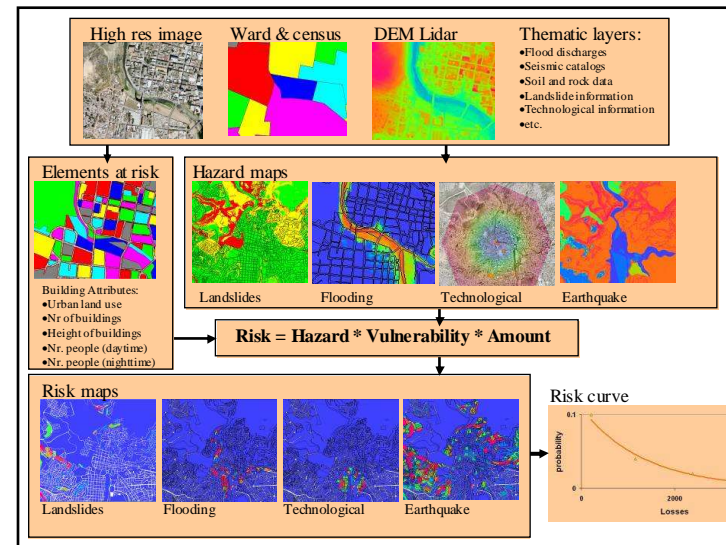


## RiskCity

### Application of GIS for multi-hazard risk assessment in an urban environment

Cees van Westen (ed)



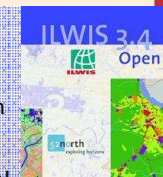
## Objective of case study

- The objective of this exercise is to demonstrate the concepts of the use of GIS for landslide susceptibility, hazard and risk assessment in an urban setting.
- Risk is defined as *the probability of harmful consequences, or expected loss (of lives, people injured, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human induced hazards and vulnerable/capable conditions.*
- Risk assessment with GIS can be done on the basis of the following basic equation:  

$$\text{Risk} = \text{Hazard} * \text{Vulnerability} * \text{Amount of elements at risk}$$

## ILWIS key features

- Import and export of widely used data formats
- On-screen and tablet digitizing
- Comprehensive set of image processing tools
- Orthophoto, image georeferencing, transformation and mosaicing
- Advanced modeling and spatial data analysis
- 3D visualization with interactive editing for optimal view findings
- Rich projection and coordinate system library
- Geo-statistical analyses, with Kriging for improved interpolation
- Production and visualization of stereo image pairs
- Spatial Multiple Criteria Evaluation



## Main window

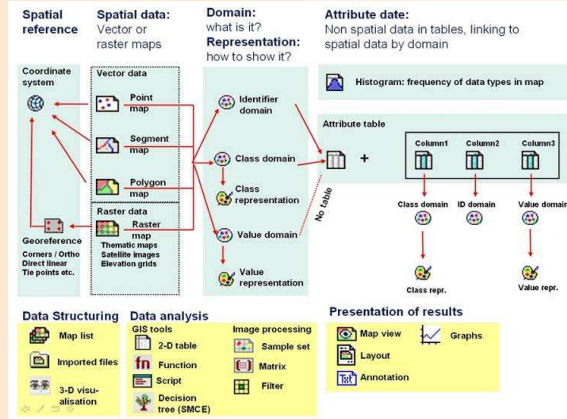
**Object selection**  
Defines which objects are visible in data catalog

**Toolbar**      **Menu bar**      **Command line:**  
Used for executing most operations      Used for executing most of the calculations with maps

**Navigation pane**  
You can also change it to operation-tree or operation list

**Data catalog**  
with icons indicating different types of data.  
Note: right-clicking on an icon gives the operations that are possible

