process. (*Before start using sketch tool, check the target drop down box.)
Stop Editing	Stop editing process.
Save Editing	Save editing process without stopping the process. (When the drawing process is very complex and needs long time, it is strongly recommended to use "Stop Editing", even if the process is not completed yet.)
Move	Move selected features by specific specifying delta X,Y coordinates.
Merge	Combines features of the same layer into one feature.
Snapping	Snapping of drawing vertex to checked layers. (When you want to draw the new feature completely following the existing feature, utilization of this function is strongly recommended.)
Options – General	
Snapping tolerance	Set the distance to snap the vertex in editing process.
Sticky move tolerance	Set the minimum distance to move the selected features. (This is very useful for protection of unexpected moving of selected feature.)

(5) Attribute Table

Steps	Action
1	Check on only "*rectifysoil map.tif*" and "*Soil*" layer and check off the other layers.
2	Right-click on "*Soil*" layer and select 'Open Attribute Tabel'.
3	Click 'Options' and select 'Add Field'.
4	Type and select following information in columns concerned and click 'OK'. Name: Soil_Type Type: Text Length: 15
5	Right click on "*Name*" field and select 'Delete Field'.
6	Close the 'Attribute' window.
7	Click 'Start Editing' in 'Editor' toolbar.
8	Select "*Soil*" to be edited in 'Start Editing' window and click 'OK'.
9	Select one feature of '*Soil*" layer and right-click to select 'Attributes'.
10	Type name of soil in "*Soil_Type*" column in 'Attribute' window. Relational table between color of "Rectifysoil map.tif" and type of soil is as follows: Green: Lithosols

	Light blue: Latosols Orange: Mediteran soil Purple: Grumsols
11	Repeat step 8 and 9 to complete filling the column of "*Soil_Type*".
12	After completion, click 'Stop Editing" in 'Editor' toolbar.
13	Open 'Attribute Table' of "*Soil*" layer.
14	Select "*Area_km2*" field and right-click to 'Calculate Values'.
15	Click 'OK' on pop up window of 'Field Calculator'.
16	Check on the check box of 'Advanced' and click 'Help' button.
17	Find the sentence of 'To Calculate area' in 'Help' window and copy the following portion. Dim Output as double Dim pArea as Iarea Set pArea = [shape] Output = pArea.area
18	Paste the copied portion in 'Pre-Logic VBA Script Code' column and modify the pasted scripts as follows. Dim Output as double Dim pArea as Iarea Set pArea = [shape] Output = pArea.area / 1000000 (* This is necessary to convert calculated area in 'Square Meter' to 'Square Kilometer'. If you want to convert from 'Square Meter' to 'Hectare', 'pArea.area' needs to be divided by 10,000.)
19	Type the letter of Output in "*Area_km2_* =" column and Click 'OK'.

(6) Printing

Before Starting of Printing Setup

Steps	Action
1	Delete following layers from 'Table of Contents'. Soil Landuse1993 rectifysoil map.tif Sub Watershed
2	Change the layer order in 'Table of Contents' as follows. Kabupaten Boundary Kecamatan Boundary Desa Boundary River (colored by "*main_river*" field) Reservoir
3	Check all layers on.

Setting Legend

Steps	Action
1	Click 'View' and select ' Layout View'.
2	Click 'File' and select ' Page and Print Setup'.
3	Fill the following information in drop boxes and check lists concerned. Paper Size: A4 Orientation: Landscape

4	Click the map in map display and change the size to fit the boundary of the page.
5	Click 'Full Extent' icon in 'Tool' toolbar.
6	Click 'Insert' and select 'egend'.
7	Check all items to give the legend and click 'Next'.
8	Click next again. (If you want to change the information, change it.)
9	Click 'Border' drop down box to select 1.0 point as a border and click 'Next'.
10	Click 'Next' if you do not need to modify the information.
11	And then, click 'OK'.
12	Change location and size of the legeng.

