Training Manual

The application of GIS and land suitability analysis to identify the potential for rainwater harvesting in the arid region of Jordan (Al-Badia)

An integrated biophysical and socio-economic approach

Safa Mazahreh, Lubna Al Mahasneh, Feras Ziadat

Introduction

This manual describes the use of improved methodologies to identify potential rainwater harvesting sites by implementing land suitability analysis. It also provides general guidelines for determining site potential in relation to various parameters. The approach integrates multi-disciplinary knowledge, use of GIS, and field verification to develop and test a methodology to identify potential sites and types of rainwater harvesting interventions. Although the data used to undertake the exercises were derived from a selected watershed within the Jordanian Badia, the approach could be applied to similar areas where rainwater harvesting is an option for sustainable land and water management.

How suitable an area is for rainwater harvesting depends on local society, farming practices, and whether the area meets the basic technical requirements of the rainwater harvesting interventions under considerations. When planning such systems, appropriate data must be available on the climate, soil, crops, topography, and socioeconomics of the project area. These data can be collected through a combination of field visits, site inspections, topographic and thematic maps, aerial photos, satellite images, and geographic information systems (GIS). The integration of these multi-disciplinary information to produce decision support outputs is explained in this manual.

The whole approach consists of two parts: the first considers the detailed criteria and the procedure used to select a benchmark watershed to represent the Baida of Jordan; the second considers the biophysical and socioeconomic characterization of the selected watershed through the implementation of the FAO framework for land evaluation (land suitability analysis adopted for rainwater harvesting interventions). This training manual detailed step-by-step exercises to undertake the second part. The whole approach demonstrates how GIS can be used at different scales, using whatever available data, to help select fields that are suitable for implementing new land-use alternatives. The approach was also successful in integrating biophysical and socio-economic criteria in the selection process to develop sustainable rainwater harvesting interventions to improve water productivity in the Badia. It is expected that this approach will be applied to similar areas to the Badia. This is facilitated easily by the changing the land suitability criteria to accommodate any differences in the biophysical or socio-economic conditions under which the intended rainwater harvesting interventions are to be implemented.

For further details about the whole process and the technical background of this approach, it is highly recommended to refer to the following published report:

> Ziadat, F., Oweis, T., Mazahreh, S., Bruggeman, A., Haddad, N., Karablieh, E., Benli, B., Abu Zanat, M., Al-Bakri, J., and Ali. A. 2006. Selection and characterization of Badia watershed research sites. International Center for Agricultural Research in the Dry Areas (ICARDA), Aleppo, Syria. vi+111 pp.

Exercise 1:

Applying criteria for first stage site selection

A. Overlay analysis (Rainfall, soil and topography):

This exercise explain the selection of watershed based on overlaying the watershed boundaries with layers represent the soil, topography or rainfall distribution.

An example using rainfall will be used. Similar analysis is required for soil and topography.

Steps:

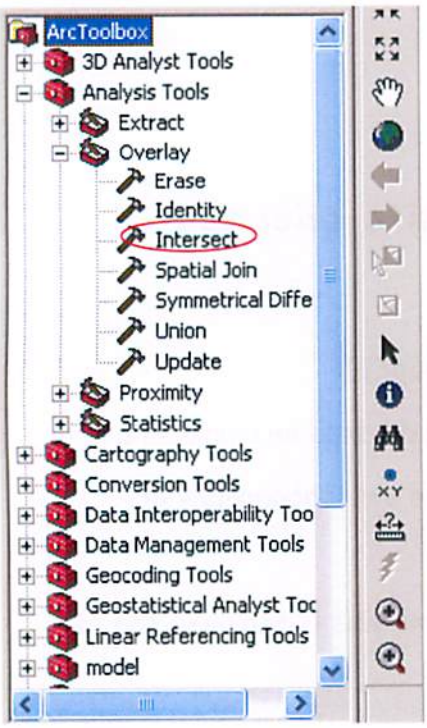
All data exist in the directory \training\data\

Start ARC Map

1. Add theme watersheds_start.shp (+)
2. Add theme rainfall's (+)
3. Activate arc tools

4- Activate analysis tools icon and extend it

5- Extend the overlay icon and select intersect



4. Overlay watershed boundaries with rainfall:

Double click the "intersect"

Input features: you select two themes:

rainfall.shp

watersheds_start.shp

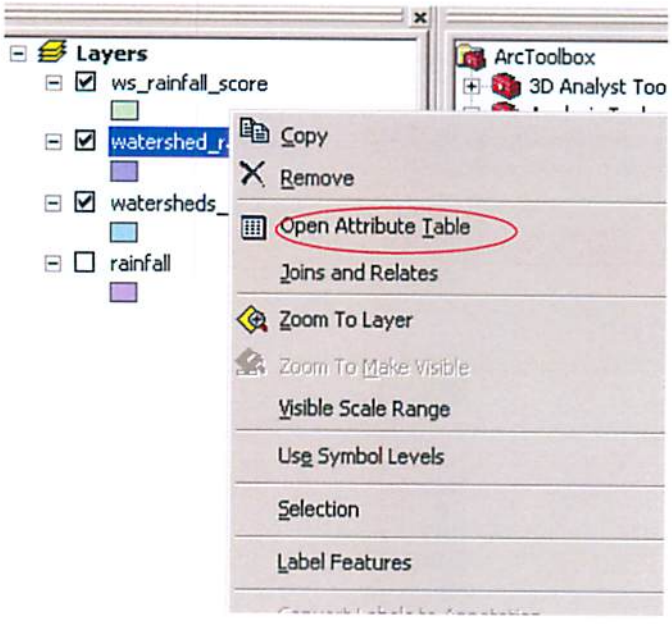
Output feature: watershed_rainfall.shp (use the same directory)

Select OK.

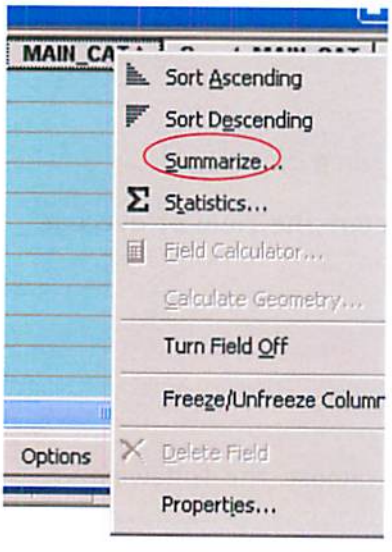
5. Summarize the rainfall value for each watershed:

You add the output theme watershed_rainfall.shp

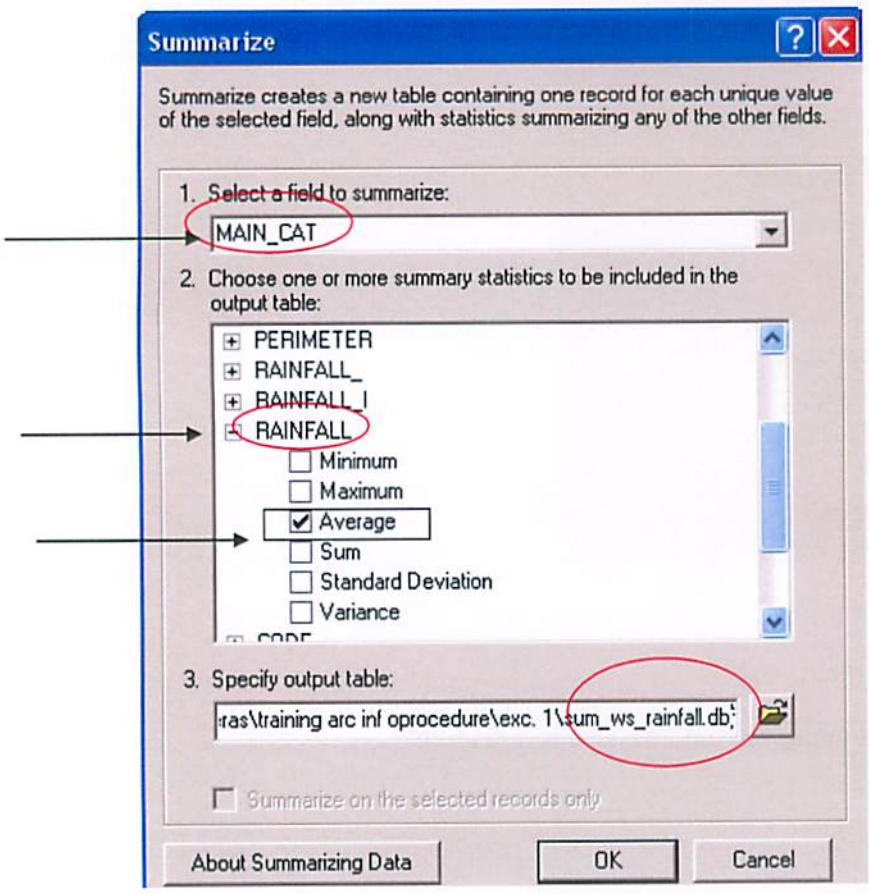
Then R click the theme and select open the attribute table



- select the field main_cat
- R. click the field main_cat and select summarize



From the field menu, select summarize as follows



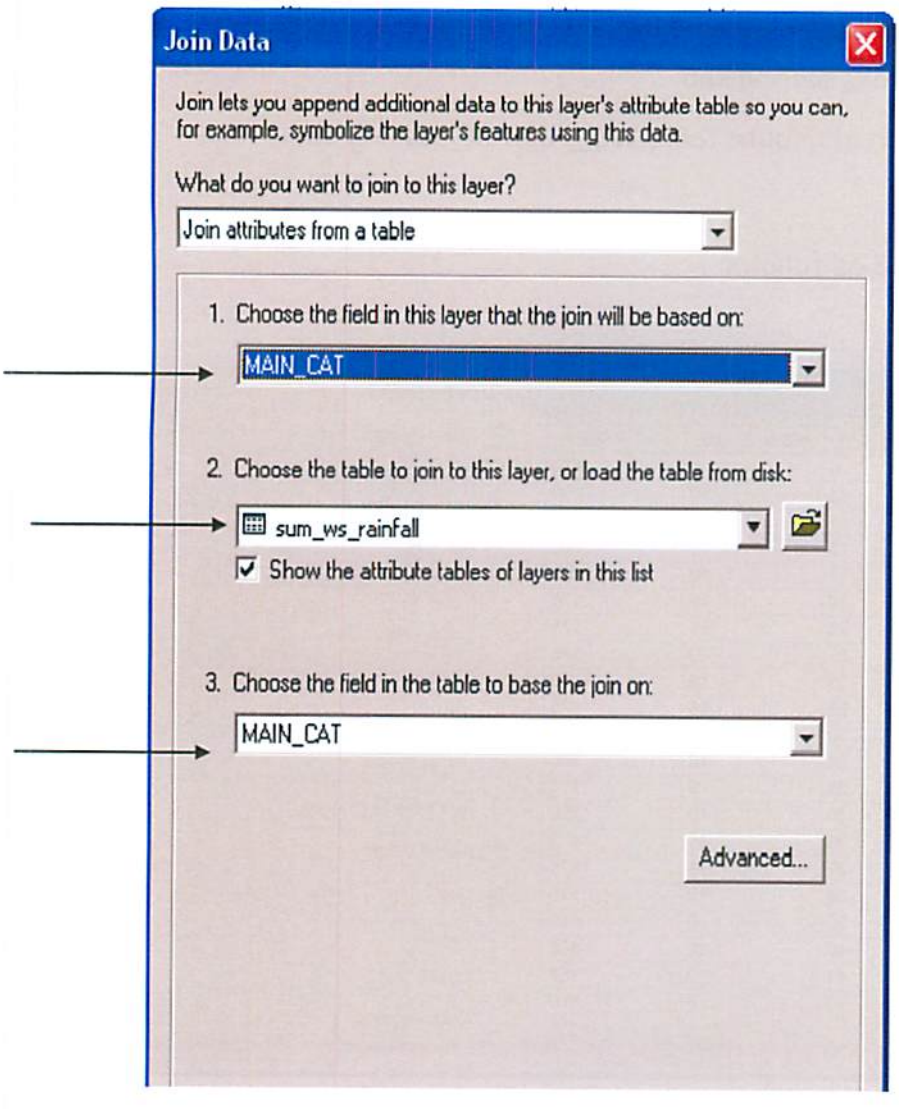
Output table: sum_ws_rainfall.dbf (use the same directory)

Then select OK and add the table and check out the field of average rainfall for each watershed

6. Join average rainfall to each watershed:

- R. click the theme watershed_rainfall.shp

- select join and relate, then select join and choose the following:



- click OK

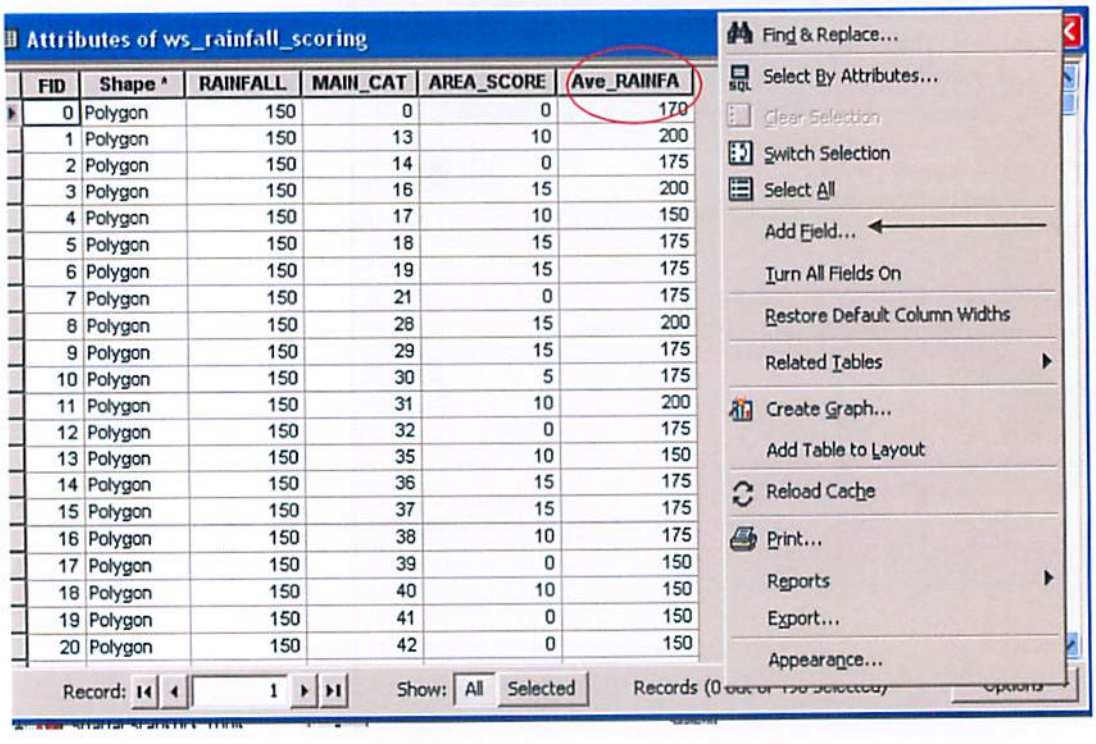
Select and add the theme watershed_rainfall.shp