## Main structure



## Installation

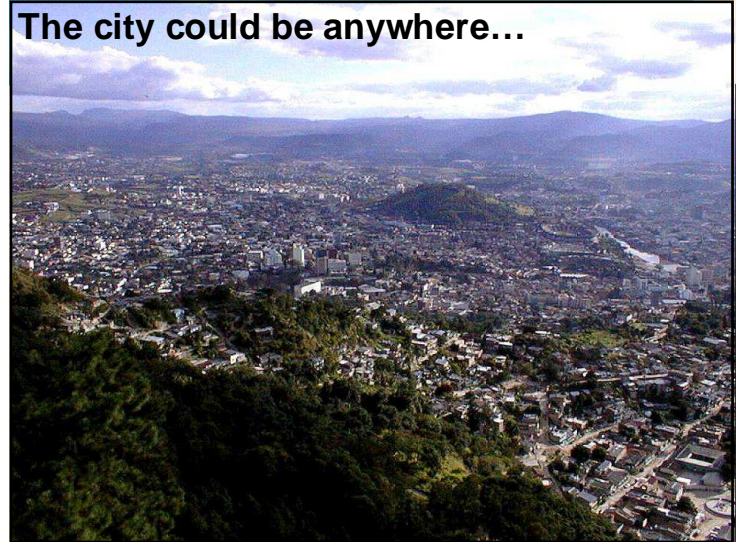
### Installation instructions

The ILWIS binaries are very simple to install. Copy the folder in the downloaded zip file. In this folder there is an ILWIS30.EXE which is the main executable for ILWIS. Double click this file to start ILWIS.

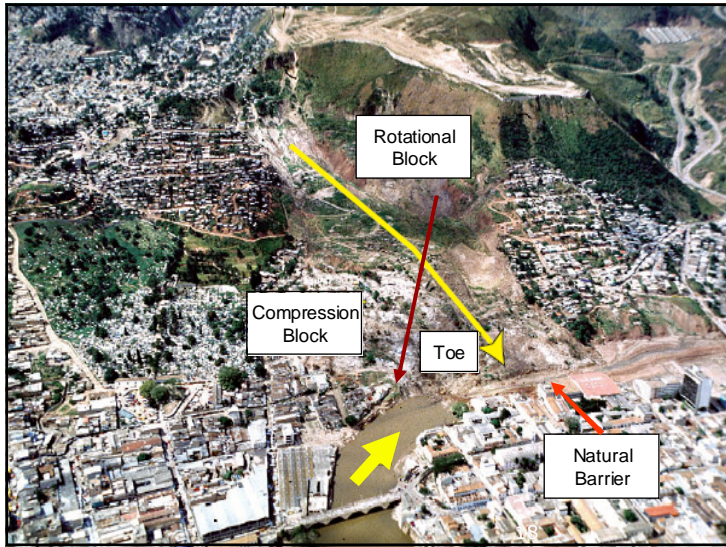
IF and ONLY IF the user wants to use the command line COM functionality of ILWIS (make the ILWIS command line available through the Windows COM functionality), the following steps must be taken. The COM registration needs two steps (assume the current directory is the directory with ILWIS30.EXE). These are started from the windows command line (via "Start/Run", or from a "Command Prompt" window).

```
regsvr32.exe /s IlwisComProxy.dll
ilwis30.exe -RegServer
```

The option -RegServer needs to be typed exactly as written here. The order in which the commands are executed is not important

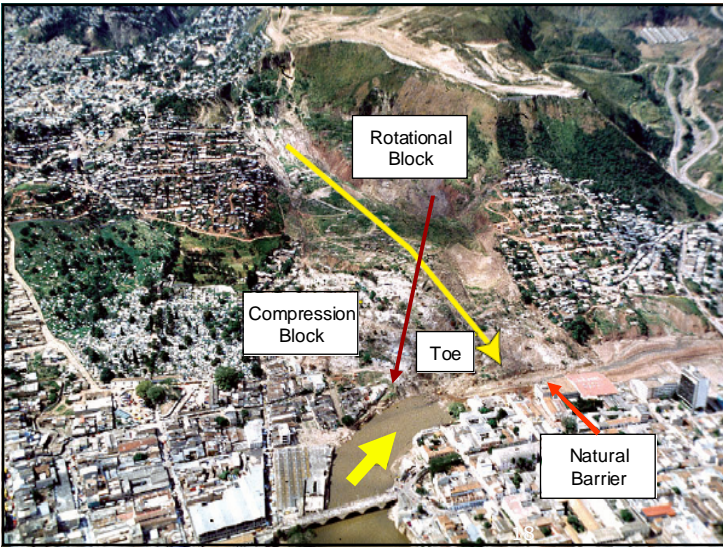






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## Example: Tegucigalpa, Honduras