Setting North Arrow

Steps	Action
1	Click 'Insert' and select 'North Arrow'.
2	Select the symbol of north arrow and click 'OK'.
3	Change location and size of the north arrow.

Setting Scale Bar

Steps	Action
1	Click 'Insert' and select 'cale Bar'.
2	Select the symbol of scale bar and click 'OK'.
3	Change location of the scale bar.
4	Right-click the scale bar and select 'Properties'.
5	Click 'Scale and Units' tab.
6	Type and select the following information in columns concerned. Number of divisions: 5 Number of subdivisions: 4 Division Units: Kilometers Label: km
7	Click 'Numbers and Marks' tab and change 'Frequency' as 'divisions and first subdivisions'.
8	Click 'OK'.
9	Change size of scale bar. (The total length of scale bar should be 20 km.)

Labeling of Features

Steps	Action
1	Right-click "*Sub Watershed*" and select 'Properties'.
2	Click 'Labels' tab and put the following information in the columns concerned. Label Field: SUBDAS Text Symbol: Arial, 16 pts, Black, Bold
3	Click 'OK'.
4	Right-click "*Sub Watershed*" and select 'Label Features'.

Export of Output as a Image File

Steps	Action
1	Click 'File' and select 'Export Map'.
2	Select the location of storage folder and type the name of image file you want to create.
3	Select the file type as GIF. Following file type is strongly recommended in each

	case. JPEG: Raster image is included in the output and it needs to be compressed. GIF: Only vector information in the output and it needs to be compressed. BMP, TIFF: You do not want to compress the image file to keep the high image quality.
4	Type resolution as 200 dpi.
5	Click 'Save'.
6	When you open the exported file, the similar image to the right will open on your display. 

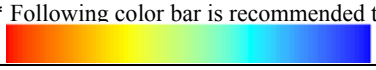
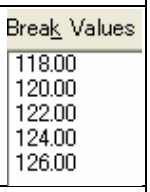
4.2 Advanced Operation of ArcGIS for Calculation of Sedimentation

4.2.1 Calculation of Sedimentation Volume

(1) Conversion of Table Data of Echo-sounding to GIS Point Data

Steps	Action
1	Open the table data filled with the survey result of echo-sounding by MS EXCEL. * The coordinate of the data should be as follows. Coordinate: WGS84 UTM (Zone number: 49S) This 'WGS84' is utilized as standard coordinate in Indonesia and Wonogiri reservoir and its watershed are located in 'Zone Number 49S'.
2	Check the sheet format especially in the following points. - Field name: less than 10 characters - Field column: only 1 line is acceptable - Cell format: to be defined - Field label: X (or Easting), Y (or Northing), and Z (or Elevation) data is inevitable. **- Less than 10 characters** **- Field must be only one line.** A B 1 NO X Y Z 2 1-9 487056 9120159 136.72 3 9L 487116 9120184 134.5000 4 2-9 487183 9120212 134.69 5 3-9 487321 9120271 132.45 **- Cell format must be defined as Number and decimal degree as 2.**
3	Save the file as 'DBF' file format.
4	Open ArcMap.
5	Click 'Add Data' and select the saved 'DBF' file in step 3.
6	Right-click on the file layer and select 'Display XY Data'.
7	Select X (or Easting) data in 'X Field' and Y (or Northing) data in 'Y Field' from drop down boxes respectively.
8	Click 'Edit' button.
9	Click 'Select' button and select 'WGS 1984 UTM Zone 49S.prj' in the following folder. Storage: Projected Coordinate Systems – UTM – Wgs1984
10	Click 'OK' twice.
11	Right-click the generated point data and select 'Data' – 'Export Data'.
12	Save the file in the folder you want to store.