- R. clicks the shape file and select data and data export and name it as

- WS_rainfall_scoring.shp (use the same directory)

7. Scoring according to rainfall:

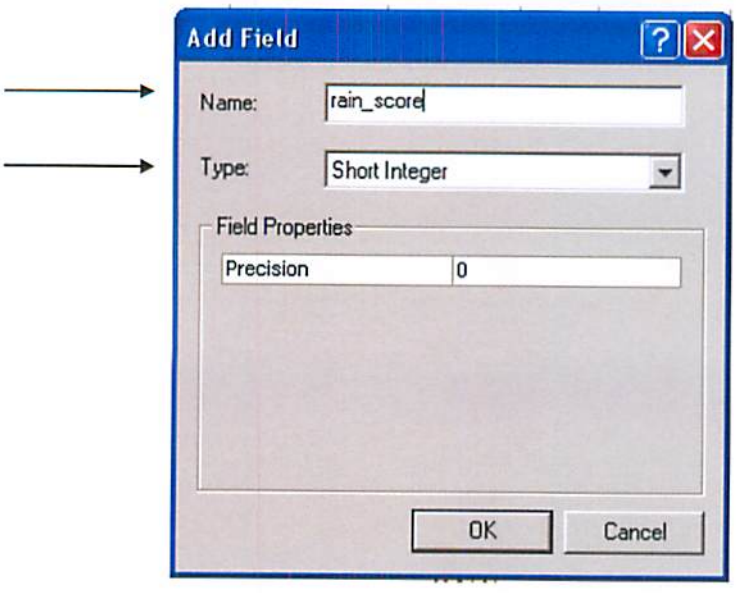
- select WS_rainfall_scoring.shp
- R. click and open attribute table WS_rainfall_scoring.dbf
- Select options
- Select add field as follows:



Name: rainfall_score

Type: short integer

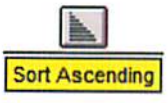
Select OK



Using the criteria table, apply the criteria for rainfall

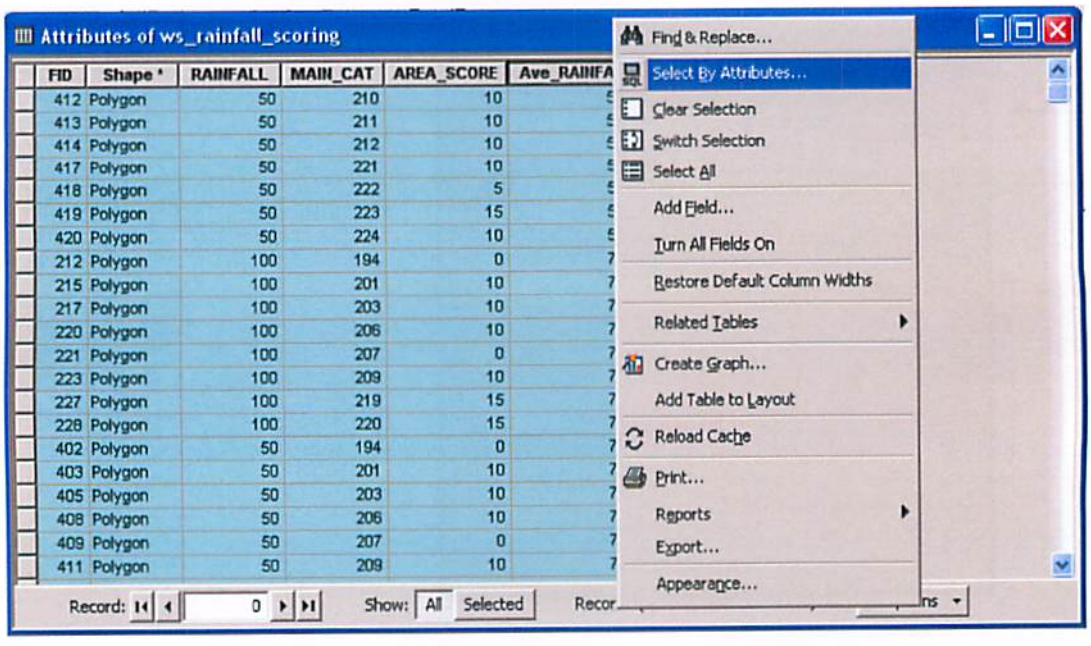
Select field Ave_Rainfall

R. clicks the field and choose sort ascending



Select rainfall values for each score:

R. clicks the field ave_rainfall and chooses options then select by attributes



A menu will open as follows

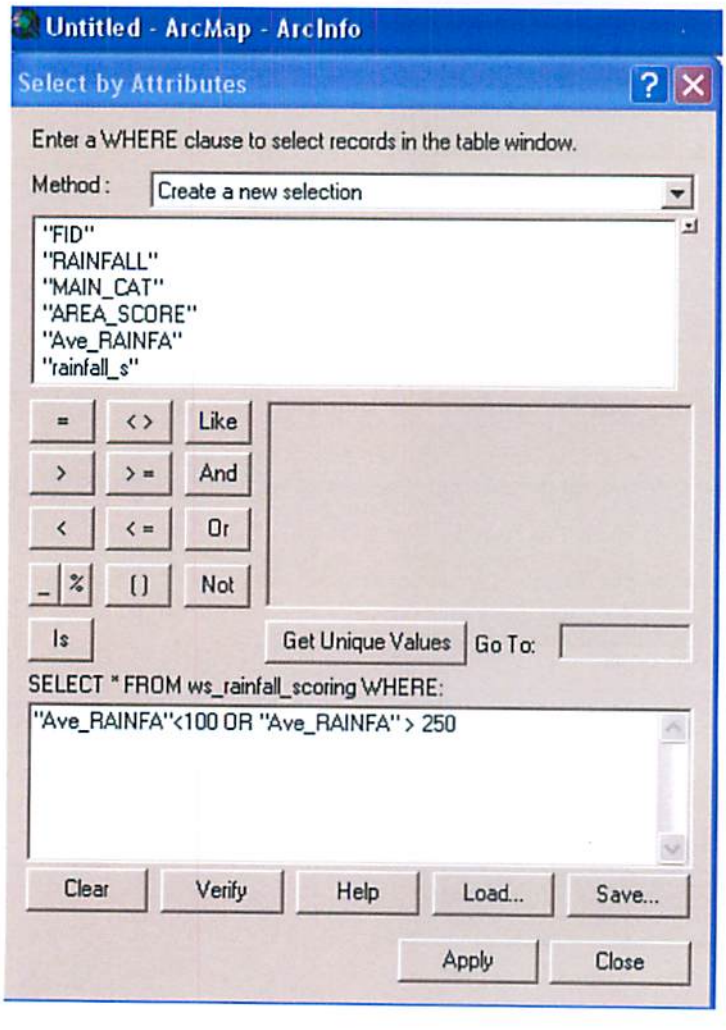
- write down the equation following the criteria and apply

1. First stage criteria:

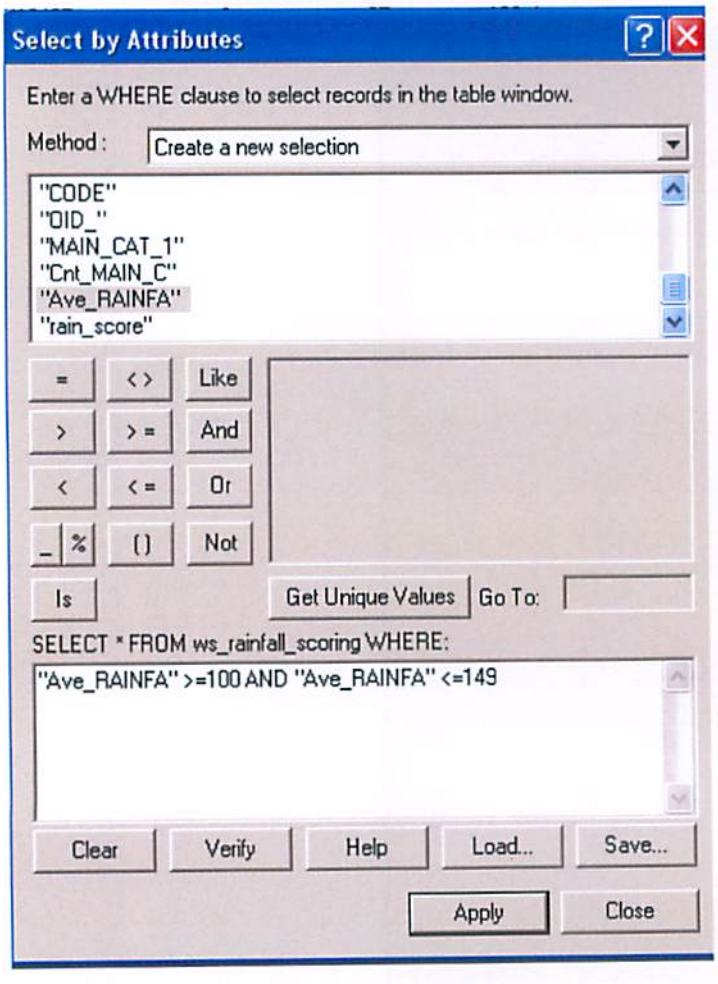
Criteria	Score*				Comments
	0	5	10	15	
Rainfall	<100 or >250	100-149	200-250	150-199	Rainfall Isohyets
Community	None	One	Two	> Two	No. Of Villages
Soil Type	Lithic, Psamment, Calcic	Lithic and/or Psammen t	Calcic	Others	Dominant Soil

Area (km^2)	< 30	110-150	30-70	70-110	Watershed area
Topography	>200m	100-200m	50-100m	< 50m	Relative Relief

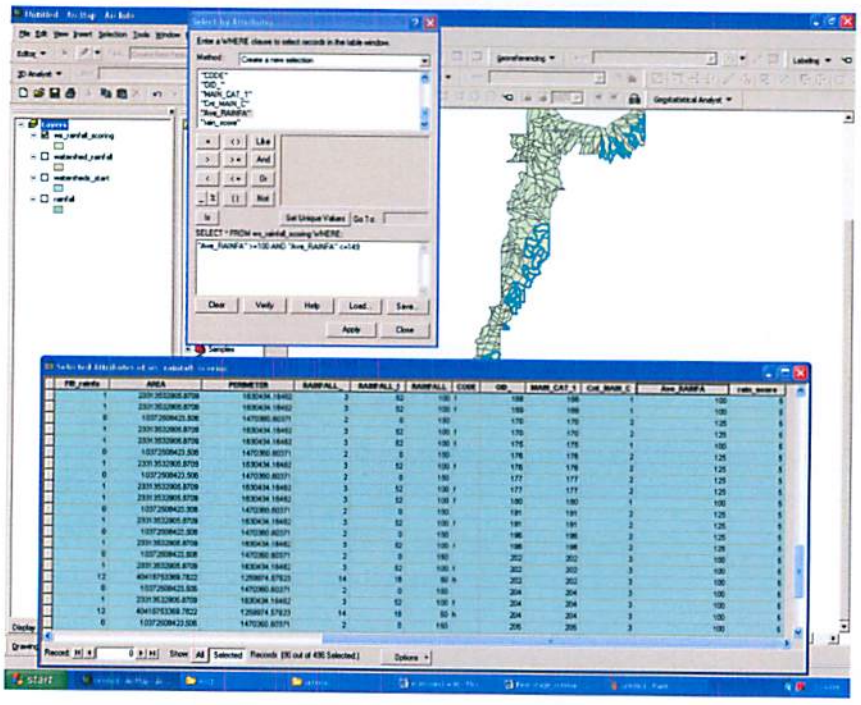
* If Assigned score is 0, the watershed should be excluded.



- Then select the field rainfall_score in the table and r. click and choose "field calculator"/or calculate values.
- Then type 0 according to the criteria. This means that all rainfall that ranges less than 100 mm and more than 250 will have score Zero.
- Open attribute table-options-clear selection.
- repeat the step above but using the following equation:



- Select the field rainfall_score in the table and r. click and choose "field calculator"/or calculate values.
- Then type 5 according to the criteria. This means that all rainfall that ranges more than and equal 100 mm and less than and equal 149 will have score 5.



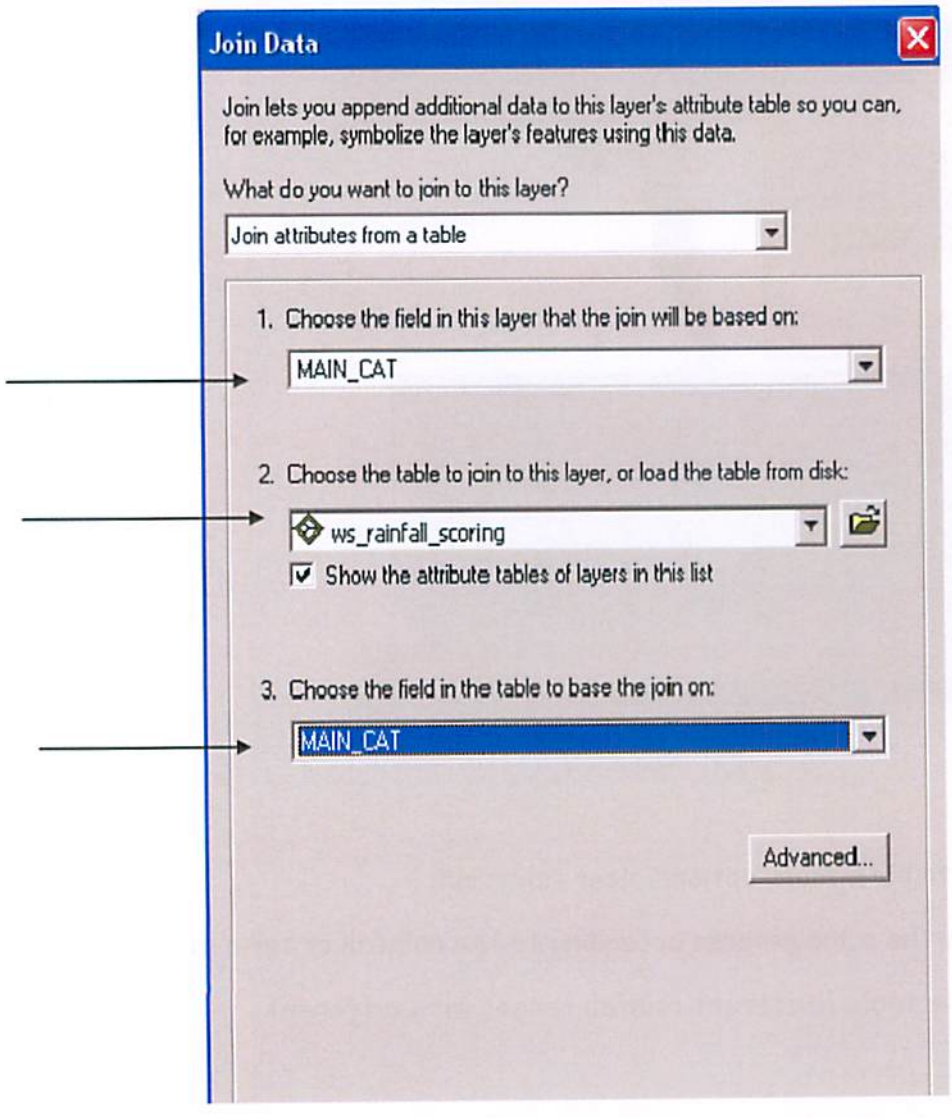
- Open attribute table-options-clear selection.
- Continue the same process according to the rainfall criteria in the above table (different rainfall ranges with different scores).
- After each selection - Open attribute table-options-clear selection.