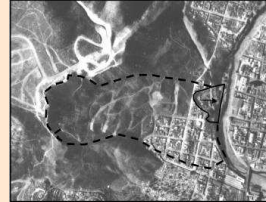


## Flood and landslide

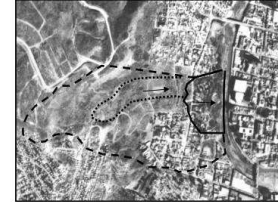


## Example: Berrinche landslide

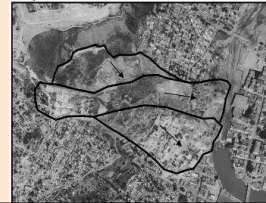
Airphoto 1:14,000 from 16-March-1975



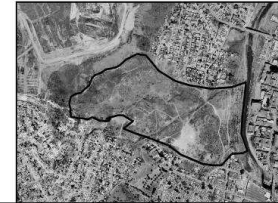
Airphoto 1:20,000 from 9-February-1990



Airphoto 1:25,000 from 1998

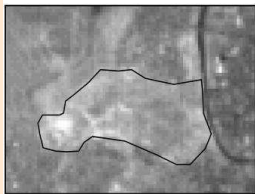


Airphoto 1:10,000 photos from May 2001

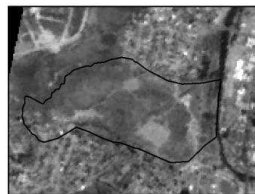


## Example: Berrinche landslide

Aster image (15 m. spatial resolution) 2005



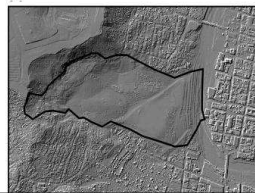
IRS-P6 (6.6 m. resolution) from 2006



Google Earth (Digital Globe image) 2007



Lidar hillshading image

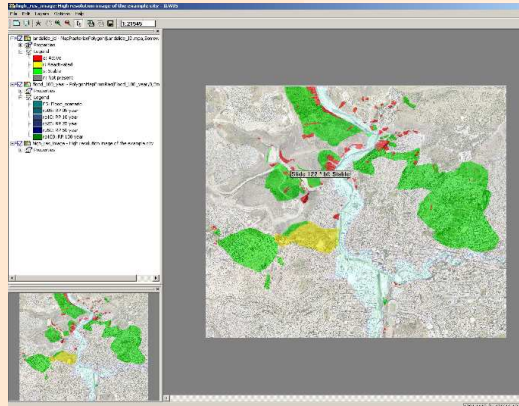


## Input data

- Image data
- Hazard data
- Elements at risk
- Height data

Name	Type
Image data	
High_res_image	Raster image
Elevation data	
LidarDEM	Raster map
Contours	Segment map
TopoDEM	Raster map
Elements at risk	
Wards	Polygon map
Mapping_units	Polygon map and table
Building_map	Raster map
Roads	Segment map
Hazard data	
Landslide_ID	Raster map
Flood_100_year	Polygon map
Rivers	Segment map