(2) Change Symbol of the Point Features of Echo Sounding Survey

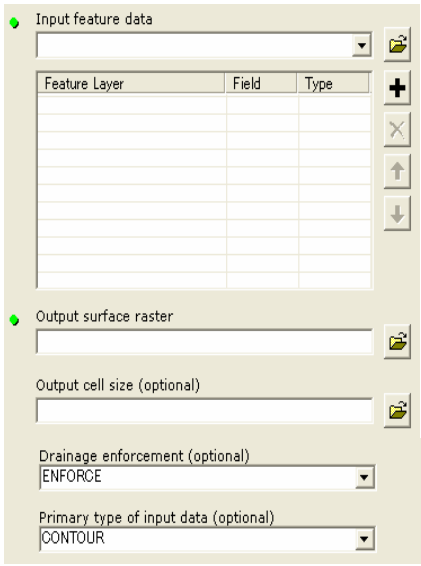
Steps	Action
1	Add the saved file in the above process.
2	Right-click the file and select 'Properties'.
Steps	Action
3	Click 'Symbology' tab and select 'Quantities' – 'Gradeated colors' in 'Show' column.
4	Select Z (or Elevation) data of the file in 'Value' drop down box of 'Fields' area.
5	Change the symbol color using 'Color Ramp' drop down box. * Following color bar is recommended to easily identify the difference of the color. 
6	Select 'Classes' drop down box as 5 and click 'Classify' button.
7	Click each value shown in 'Break Value' box and type the number you wan to classify. After setting all values, click 'OK'. * The right figure is the example of classification. In this case, the color of features will change in each 2 meters. 
8	Click 'OK' again and you will find the colored features in the map display.

(3) Digitizing Contour Line

Steps	Action
1	Open ArcCatalog and select a folder you want to store a new file to draw contour lines.
2	Right-click a blank area in the right window and select 'New' – 'Shapefile'.
3	Put the following information in columns concerned. Name: Contour[Surveyed Year] Feature Type: Polyline Description: WGS 1984 UTM Zone 49S.prj
4	Click 'OK'.
5	Open ArcMap and add the following data as following layer order. - New shape file prepared in step 2-4 - Echo sounding survey data converted as point features - Contour line files drawn based on the previous survey result
6	Open attribute table of the new shapefile.
7	Click 'Option' button and select 'Add Field'.
8	Type and select the following information and click 'OK'. Name: Elevation Type: Float Precision: 5 Scale: 2
9	Change symbol and put label of the added layers. - Echo sounding survey data (Colored symbol by elevation Label of elevation, if necessary) - New shape file (Label of elevation) - Contour line files (Label of elevation)
10	Click 'Start Editing' in 'Editor' toolbar and select a folder storing the new shapefile.
Steps	Action
11	Draw a new contour line using 'Sketch Tool' icon based on the color of

	surveyed data and the previous contour lines. * Before drawing, check the following information Task: Create New Feature Target: Contour[Year] (new file for drawing contour line)
12	Select the new drawing contour line feature using 'Edit Tool' icon and right-click to select open 'Attribute'.
13	Type elevation of the contour line in "*Elevation*" column.
14	Continue the step 11 to 13 until finish the drawing and click 'Stop Editing'.
15	Open attribute table and chack elevation data filled in each feature.

(4) Generating DEM from Contour Lines

Steps	Action
1	Add "*Reservoir.shp*" file on ArcMap.
2	Click 'ArcToolbox' icon on ArcMap.
3	Select 'Spatial Analysis Tools' – ' Interpolation' – 'Topo to Raster'.
4	Fill the following information in the columns concerned. Input feature data: - New contour line Field: Elevation Type: Contour - Reservoir Type: Boundary Output surface raster: - select the storage folder and file name Output cell size: 10 Drainage enforcement: - NO_ENFORCE Primary type of input data: - CONTOUR Others: default 
5	Click 'OK'.