8. Attach rainfall score to watersheds

Select theme watersheds_start.shp

R. click and select join and relate and choose join

- follow figure below:



- select OK
- select the theme in the view window
- From the theme menu, R. click and export data to a new shapefile watershed_score 1.shp
- add the watershed_score1.shp to the window and open its attribute table you will find two scores for each watershed: score for area and a score for rainfall.

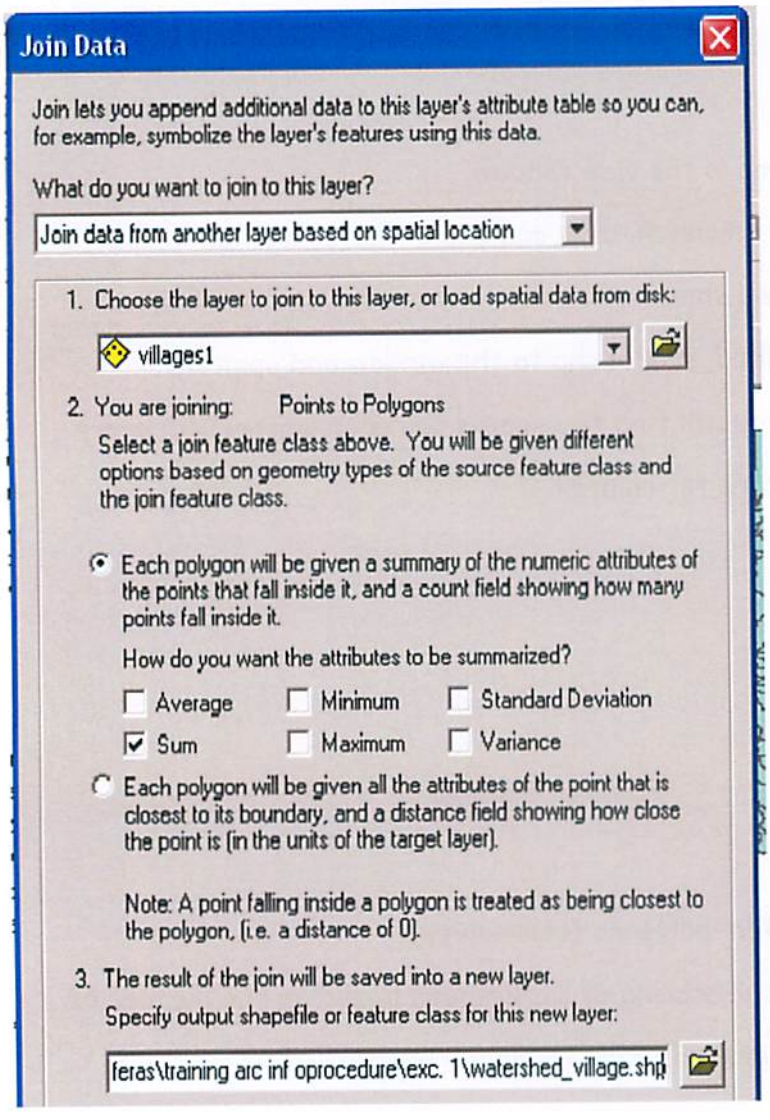
B. Counting points-within-polygons (community):

This exercise explains the scoring of watersheds based on the number of villages within each watershed.

Steps:

1. Add theme watersheds_start.shp
2. Add theme villages1.shp
3. Overlay points within polygons:

- R. clicks the theme watersheds_start.shp and choose join and relate and select join: use the spatial join as the following figure:



- save the new shapefile as watershed_village.shp

- This will add the watershed number within which each village is located based on its geographic location.

- Open the attribute table of the watershed_village.shp, you will find each watershed has a no. of villages under the field "count"

- export the shapefile to a new shapefile and name it as:

ws_village_score.shp

6. Scoring according to community:

-open the ws_village_score.dbf file

And choose options and select add field

Name: community_score

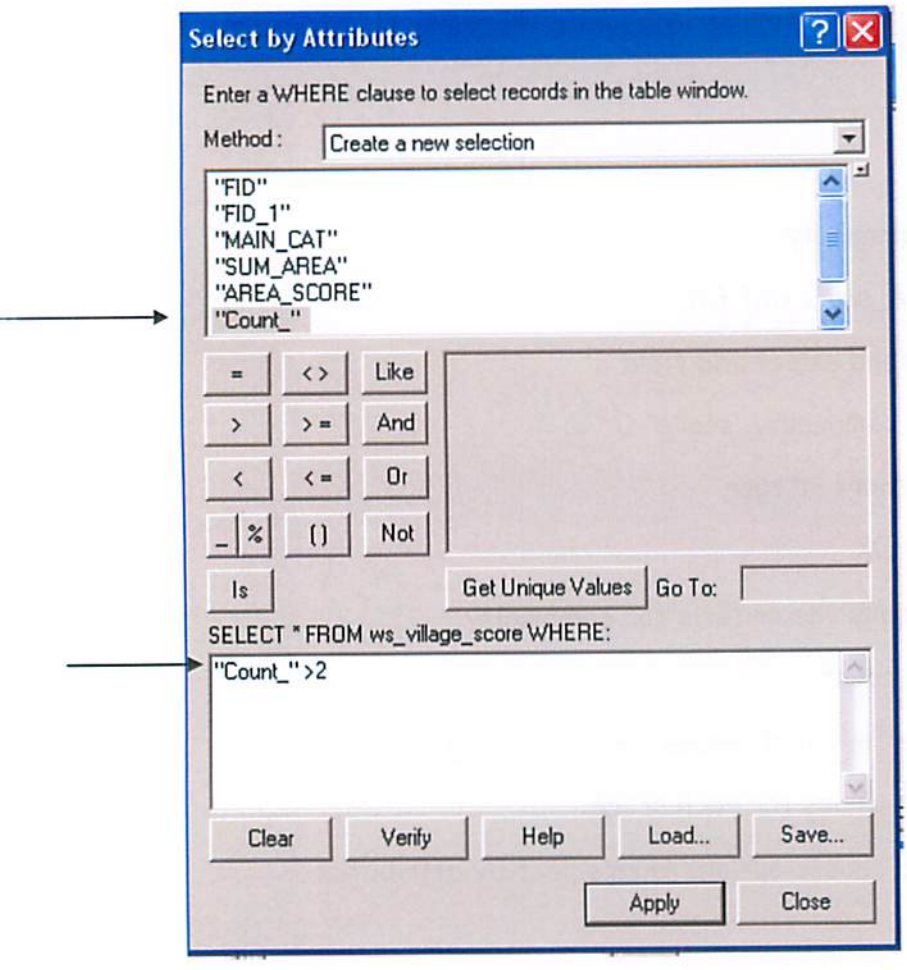
Type: short integer

Select OK

Using the criteria table, apply the criteria for community

- select field count
- R. clicks the field and choose sort ascending
- select count values for each score:

R. click the field count and choose options then select by attributes



-select the field count

- sort the data
- select the number of villages for each score
- Select the field community score
- Use the field calculator calculates values to type in the score.

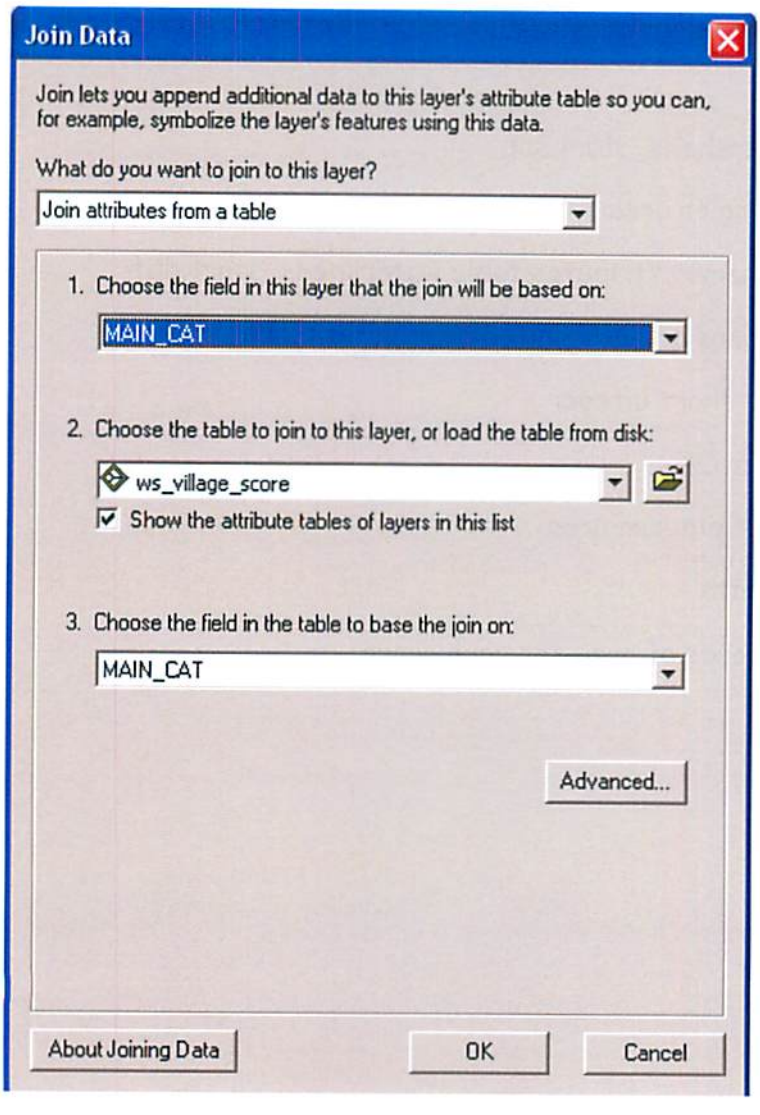
-Apply the same process for all scores according to the criteria.

-Clear selection after each step.

7. Attach community score to watersheds:

- add the theme watersheds_score1.shp and ws_village_score.shp

- R. click watersheds_score1 and select join and relate and choose join as follows



- R. click watersheds_score1 and data- export the shape file to a newshape file and name it as: watersheds_score_rain_vilge.shp

C. Classification of watersheds based on area:

This exercise explains the scoring of watersheds based on the area of each watershed.

Steps:

1. Add theme watersheds_start.shp
2. Scoring according to area:

    Open the theme attributes table watersheds_start.dbf

    - select options and add and name it: area score

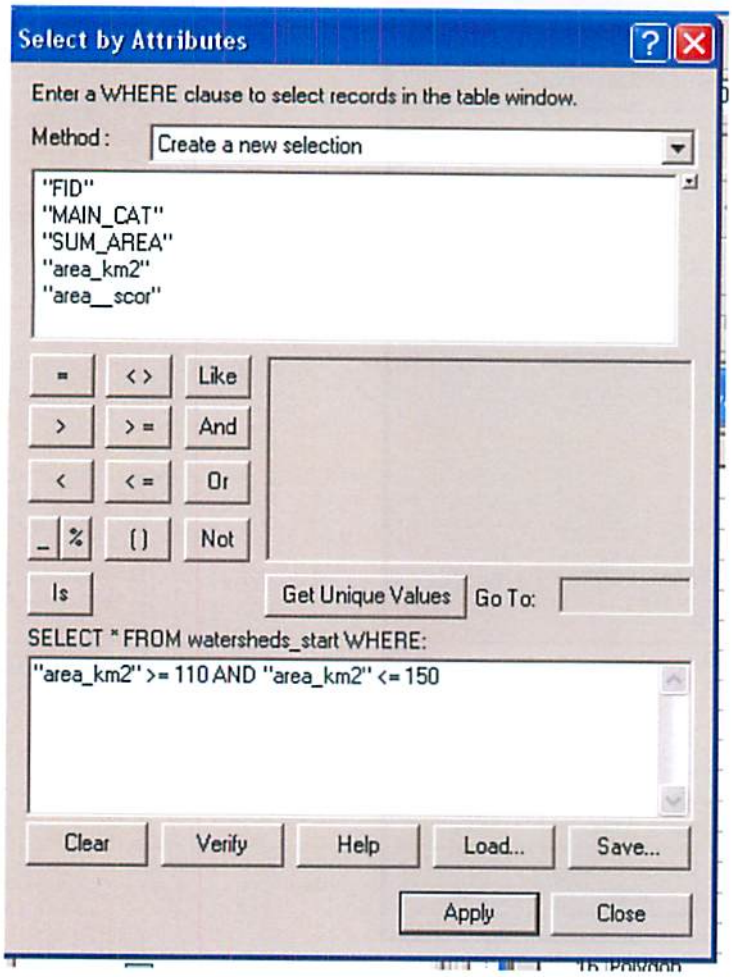
        Type: short integer

        Select OK

    -select the field sum area

    - sort the data

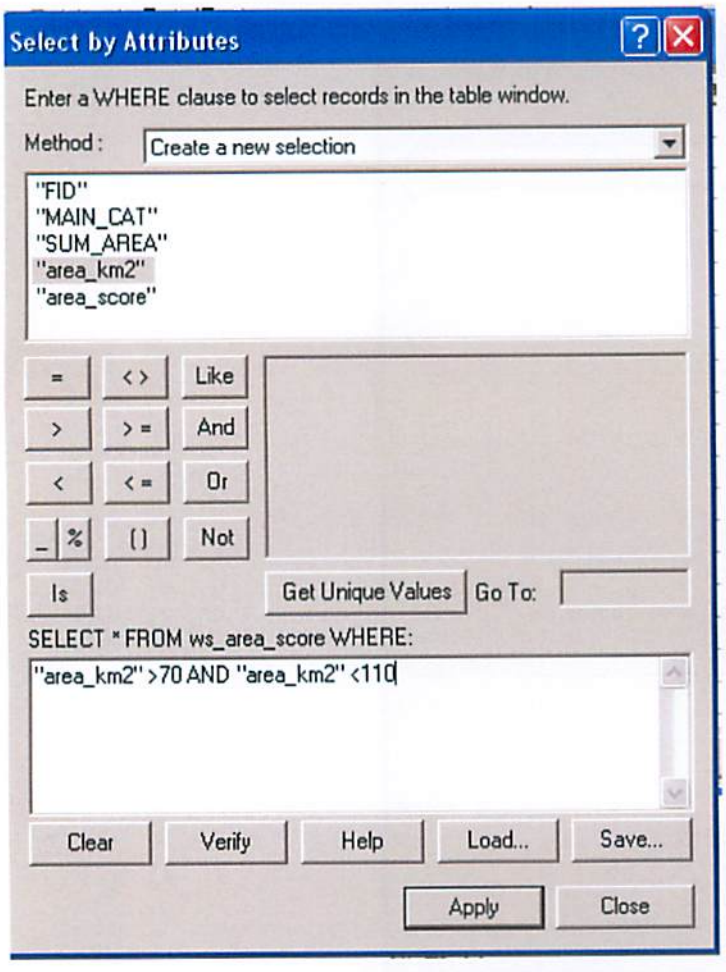
    - select records of area for each score



Select the field area score

Use the field calculator to type in the score

-apply all area criteria and scores.