# HAZARD DATA



Landslides

# Landslide inventory

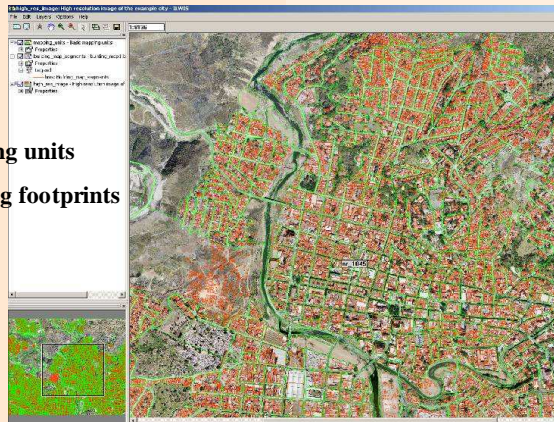
Ln	Landslide part	Activity	Fact	ReturnPeriod	Area	Landslide nr	Depth
Slide	Scarp of recent landslide	Active	Scarp	1/100 years	274	Slide 1	3.40 Mtr
Slide	Body of fossil landslide	Stable	Body	1/300 years	14128	Slide 10	16.00 Mtr
Slide	Scarp of fossil landslide	Stable	Scarp	1/300 years	70188	Slide 10	16.00 Mtr
Slide	Body of fossil landslide	Stable	Body	1/200 years	9102	Slide 100	7.90 Mtr
Slide	Scarp of fossil landslide	Stable	Scarp	1/200 years	27204	Slide 101	40.00 Mtr
Slide	Body of fossil landslide	Stable	Body	1/200 years	59058	Slide 102	34.00 Mtr
Slide	Scarp of fossil landslide	Stable	Scarp	1/200 years	19202	Slide 103	11.38 Mtr
Slide	Body of recent landslide	Active	Body	1/100 years	9063	Slide 104	7.80 Mtr
Slide	Scarp of recent landslide	Active	Scarp	1/100 years	7943	Slide 105	6.40 Mtr
Slide	Body of fossil landslide	Stable	Body	1/200 years	60845	Slide 107	24.00 Mtr
Slide	Scarp of fossil landslide	Stable	Scarp	1/200 years	29820	Slide 107	24.00 Mtr
Slide	Body of reactivated landslide	Reactiva	Body	1/100 years	186124	Slide 109	45.00 Mtr
Slide	Scarp of recent landslide	Active	Scarp	1/1050 years	230	Slide 11	3.30 Mtr
Slide	Scarp of reactivated landslide	Reactiva	Scarp	1/200 years	28527	Slide 112	38.00 Mtr
Slide	Scarp of recent landslide	Active	Scarp	1/100 years	939	Slide 113	1.30 Mtr
Slide	Scarp of recent landslide	Active	Scarp	1/1050 years	941	Slide 115	3.70 Mtr
Slide	Scarp of recent landslide	Active	Scarp	1/100 years	477	Slide 116	1.30 Mtr
Slide	Body of fossil landslide	Stable	Body	1/200 years	23718	Slide 117	40.00 Mtr
Slide	Scarp of fossil landslide	Stable	Scarp	1/200 years	3304	Slide 117	40.00 Mtr
Slide	Scarp of recent landslide	Active	Scarp	1/100 years	1470	Slide 118	1.28 Mtr
Slide	Scarp of recent landslide	Active	Scarp	1/1050 years	8585	Slide 119	7.48 Mtr
Slide	Scarp of recent landslide	Active	Scarp	1/1050 years	219	Slide 12	1.80 Mtr
Slide	Scarp of fossil landslide	Stable	Scarp	1/200 years	4744	Slide 120	4.14 Mtr
Slide	Scarp of recent landslide	Active	Scarp	1/100 years	901	Slide 121	1.20 Mtr
Slide	Body of fossil landslide	Stable	Body	1/300 years	67406	Slide 122	39.00 Mtr
Slide	Scarp of fossil landslide	Stable	Scarp	1/300 years	32772	Slide 122	33.00 Mtr
Slide	Scarp of fossil landslide	Stable	Scarp	1/200 years	43640	Slide 124	55.00 Mtr
Slide	Body of fossil landslide	Stable	Body	1/200 years	14889	Slide 125	14.49 Mtr
Slide	Scarp of recent landslide	Active	Scarp	1/100 years	2519	Slide 126	2.20 Mtr
Slide	Body of fossil landslide	Stable	Body	1/200 years	2821	Slide 127	2.46 Mtr
Slide	Scarp of recent landslide	Active	Scarp	1/100 years	611	Slide 128	1.40 Mtr
Min					110		1.02
Max					374143		55.00
AVG					14480		8.92
STD					45433		13.33
Sum					4242881		1624.11