(5) Calculation of Sedimentation Volume in the Reservoir

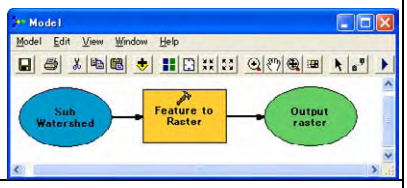
Steps	Action
1	Click 'ArcToolbox' icon on ArcMap.
2	Select 'Spatial Analysis Tools' – 'Math' –'Minus'.
3	Fill the following information in the columns concerned. Input raster or constant value 1: generated DEM from the previous steps Input raster or constant value 2: DEM named as"dem2005" stored in the following folder 'Wonogiri GIS database/Training/02. Sedimentation in Reservoir/033. Sedimentation in 2005 Output raster: select the storage folder and decide the file name
Steps	Action
4	Open the generated DEM and check the reliability of the data. * If the DEM looks unreliable, check the contour line drawn in previous session and the attribute again and modify the contour line, if necessary.
5	Select 'Spatial Analysis Tools' – 'Zonal' – 'Zonal Statistics as Table'.

6	Fill the following information in the columns concerned and click 'OK'. Input raster or feature zone data: Reservoir Zone field: ID Input value raster: differential DEM generated from step 3 Output table: select the storage folder and decide the file name
7	Open the generated table file and calculate the sedimentation volume. Sedimentation volume (m^3) = number in AREA (m^2) * number in Mean (m)

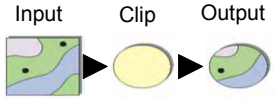
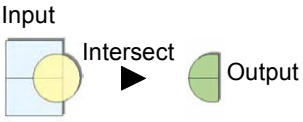
4.2.2 Calculation of Sediment Yield in the Watershed

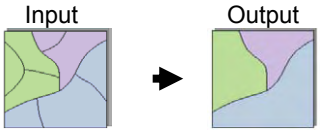
In this clause, the modeling process is described since the difficulty of the calculation in USLE is the process of making calculation model if the data has been already prepared.

(1) Making and Running Model by Model Builder

Steps	Action
1	Click 'ArcToolbox' icon on ArcMap.
2	Right-click in the ArcToolbox window and select 'New Toolbox'.
3	Type the name of the new toolbox.
4	Right-click on the new toolbox and select 'New' – 'Model'.
5	Open 'Conversion Tools' – 'To Raster' folder in ArcToolbox window.
6	Drag 'Feature to Raster' tool and Drop into new 'Model' window. 'Feature to Raster' tool will be launched on the new model.
7	Add "*Sub Watershed*" layer on ArcMap.
8	Drag the layer and drop into the 'Model' window.
9	Click 'Add Connection' button and connect from "*Sub Watershed*" to 'Feature to Raster' tool. The 'Model' window will look like the right figure. 
10	Double-click on "*Output raster*" symbol and decide the file name to be stored.
11	Click 'Model' and select 'Run'. New file is generated by running your model.
12	Click 'Model' and select 'Save'. And then close the window.
13	Change the model name and the toolbox name.
14	Right-click on the new toolbox to search the storage location of the model.
15	When you edit or run the model, right-click on the model icon and select 'Edit' (not 'Open').

(2) Utilized Tools in USLE

Tool	Storage	Function
Clip	Analysis Tools - Extract	Clip 'Input Features' by 'Clip Features'. 
Intersect	Analysis Tools - Overlay	Cut 'Input Features' by 'Intersect Features' within the overlapped area. 
Feature to Raster	Conversion Tools - To Raster	Convert features to a raster image. * 'Field' and 'Output cell size' needs

		to be identified. (20 m is applied in the JICA Study.)
Dissolve	Data Management Tools - Generalization	Aggregate features based on the attributes you select. 
Con	Spatial Analyst Tools - Conditional	Perform a conditional if/else evaluation on each of the input cells. * Expression for classification should be checked.
Topo to Raster	Spatial Analyst Tools - Interpolation	Refer to Clause 4.2.1 (4).
Plus, Minus Times, Square Square Root	Spatial Analysis Tools - Math	Calculate the values of two raster images on a cell-by-cell basis.
Reclassify	Spatial Analyst Tools - Reclass	Change the values in each cell of a raster based on 'Reclassification' table. * Reclassification table should be checked.
Slope	Spatial Analyst Tools - Surface	Generate slope steepness by Degree/Percent based on DEM.
Zonal Statistics as Table	Spatial Analyst - Zonal	Summarizes values of a raster image within the zones of another dataset as a table.