Clear selection after each step.

3. Save scores:

-select the theme watersheds_start.shp

-R. clicks and exports it to shapefile

- name it as: ws_area_score.shp

4. Attach area score to watersheds:

-add watersheds_score1.shp and ws_area_score.shp

- use join and relate and join

- Select field main cat in shape files (common field)

After you join you will have a shape file named as watersheds_score1.shp which has 3 scores: rainfall score, area score, and community score

- R. clicks watersheds_score1 - data- export the shape file to a new shape file and name it as: watersheds_score_rain_vilge-area.shp

D. Using the scores to select the best watersheds

This exercise explains the integration of the five different scores to undertake the final selection of the watersheds.

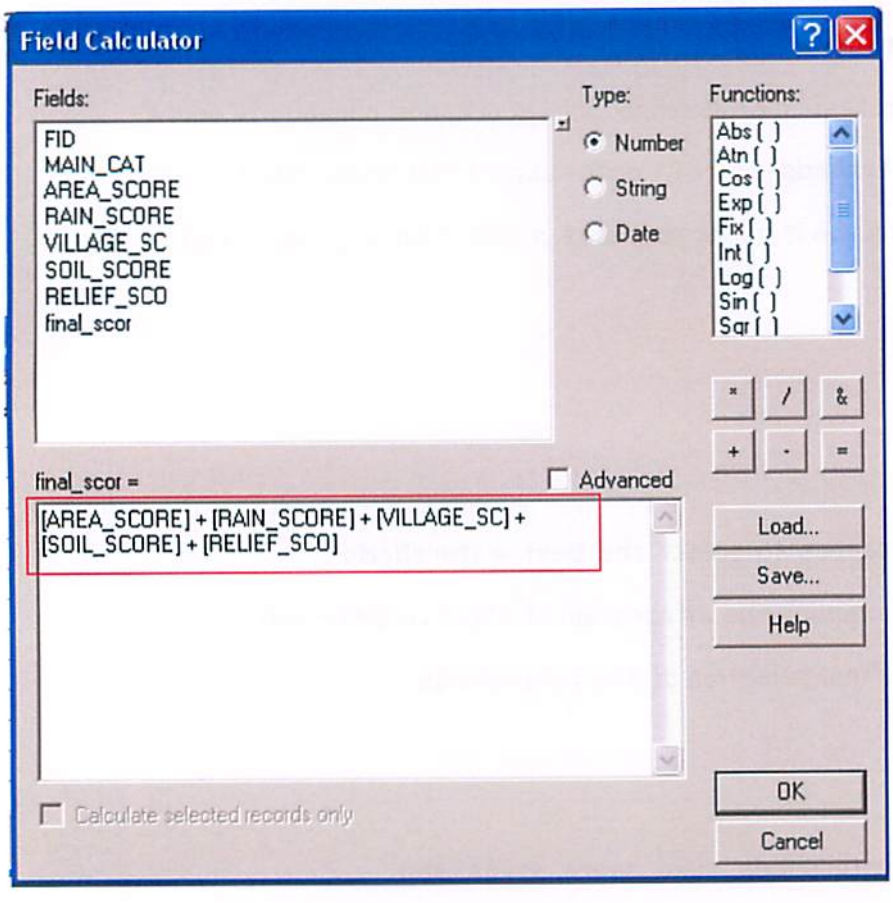
Steps:

1. Add theme watersheds_final_score_stage1.shp
2. R. click and open attribute table
3. Click options and then add field

Name it as final score and choose short integer

4- Calculate final score:

R. clicks the field "final score" and select field calculator as follows:



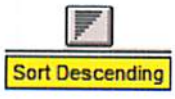
From the field menu, select the field name area score (double click)

Select the summation sign + (double click) and so on for the other four fields:

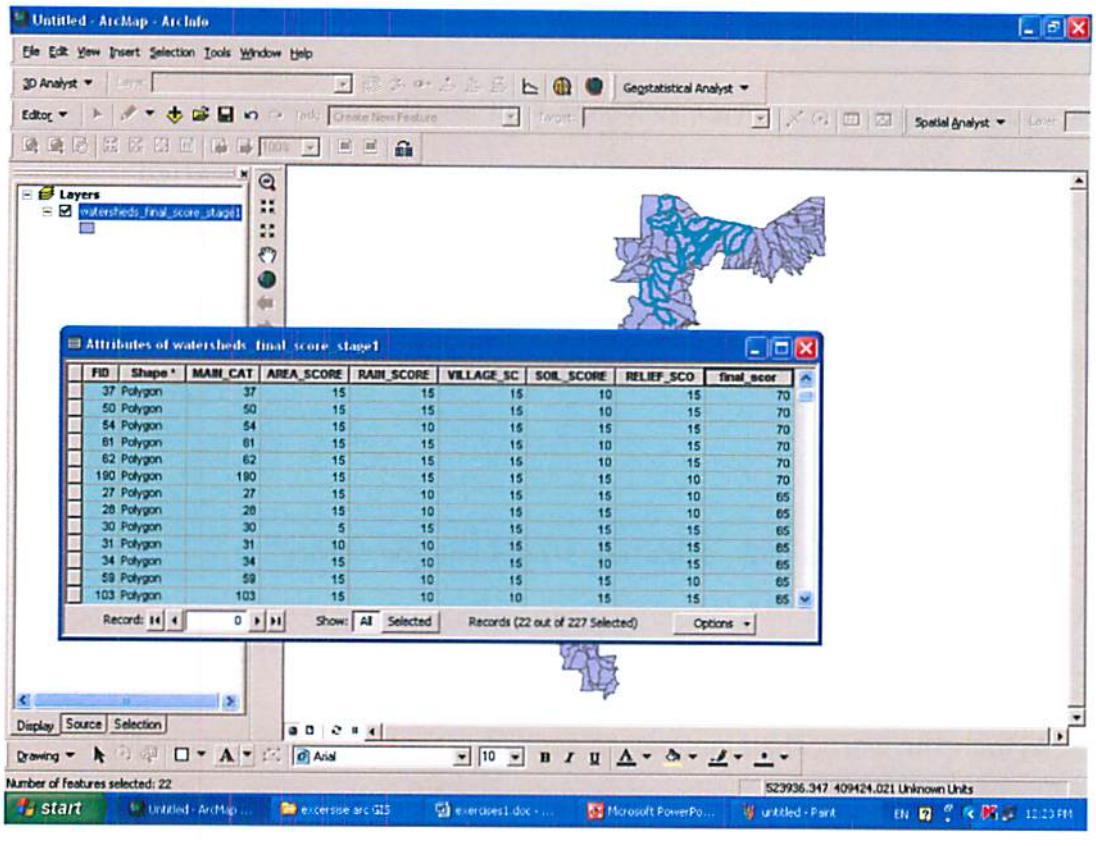
- click OK

4. Select the best watersheds:

In the attribute table watersheds_final_score_stage1.dbf, select the field final score and sort the data descending



Select the watersheds with the highest records (for example those with score 65 and more):



You will find that 22 watersheds have a high score 65-70. And they will be displayed as selected watersheds.

- After selection, r.click theme watersheds_final_score_stage1.shp and select data and export data and name it as selected_ws_stage1.shp, select yes to add the theme to the view

- make the theme active and note the selected watersheds

The selected watersheds are ready to be screened by the second stage selection process.

Exercise 2:

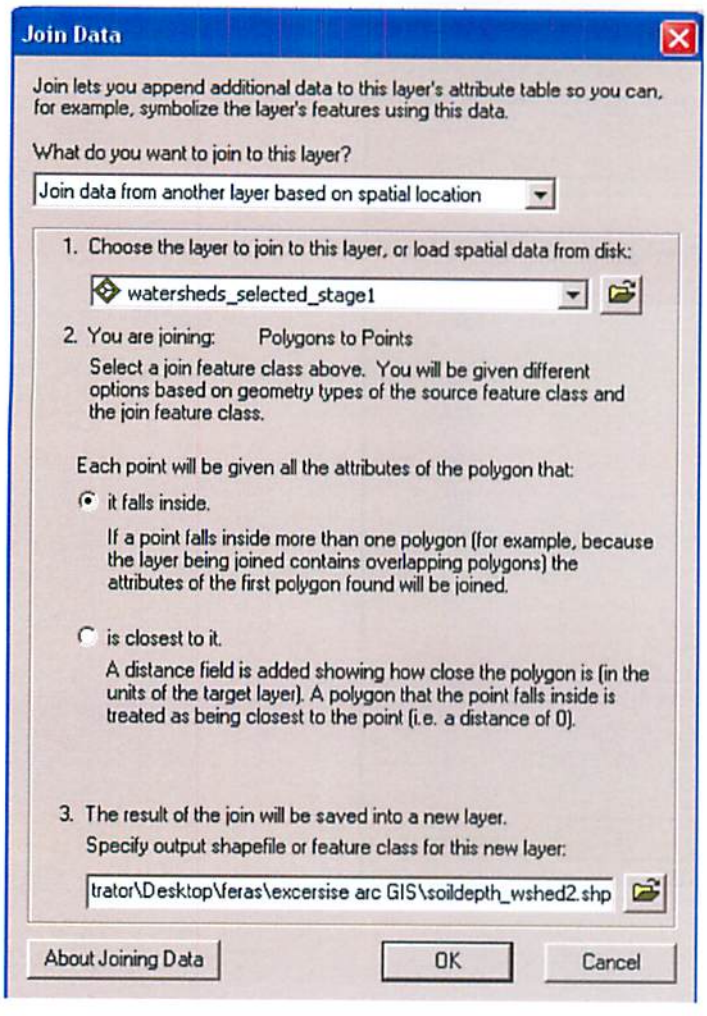
Applying criteria for second stage site selection

A. Summarize values within polygons (soil depth example)

This exercise explains how polygons (watershed) might be classified based on the average soil depth of observation points within the polygon. Similar analysis could be applied to classify the watersheds based on slope steepness, rangeland-based system, and land use.

Steps:

1. Add theme watersheds_selected_stage1.shp (directory \training\data\)
2. Add theme field observations depth.shp
3. Attach the watershed number to each observation: using spatial join
4- Activate field observations depth.shp-R.C -Join-and do as following below:

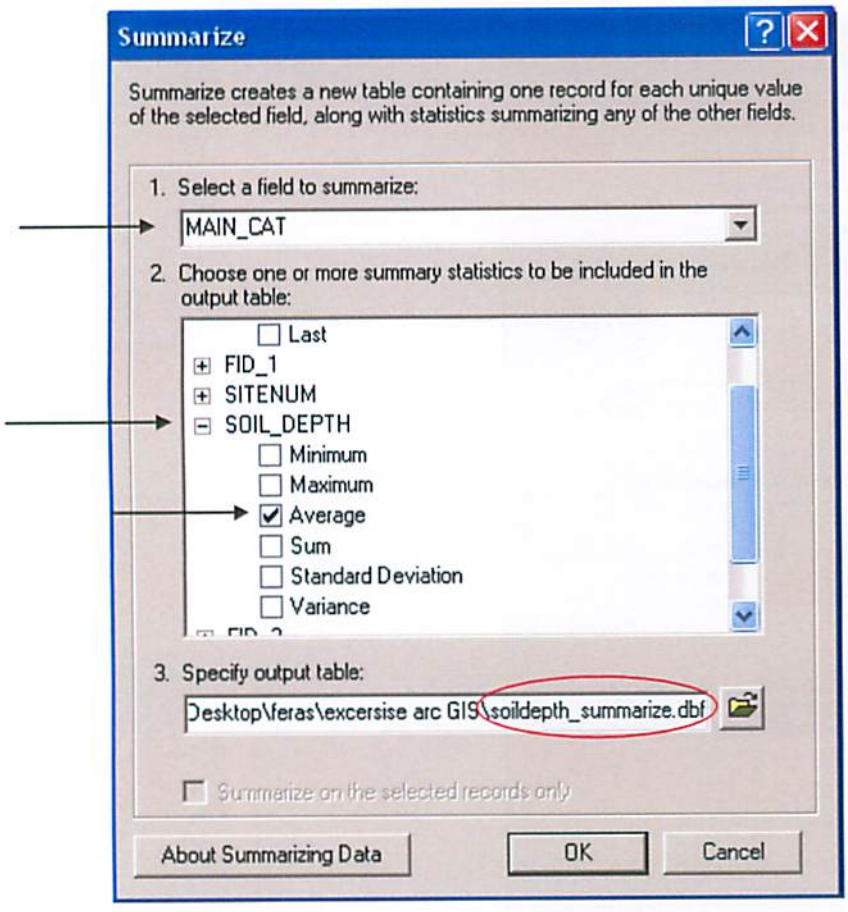


- save the process as soildepth_wsshed2.shp

4. Summarize the soil depth values for each watershed:

- open attribute table of soildepth_wshed2.shp, select the field main_cat

R. click and select summarize as follows:

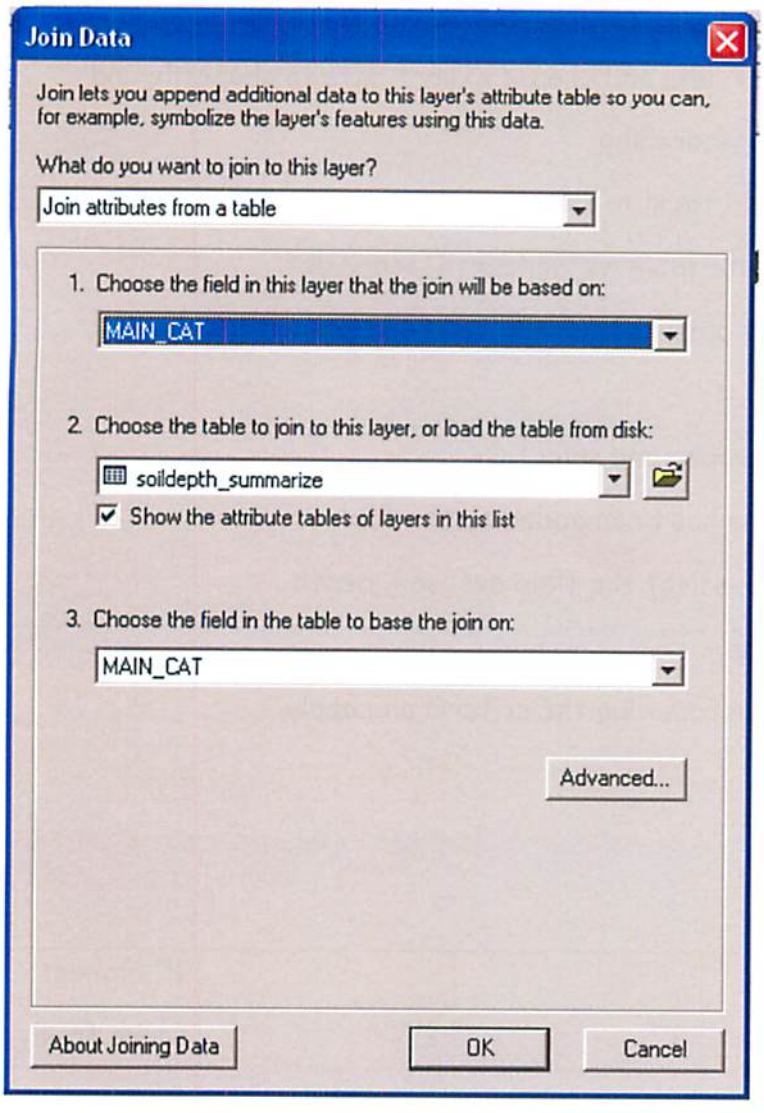


- Select field: soil_depth
- summarize by: average
- save as: soildepth_summarize.dbf
- select OK

5. Attach soil depth value (average) to each watershed:

    - activate theme "watersheds_selected_stage1.shp"and r.click

- select join and relate and choose join and follow the figure



- select the field main_cat in both tables

- choose table ws_soildepth_summarize.dbf

-click ok.

- Open the attribute table of the "watersheds_selected_stage1.shp", you will find a field of average soil depth for each watershed.

6. Score the watershed according to soil depth:

- activate the theme watersheds_selected_stage1.shp

- r. click and select data and choose export data to shapefile and name it as: ws_soildepth_score.shp

- select OK and add them to the view

- open the attribute table ws_soildepth_score.dbf

- r.click and select options then add field and name it as: depthscore

- select integer number and select OK.

A field named depthscore has been added to the table

- In the attribute table, select the field ave_soil_depth

- sort the data ascending

- write down the equation following the criteria and apply

2. Second stage criteria:

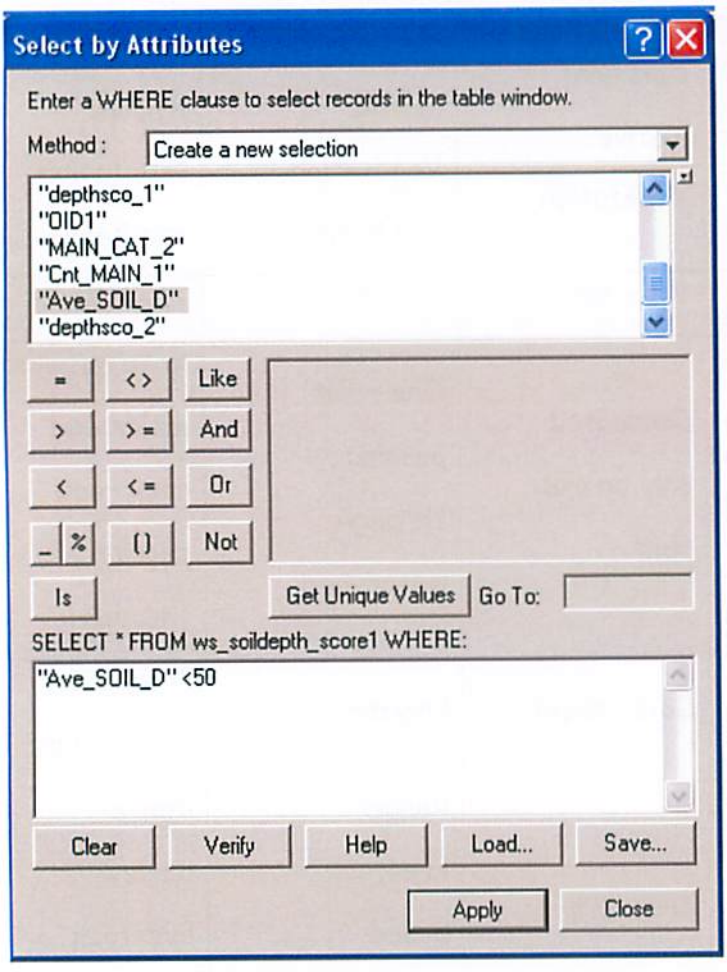
Potential for water harvesting[1]	4th	3rd	2nd	1st highest score from first stage
Soil Depth	< 50 cm	50-100 cm	100-200 cm	> 200 cm
Slope Steepness	<1% or >10%	8 - 10 %	5 - 8 %	1 - 5 %
Community	Upper and/or mid	Lower and/or mid	Upper & lower	Upper, mid & lower

Rangeland-Based system	Dominant Barley and/or Irrigated agriculture	Dominant Native Vegetation	Dominant Native Vegetation and Barley	Lack of Native vegetation and Barley
Area (km^2)	< 30	110 - 150	30 - 70	70 - 110
Accessibility & visibility	Not connected to roads	Connected only on one part	One road passing through watershed	Road network inside and main road passing through
Land tenure		Government	Private	Private & Government
Land Use	Field crop land	Rangeland	Range-livestock-based system	Range-barley-livestock based system
Basic data	Not available & no previous studies	Not enough & previous studies	Available & previous studies	Available

-Apply soil depth criteria.

- click field avg_soil depth and select options
- click select by attribute as follows

And follow the figure:

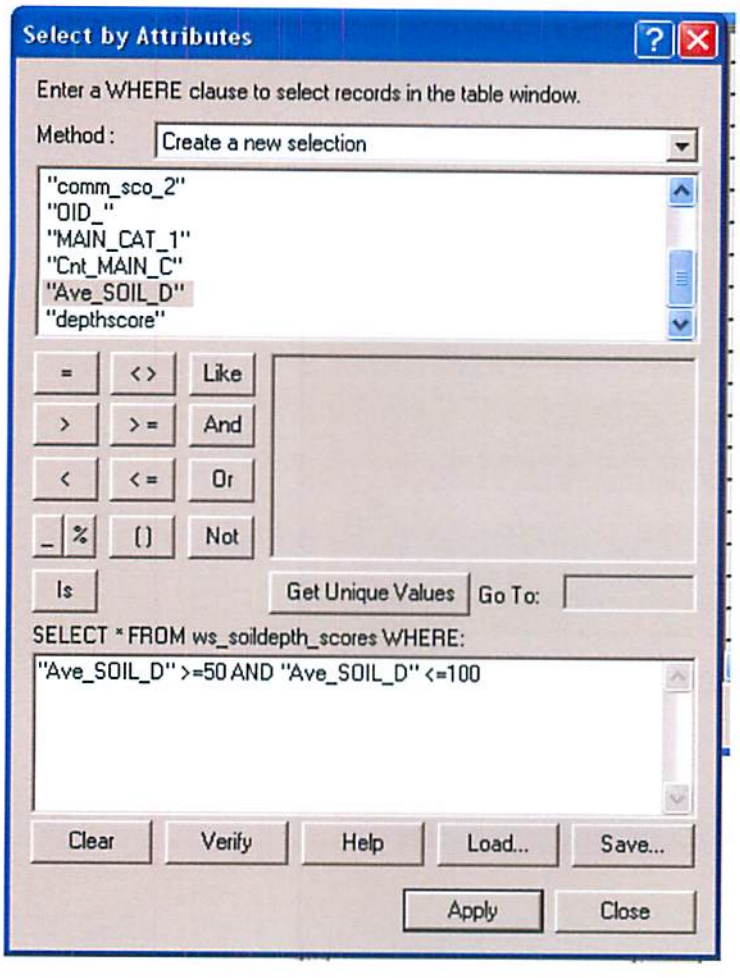


- And clicks apply.

You will see the watersheds that have soil depth less than 50 cm selected.

- Then r. clicks field depthscore and select field calculator and type 4.
- Clear selection

Do the same for the rest of the score according to the following equation:

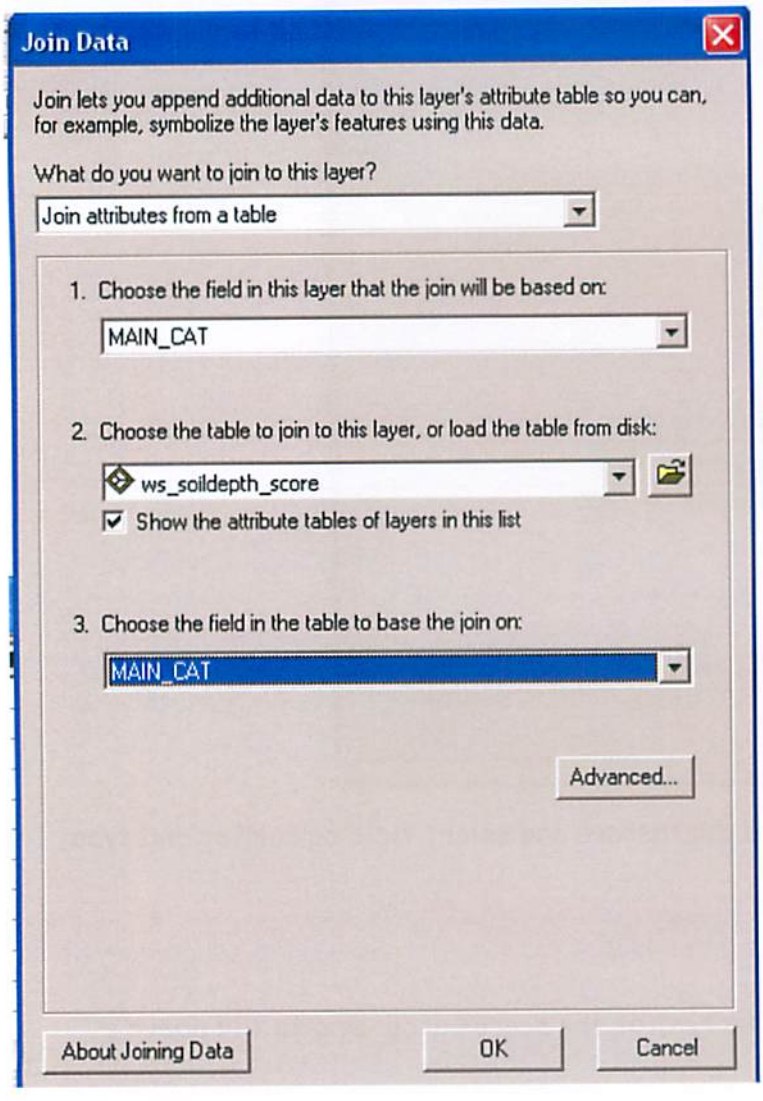


- Then r. clicks field depthscore and select field calculator and type 3.
- Clear selection
- Do the same for the rest of the scores according to the above 2nd stage criteria.

7. Join the depth scores from the table ws_soildepth_score.dbf to the table watersheds_selected_stage1.dbf:

- activate watersheds_selected_stage1.shp

-r. click and select join and relate and choose join and follow the following figure



- Then r. click the shape file watersheds_selected_stage1.shp and select data export and name it as: file name: ws_scores_stage2.shp You will add all other scores to this shapefile.