Statistics of Landslide area

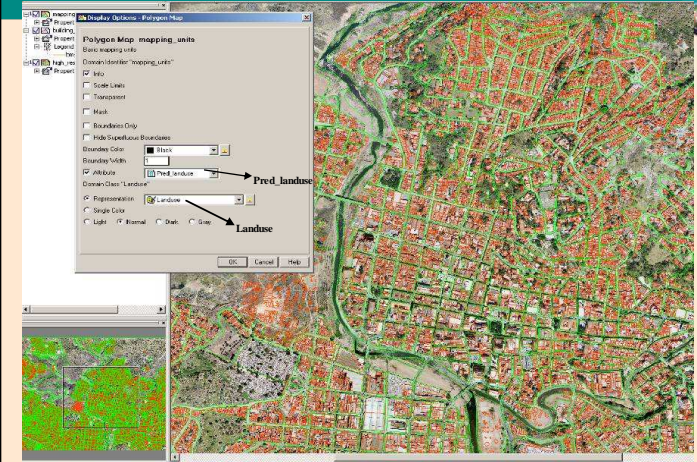
Total landslide area

# Element at risk data

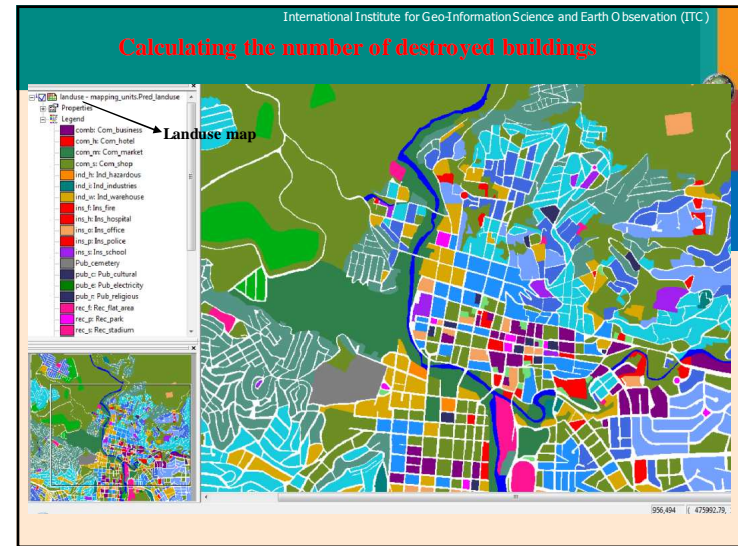
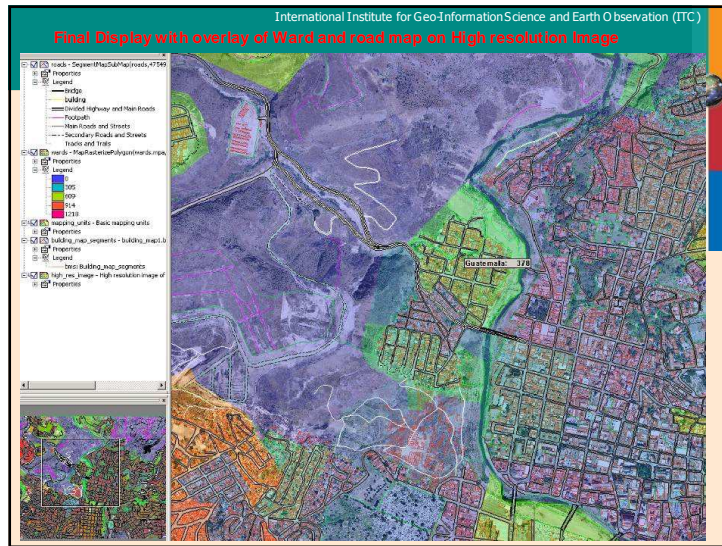
wards  
mapping units  
building footprints  
roads