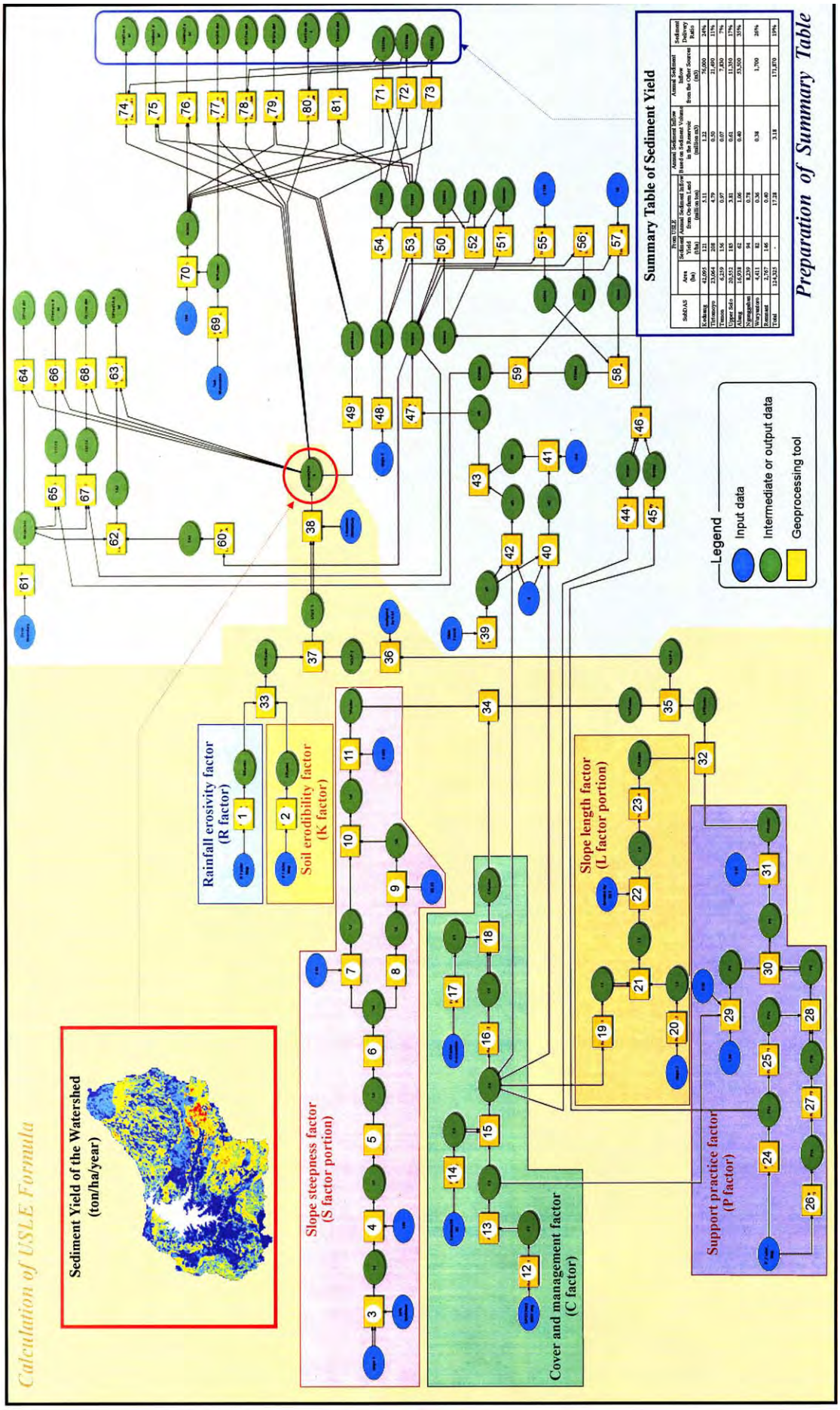


Figure 4.2.1 USLE Calculation Model in ArcGIS

(3) Detailed Flow of USLE Model

Steps	Tool	Input	Output	Remarks
R factor (Converting R factor map to R factor raster data)				
1	Feature to Raster	R Factor Map	RRaster	Grid:20 m/pixel
K factor (Converting K factor map to K factor raster data)				
2	Feature to Raster	K Factor Map	KRaster	Grid:20m/pixel
S factor (Calculation of the following equation: $65.41 \sin^2\theta + 4.56\sin\theta + 0.065$)				
3	Con	slope	S1	Steepness more than 50% regards as 50 %.
4	Divede	S1	S2	Percentised steepness is changed to decimal.
5	Atan	S2	S3	Arc tangent of S2
6	Sin	S3	S4	$\sin\theta$
7	Times	S4	S7	$4.56 \sin\theta$
8	Square	S4	S5	$\sin^2\theta$
9	Times	S5	65.41	$65.41 \sin^2\theta$
10	Plus	S6, S7	S8	$65.41 \sin^2\theta+4.56 \sin\theta$
11	Plus	S8	SRaster	S factor map
C factor (Converting to raster data and classification by land use category)				
12	Reclassify	SPOT20030801	C2	Classification of settlement area and upland field in settlement
13	Aggregate	C2	C3	Aggregation of 4 x 4 pixel's window.
14	Feature to Raster	Landuse2005	C4	Grid:20m/pixel
15	Con	C3, C4	C5	Replacement of settelment GIS data to satellite based data.
16	Reclassify	C5	C6	Conversion of land use data to C factor*100 except upland field
17	Feature to Raster	Cfactor Kecamatan	C1	C factor*100 in upland field by village
18	Con	C1, C6	CRaster	Replacement of C factor*100 in upland field to village basis C factor*100
L factor (Calculation of the following equation: $(\lambda /22.1)^{0.5}$				
19	Reclassify	C5	L1	Classification by land use
20	Reclassify	slope	L2	Classification by slope steepness