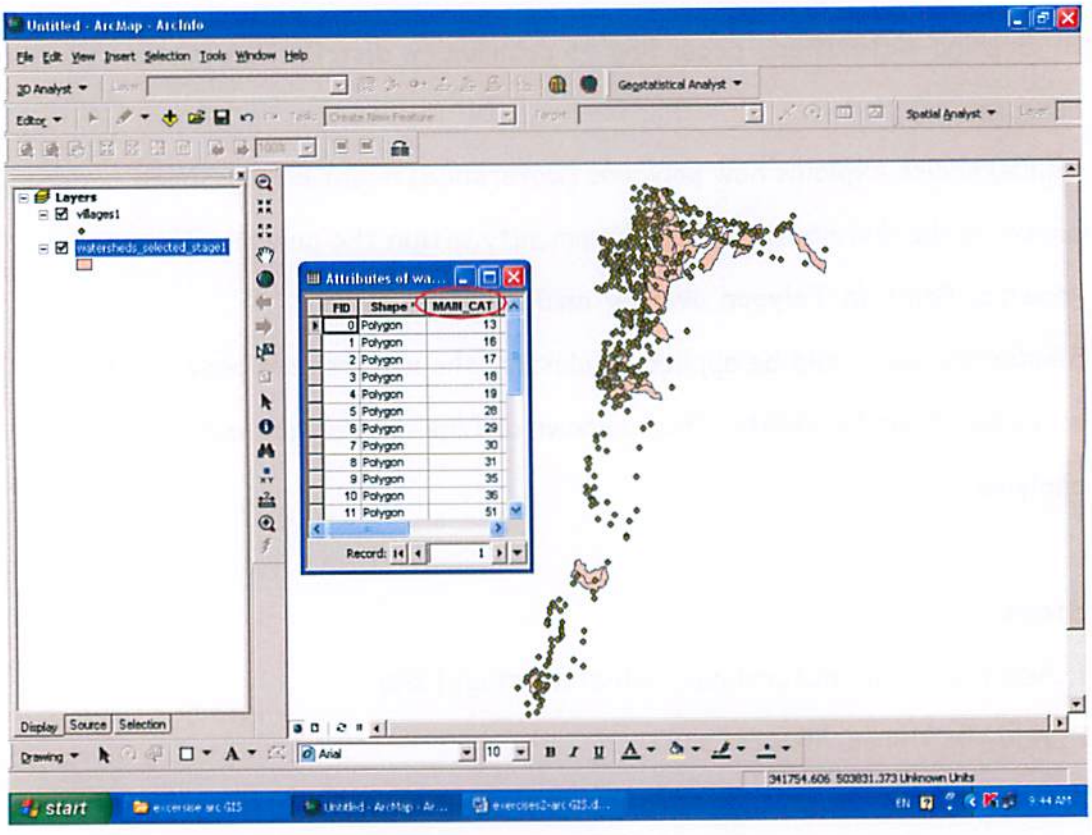
B. Scoring watersheds according to community distribution (visual assessment)

This exercise explains how polygons (watershed) might be classified based on the distribution of the community within the polygon. This is known as **Point-in-Polygon overlay analysis.**

Similar analysis could be applied to classify the watersheds based on the accessibility and visibility. This is known as **Line-in-Polygon overlay analysis.**

Steps:

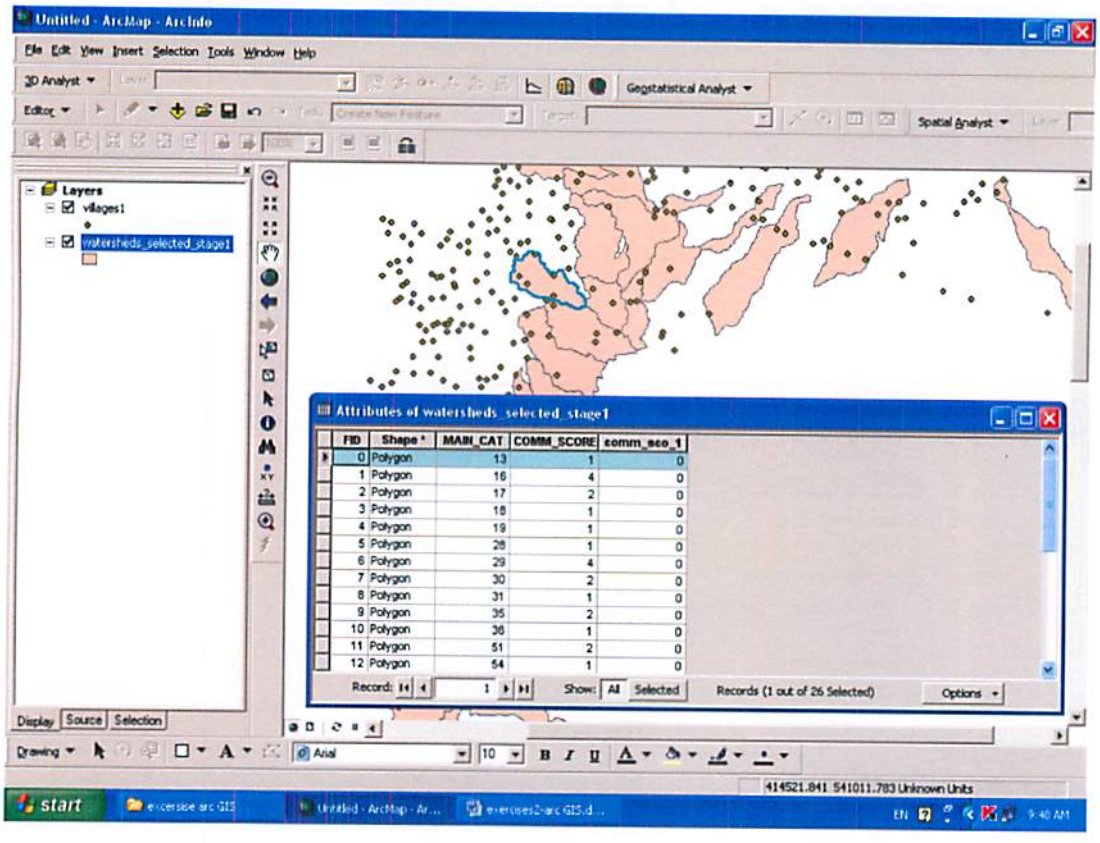
1. Add the theme watersheds_selected_stage1.shp
2. Add the theme villages1.shp
3. r. click watersheds_selected_stage1.shp and open the attribute table as in the following figure



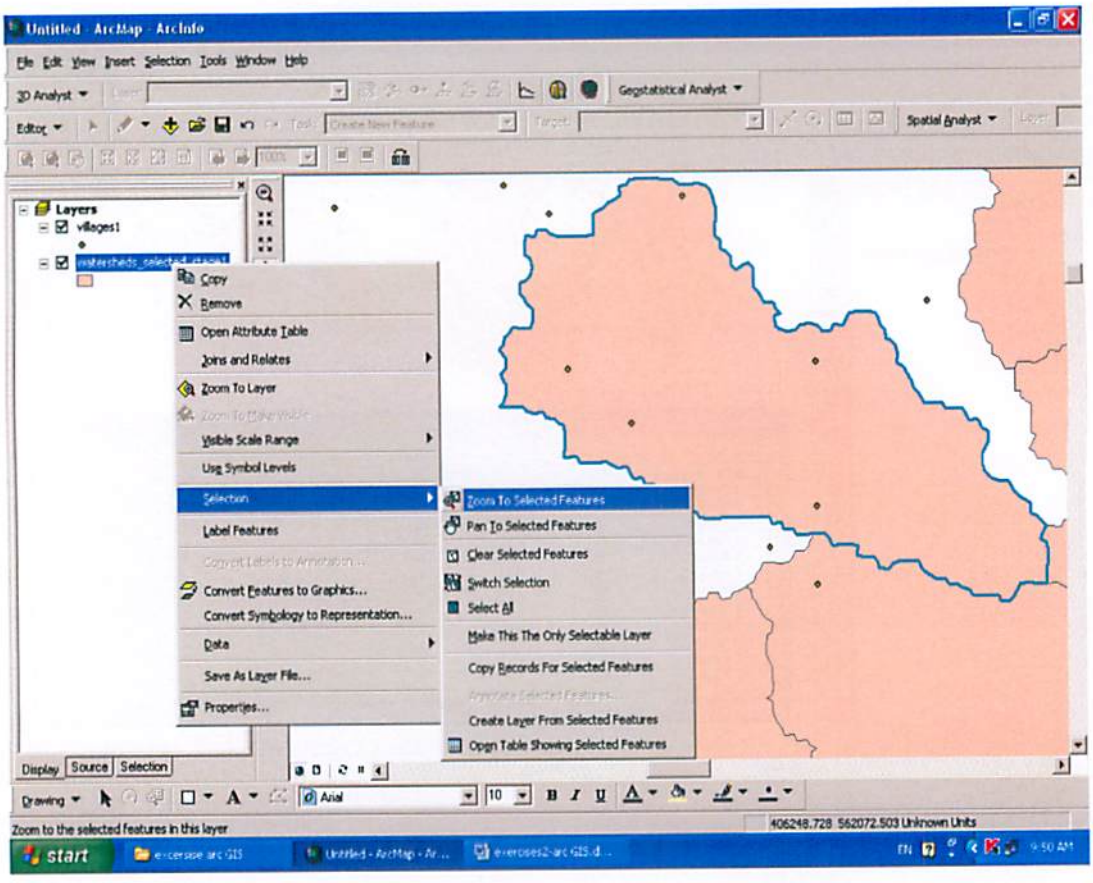
4. Select options and select add field and name it: comm_score-

type:short intger

5. Select any watershed in the attribute table



6. R.click watersheds_selected_stage1.shp, select selection and choose zoom to select as follows.



Make your visual assessment to score the watershed based on the distribution of the villages within the watershed according to the second stage criteria.

7. Activate the watersheds_selected_stage1.shp and select start editing and open the attribute table.

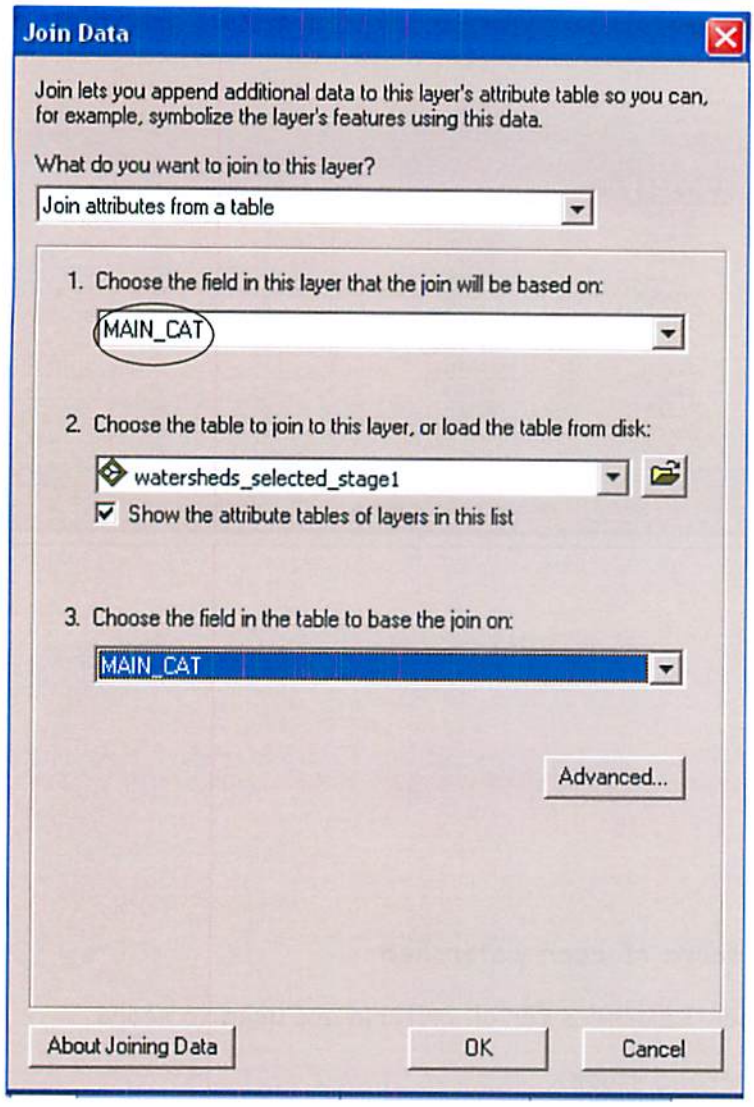
8. Type the score in the attribute table; continue for the rest of the watersheds

9. Deselecting all the records

10. Add theme ws_scores_stage2.shp

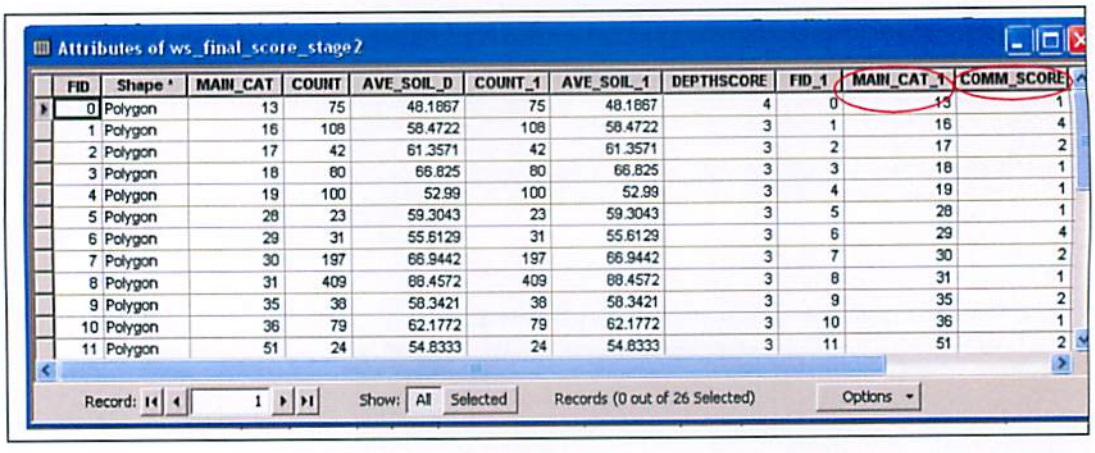
To join the community scores to the ws_scores_stage2.shp

11. r. click ws_scores_stage2.shp and select join and relate and choose Join as follows



12. And r. clicks ws_scores_stage2.shp and select export - data export to a new shapefile and name it ws_final score_stage two.shp

Open the attribute table of the exported shapfile you will see the table with the scoring for depth and community. (The criteria you score)



Attributes of ws_final_score_stage2

FID	Shape *	MAIN_CAT	COUNT	AVE_SOIL_D	COUNT_1	AVE_SOIL_1	DEPTHSCORE	FID_1	MAIN_CAT_1	COMM_SCORE
0	Polygon	13	75	48.1867	75	48.1867	4	0	13	1
1	Polygon	16	108	58.4722	108	58.4722	3	1	16	4
2	Polygon	17	42	61.3571	42	61.3571	3	2	17	2
3	Polygon	18	80	66.825	80	66.825	3	3	18	1
4	Polygon	19	100	52.99	100	52.99	3	4	19	1
5	Polygon	28	23	59.3043	23	59.3043	3	5	28	1
6	Polygon	29	31	55.6129	31	55.6129	3	6	29	4
7	Polygon	30	197	66.9442	197	66.9442	3	7	30	2
8	Polygon	31	409	88.4572	409	88.4572	3	8	31	1
9	Polygon	35	38	58.3421	38	58.3421	3	9	35	2
10	Polygon	36	79	62.1772	79	62.1772	3	10	36	1
11	Polygon	51	24	54.8333	24	54.8333	3	11	51	2