# Display the Urban Landuse as an attribute





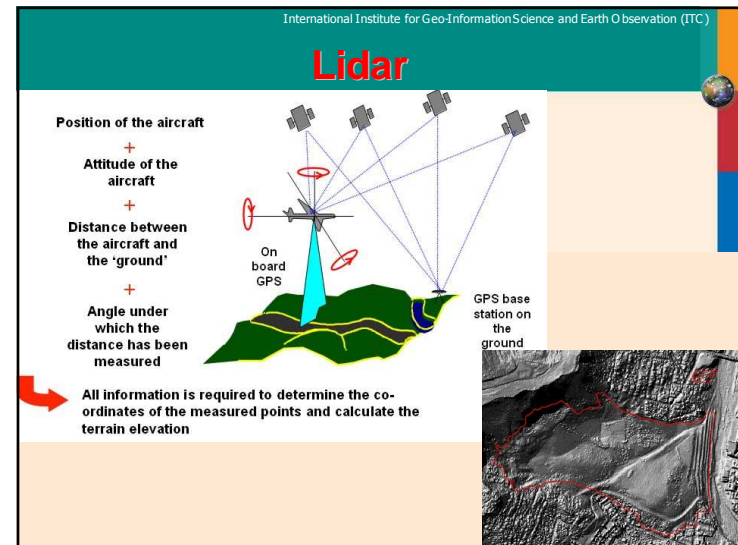


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### Cross table after the cross operation with the raster maps Landuse and building map

Dependent Table "Landuse\_buildings" - TableCross(landuse.mpr,building\_map,mpr,IgnoreUndefs) - ILMWS

landuse	building_map	NPix	Area	Vac_damaged
ind_w * B_27344	Ind_warehouse	B_27344	70	29594
ind_w * B_27368	Ind_warehouse	B_27368	53	29594
ind_w * B_27389	Ind_warehouse	B_27389	67	29594
ind_w * B_27401	Ind_warehouse	B_27401	58	29594
ind_w * B_27427	Ind_warehouse	B_27427	2	29594
ind_w * B_28194	Ind_warehouse	B_28194	1352	29594
ind_w * B_28630	Ind_warehouse	B_28630	296	29594
ind_w * B_28694	Ind_warehouse	B_28694	1469	29594
ind_w * B_28695	Ind_warehouse	B_28695	134	29594
ind_w * B_28792	Ind_warehouse	B_28792	140	29594
ind_w * B_28836	Ind_warehouse	B_28836	126	29594
ind_w * B_28924	Ind_warehouse	B_28924	444	29594
ind_w * B_28938	Ind_warehouse	B_28938	121	29594
ind_w * B_28940	Ind_warehouse	B_28940	84	29594
ind_w * B_28955	Ind_warehouse	B_28955	172	29594
ind_w * B_28975	Ind_warehouse	B_28975	165	29594
ind_w * B_28984	Ind_warehouse	B_28984	233	29594
ind_w * B_29091	Ind_warehouse	B_29091	109	29594
ind_w * B_29154	Ind_warehouse	B_29154	200	29594
ind_w * B_29166	Ind_warehouse	B_29166	117	29594
com_h * B_010072	Com_hotel	B_010072	582	29594
com_h * B_01108	Com_hotel	B_01108	281	29594
com_h * B_01358	Com_hotel	B_01358	6	29594
com_h * B_01369	Com_hotel	B_01369	106	29594
com_h * B_01410	Com_hotel	B_01410	237	29594
com_h * B_01541	Com_hotel	B_01541	279	29594
com_h * B_01920	Com_hotel	B_01920	5	29594
com_h * B_01950	Com_hotel	B_01950	4	29594
com_h * B_02123	Com_hotel	B_02123	445	29594
com_h * B_02217	Com_hotel	B_02217	34	29594
com_h * B_02557	Com_hotel	B_02557	1	29594
com_h * B_02738	Com_hotel	B_02738	1577	29594
com_h * B_02880	Com_hotel	B_02880	9	29594
Min			1	29594
Max			28578	29594
AVG			108	29594
STD			231	0
Sum			3207970	875804836