21	Con	L1, L2	L3	Replacement L1 value to L2 value by land use category
Steps	Tool	Input	Output	Remarks
22	Times	L3	L4	$\lambda /22.1$
23	Square Root	L4	LRaster	$(\lambda/22.1)^{0.5}$
P factor (Converting to raster data and classification by land use and terrace type)				

24	Feature to Raster	P Factor Map	P1a	Rasterization by terrace type
25	Reclassify	P1a	P2a	Conversion of terrace type data to P factor*100 except upland field
26	Feature to Raster	P Factor Map	P1b	Rasterization by land use data in P Factor Map
27	Reclassify	P1b	P2b	Replacement of land use data to P factor*100 except upland field and settlement area.
28	Con	P2a, P2b	P3	Replacement of P factor*100 in upland field based on terrace condition.
29	Con	C3	P4	Conversion of land use in settelement area to P factor*100
30	Con	P3, P4	P5	Replacement of P factor*100 in settlement area to P factor*100 calculated based on satellite image.
Calculation of USLE				
31	Times	P5	PRaster	P factor map
32	Times	LRaster, PRaster	LPRaster	L * P
33	Times	RRaster, KRaster	RKRaster	R * K
34	Times	SRaster, CRaster	SCRaster	S * C*100
35	Times	SCRaster, LPRaster	SCLP-1	S * C*100 * L * P
36	Times	SCLP-1	SCLP-2	S * C * L * P
37	Times	SCLP-2, RKRaster	USLE-1	R * K * L * S * C * P
38	Con	USLE-1	Present2005	Limitation of erosion: 2,000 ton/ha/year at maximum
Preparation of Sammry Table				
39	Feature to Raster	State Forest	sf1	Rasterazation by state forest area
40	Con	C5, sf1	sf2	Selection of C5 value inside state forest area
Steps	Tool	Input	Output	Remarks
41	Times	sf2	sf4	C5 value*10 inside state forest area
42	Con	C5, sf1	sf3	Selection of C5 value outside state forest area
43	Plus	sf3, sf4	sf5	Inside state forest: C5 Outside state forest:

				C5*100
44	Reclassify	C5	terrsat	Selection of settlement area and upland field
45	Reclassify	P1a	terrshp	Selection of upland field by terrace condition
46	Con	terrsat, terrshp	terrace	Replacement of value in upland field to the value by terrace condition
47	Reclassify	sf5	luclass	Replacement of value by land use
48	Reclassify	slope	slopeclass	Classification by slope steepness
49	Reclassify	present2005	yieldclass	Classification by sediment yield
50	Plus	luclass, terrace	12000a	Classification by land use and terrace condition
51	Reclassify	luclass	classws	Selection of settlement area, upland field and state forest area not used as dense forest (hereinafter refered to as Target area)
52	Times	classws, 12000a	12000b	Classification by land use and terrace condition in Target area
53	Plus	slopeclass, luclass	10300	Classification by land use and slope steepness
54	Plus	slopeclass, 12000b	12300	Classification by slope steepness, land use and terrace condition in Target area
55	Times	slopeclass	sclass	slopeclass*100
56	Reclassify	luclass	lclass	Selection of settlement area and upland field outside state forest (hereinafter refered to as Action area)
57	Times	terrace	tclass	Terrace*10
Steps	Tool	Input	Output	Remarks
58	Plus	sclass, tclass	02300a	Classification by slope steepness and terrace condition
59	Times	02300a, lclass	02300b	Selection of 02300a in Action area
60	Reclassify	luclass	TA1	Selection of Action area
61	Feature to Raster	Desa Boundary	desaclass	
62	Times	TA1, desaclass	TA2	Classification of Action area by village

63	Zonal Statistics as Table	TA2, present2005	DProdTA	Sediment production in Action area by village
64	Zonal Statistics as Table	desaclass, present2005	DProd	Sediment production by village
65	Plus	desaclass, 02300b	12123	Classification of Action area by village, slope steepness and terrace condition
66	Zonal Statistics as Table	12123, present2005	DTerrace	Sediment production in Action area by village, slope steepness and terrace condition
67	Plus	luclass, desaclass	10123	Classification by village and land use
68	Zonal Statistics as Table	10123, present2005	DLUse	Sediment production by village and land use
69	Feature to Raster	Sub Watershed	WRaster	Rasterization by sub watershed
70	Times	WRaster	wclass	WRaster*100
71	Plus	10300, wclass	10340w	Classification by land use, slope steepness and sub watershed
72	Plus	12300, wclass	02340w	Classification by slope steepness, land use, terrace condition and sub watershed in Target area
73	Plus	10300, yieldclass	10340y	Classification by land use, slope steepness and sediment yield category
74	Zonal Statistics as Table	10340y, present2005	YieldTon	Sediment production by land use, slope steepness and sediment yield category
75	Tabulate Area	10300, yieldclass	YieldHa1	Area by land use, slope steepeness and sediment yield category
Steps	Tool	Input	Output	Remarks
76	Tabulate Area	wclass, yieldclass	YieldHa2	Area by subwatershed and sediment yield category
77	Zonal Statistics as Table	WRaster, present2005	forSDR	Sediment production by subwatershed
78	Zonal Statistics as Table	10340w, present2005	WSTon	Sediment production by landuse, slope steepness and sub watershed
79	Tabulate Area	10300, wclass	WSHa	Area by land use, slope steepness and sub watershed
80	Zonal Statistics	02340w,	TerrTon	Sediment production by

	as Table	present2005		slope steepness, land use, terrace condition and sub watershed in Target area
81	Tabulate Area	12300, wclass	TerrHa	Area by slope steepness, land use, terrace condition and subwatershed in Target area.