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## Altitude Data & Digital Elevation Model

After the overlay the topodem map over the contour map with gray representation

The screenshot shows a GIS interface with a legend on the left listing 'Contours - Seg' and 'topodem - Map'. The 'topodem - Map' dialog box is open, showing 'Gray representation' selected. The map area displays a colorful contour map with a gray topodem overlay.

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## Statistics/Histogram of Topo\_DEM :

Value	Depth	Height	Area	
1	900.00	15327	0.11	15327
2	900.04	1	0.00	15328
3	900.05	232	0.00	15560
4	900.06	37	0.00	15897
5	900.07	81	0.00	16478
6	900.08	89	0.00	17377
7	900.09	90	0.00	18277
8	900.10	100	0.00	19277
9	900.11	43	0.00	19990
10	900.12	67	0.00	20284
11	900.13	60	0.00	20177
12	900.14	107	0.00	20284
13	900.15	51	0.00	20275
14	900.16	49	0.00	20461
15	900.17	48	0.00	20322
16	900.18	60	0.00	20462
17	900.19	93	0.00	20555
18	900.20	86	0.00	20661
19	900.21	62	0.00	20703
20	900.22	99	0.00	20766
21	900.23	95	0.00	20837
22	900.24	81	0.00	20918
23	900.25	53	0.00	20971
24	900.26	79	0.00	21040
25	900.27	57	0.00	21102
26	900.28	89	0.00	21191
27	900.29	85	0.00	21276
28	900.30	64	0.00	21340
29	900.31	51	0.00	21377
30	900.32	30245	0.22	1400000
31	900.33	343	0.01	9397077
32	900.34	635	0.01	4107139
33	900.35	4511689	38.93	14000000

Statistics:  
 Mean=1036.48 Std. Dev=101.42  
 Median=1005.40 Prod=980.00 (30245)  
 Q1=900.00 Q3=1133.00 Q4=905.44  
 L1=900.00 L3=1236.02 S1=900.06 S3=1176.91

Average altitude: 1036.48

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## Image Stretching

Overlay the Lidar DEM over the TopoDEM with default stretch values:

The screenshot shows a grayscale map of a river valley. A 'Raster Map' dialog box is open for 'LidarDEM - Lidarplus', showing 'Stretch' values of 900.000000 and 1294.600000. The map area shows the Lidar DEM overlaid on the TopoDEM.

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## Changes seen below after using different stretch options:

The screenshot shows the same grayscale map as the previous slide, but with a different stretch applied. A 'Raster Map' dialog box is open for 'LidarDEM - Lidarplus', showing 'Stretch' values of 900.000000 and 950.000000. The map area shows the Lidar DEM overlaid on the TopoDEM with a different contrast.



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## Filtering

Generation of a hillshading image from Lidar map using shadow filter and different stretch values

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## Comparison between High Resolution Image and Hillshading Image:

**High Resolution Image**

**Hillshading Image**

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## Map Calculation

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## Pixel Information

Attribute	Value
Coordinates	95,1559628.57
high_r	,177
Mapping	Always on top
PerVacant	0.11
Percfloor	0.16
Perofffloor	0.43
Perofffloor	0.23
Percoversfloor	0.01
Per buildings	59
daytime population	124
nighttime population	413
wards	Sogor
Per buildings	538
Daytime population	746
Nighttime population	2352
Landslide ID	?
Landslide part	?
Activity	?
Part	?
ReturnPeriod	?
Area	?
Landslide nr	?
Depth	?
Activity1977	?
Activity1998	?
Activity2001	?
Activity2006	?