Record: 1 Show: All Selected Records (0 out of 26 Selected) Options

C. Calculating the final score of each watershed

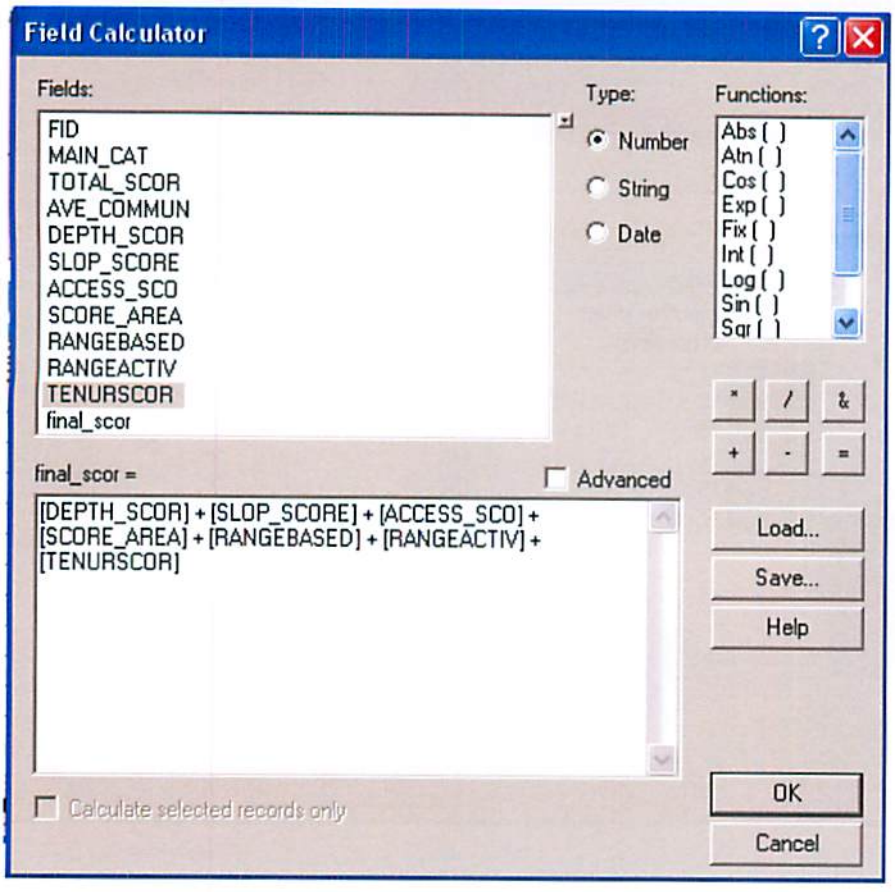
This exercise explains how the scores for all criteria are used to score each watershed for the second stage.

Steps

1. Add the theme watersheds_final_score_stage2.shp

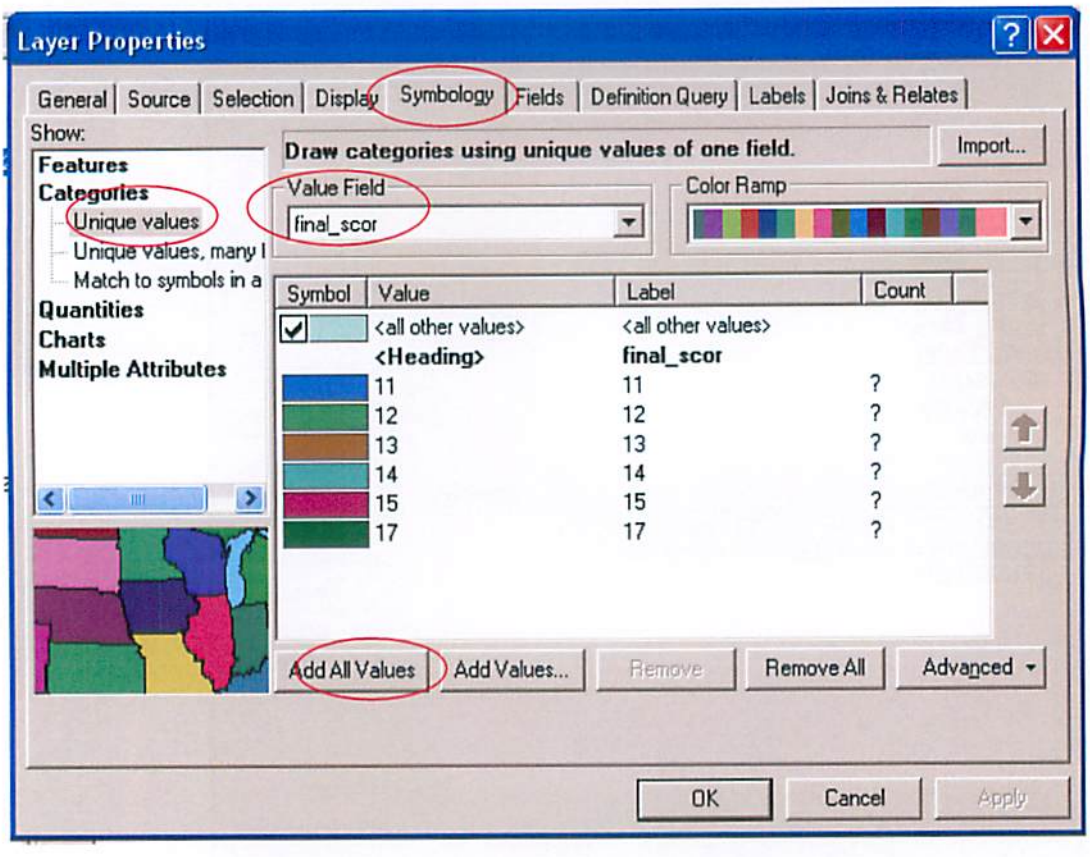
2. Open the attribute table and select options and add field name it as: final score

4. r. clicks the field "final score" and select field calculator to make the summation of all scores as shown below:



Examine the final score and select the best watersheds

- r.click the watersheds_final_score_stage2 and select properties
- - choose symbology and use value field "final score"
- From categories select unique values and add all values and click ok as follows:



Go to the view and see how the final scores are displayed on the watersheds.

Exercise 3:

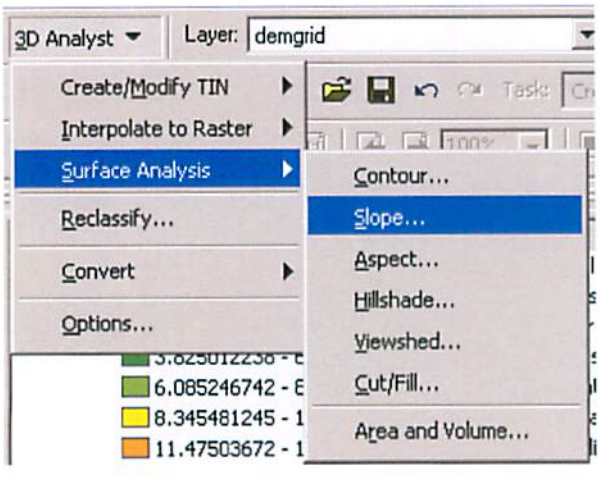
Suitability maps for water harvesting

A. Deriving slope map for the area

This step explains the preparation of slope mapping units to be used as suitability mapping units for water harvesting.

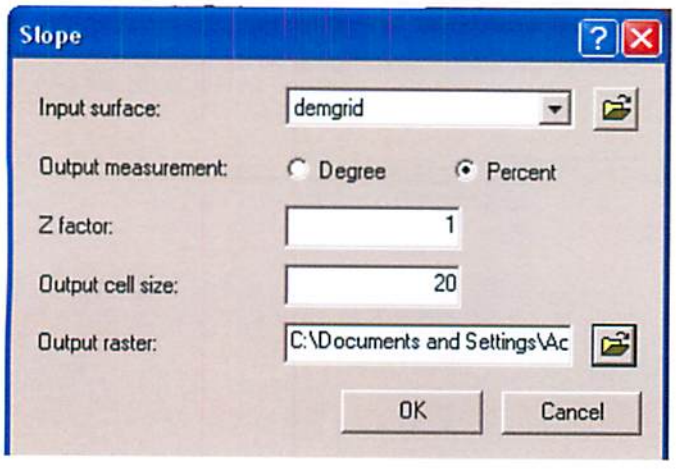
Steps

1. Open the Arc Map
2. Add image data source: data\data1\demgrid (digital elevation model)
3. Be sure that the module 3D Analyst and spatial analyst are activated
4. Click 3 D analyst and select surface analysis and choose slope

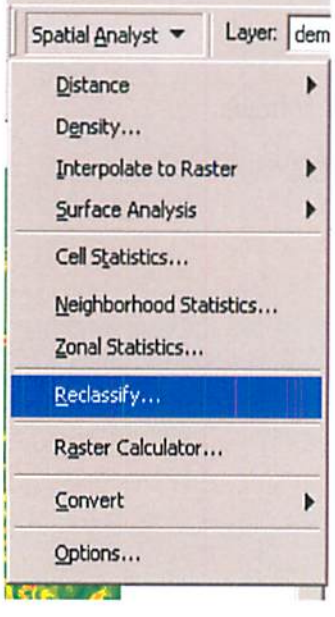


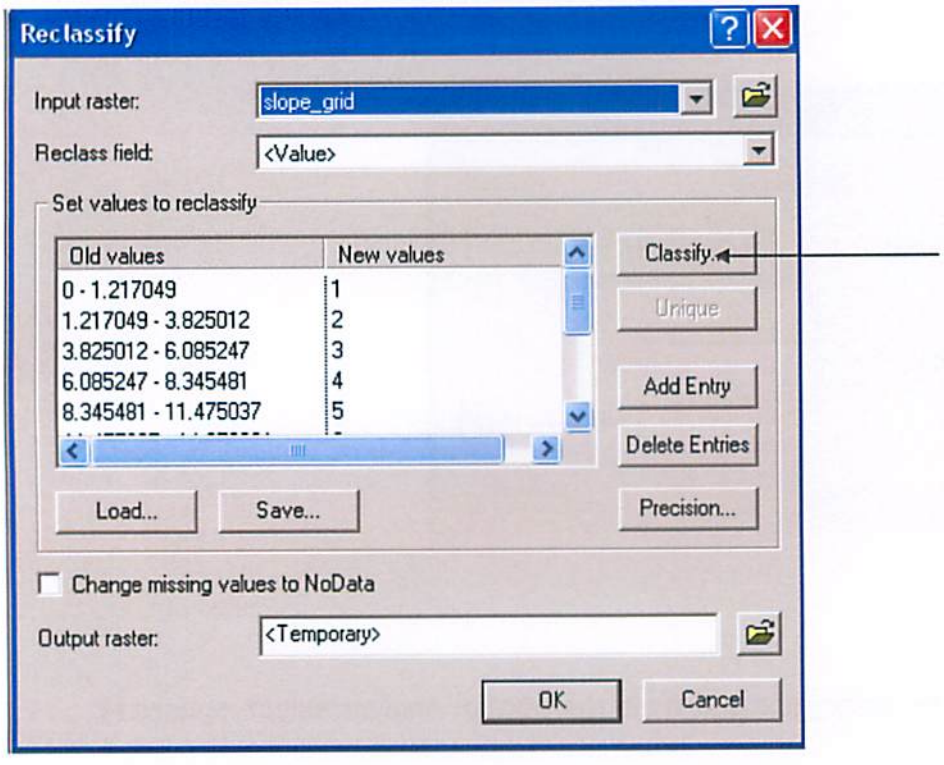
Examine the grid by zooming in and out to see the individual pixels

5. From the surface menu, derive slope and choose percentage and save it as slope_grid



6. Select the slope_grid and from the Spatial Analyst select reclassify

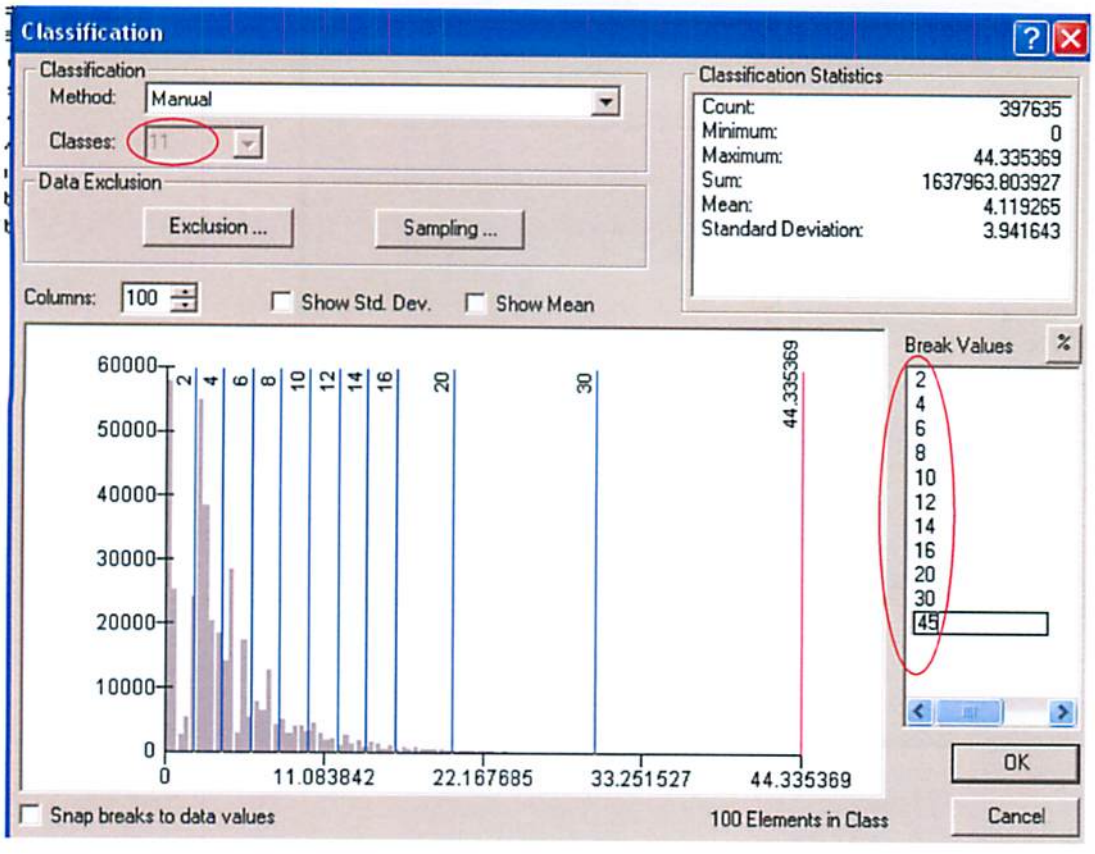


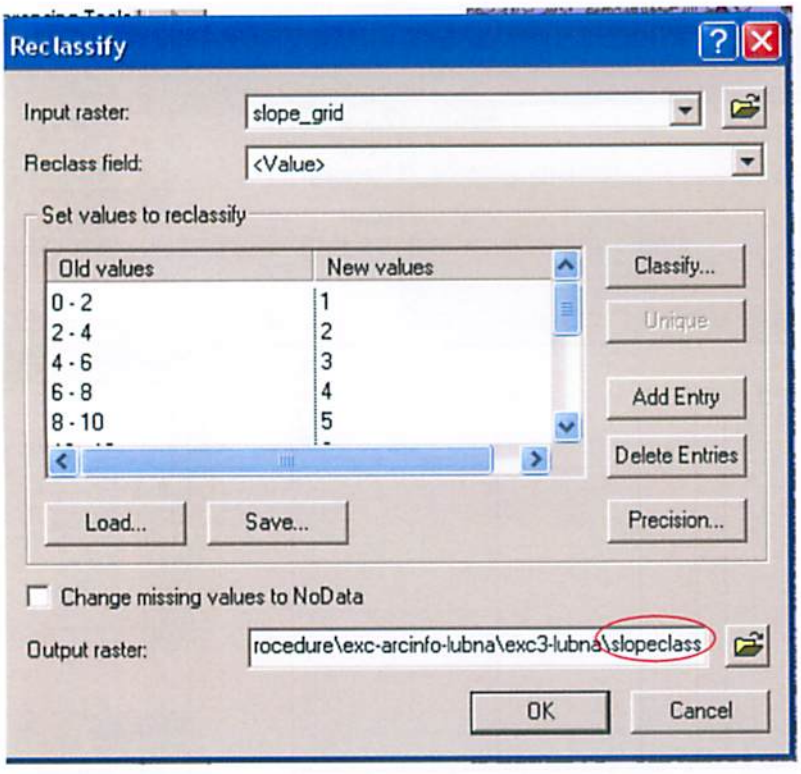


-Select classify and add the classes as follow:

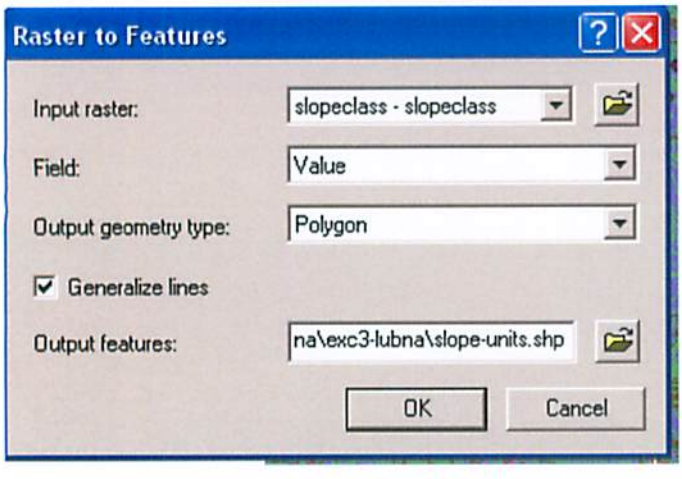
Choose 11 classes and enter values for slope classes as follows:

Note: Use detailed classification for slope less than 10%

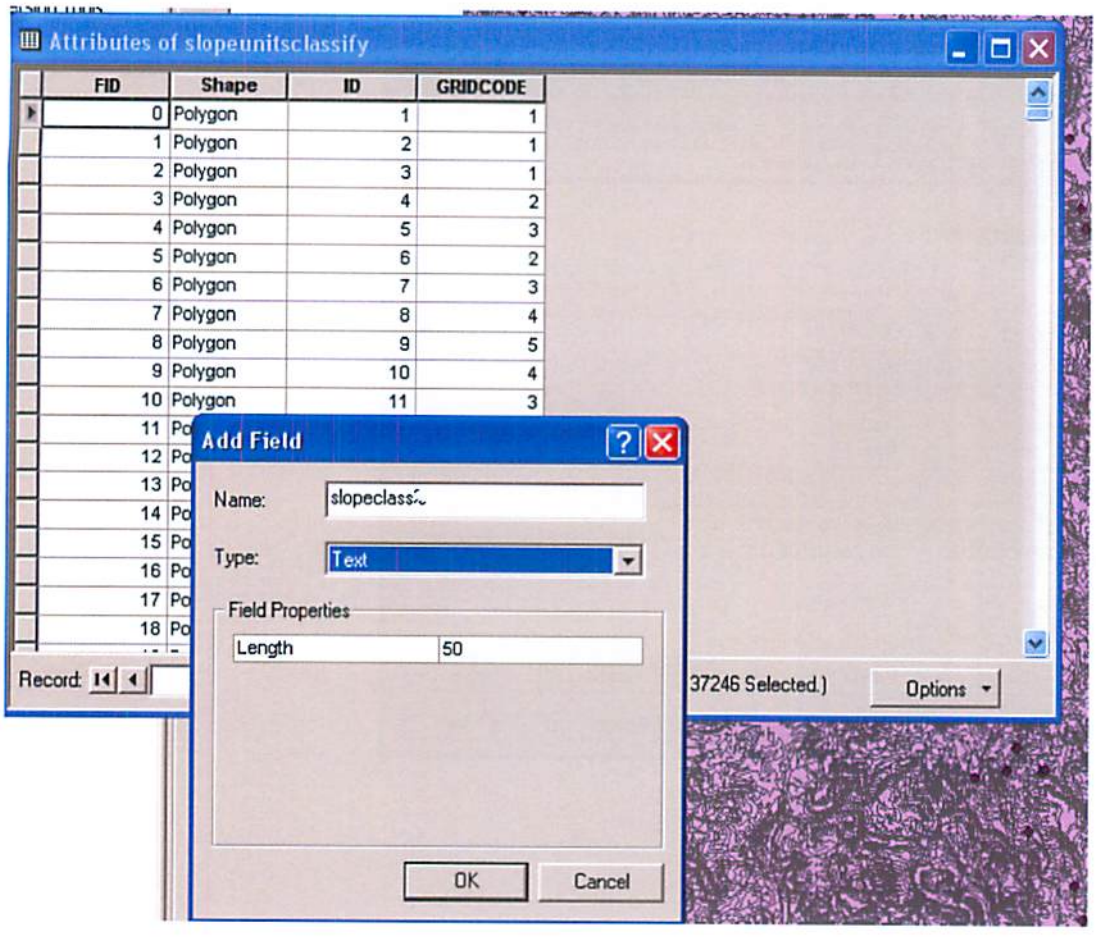

Classification
Classification
Method:
Manual
Classes:
11
Data Exclusion
Exclusion ...
Sampling ...
Classification Statistics
Count: 397635
Minimum: 0
Maximum: 44.335369
Sum: 1637963.803927
Mean: 4.119265
Standard Deviation: 3.941643
Columns:
100
Show Std. Dev.
Show Mean
60000
50000
40000
30000
20000
10000
0
2
4
6
8
10
12
14
16
20
30
44.335369
0
11.083842
22.167685
33.251527
44.335369
Break Values
2
4
6
8
10
12
14
16
20
30
45
OK
Cancel
Snap breaks to data values
100 Elements in Class



7. Click 3D analyst-select convert- raster to features name as: slope-units, the output will be shapefile

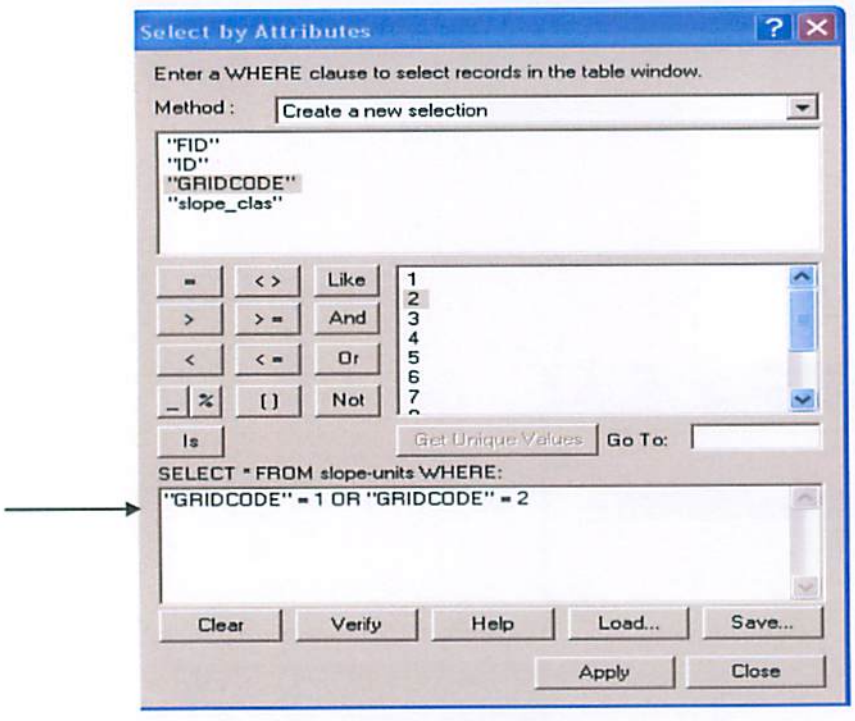


8. Activate slope-units.shp - r.click- open attribute table-options-add field name as: slope_class, type-Text



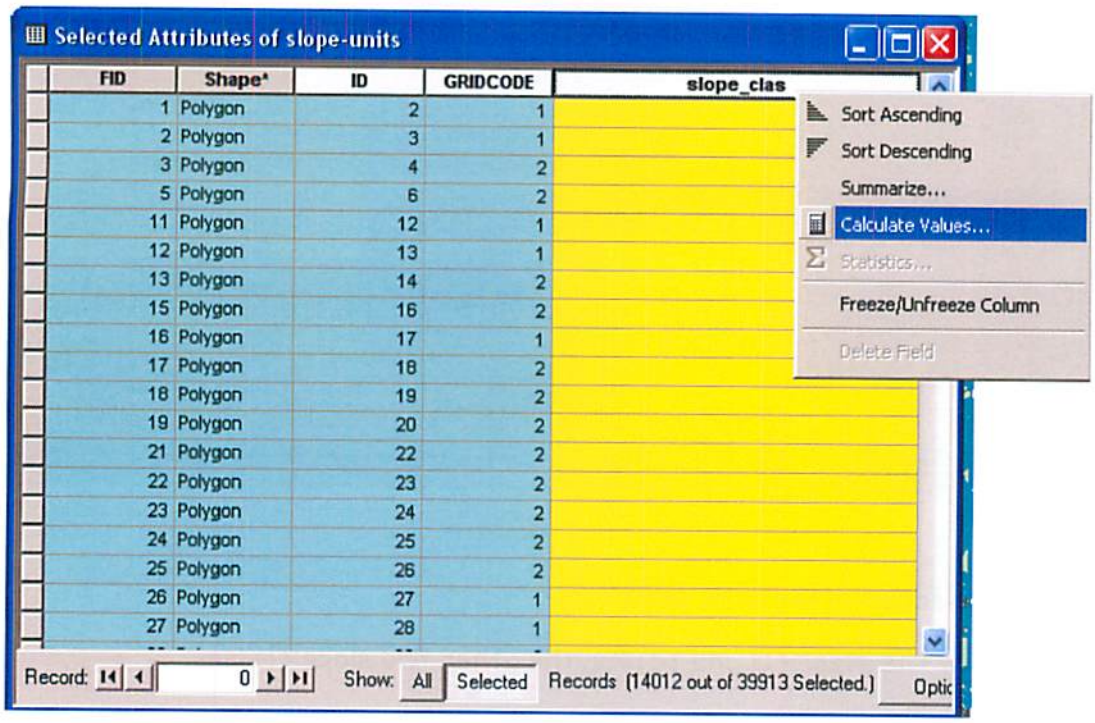
Note: According to WH criteria the slope units have three slope classes class 1: (0-4% low), class2: (4-12% med), class3: (>12% steep).

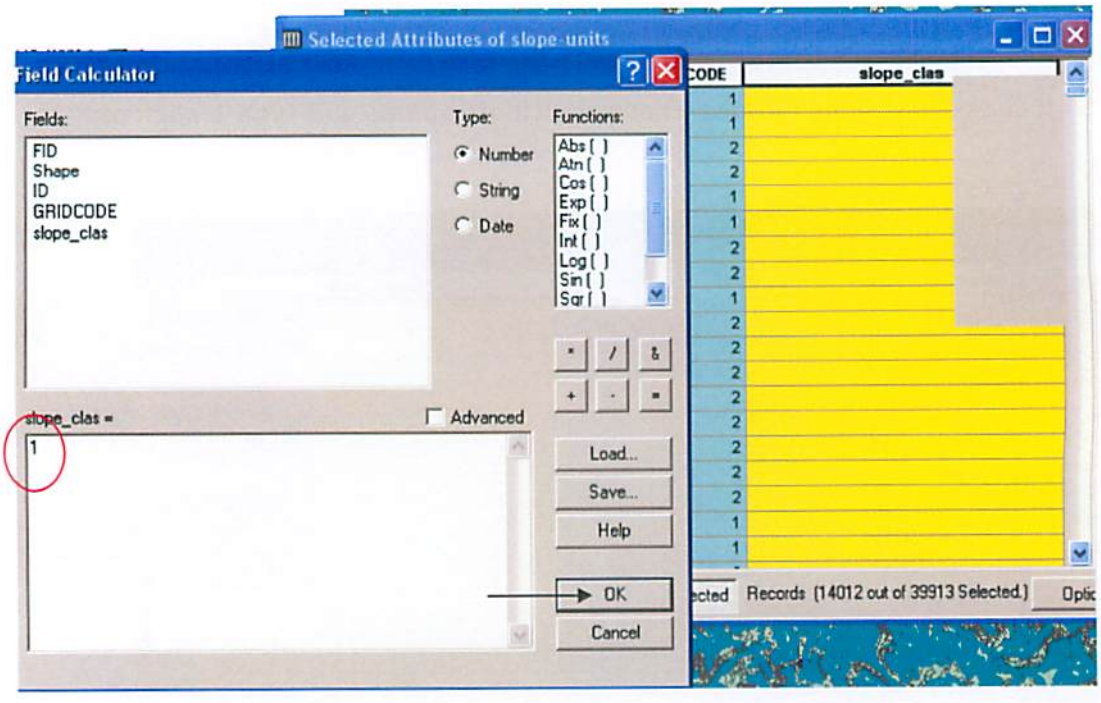
11. Editor-start editing- (target: slope-units.shp)-open attribute table-options-select by attribute- using equation below:



-This will select all slope class 1 and 2.

9- R.click-field slope classes-choose calculate values and type 1-click ok





- Clear selection after each selection.

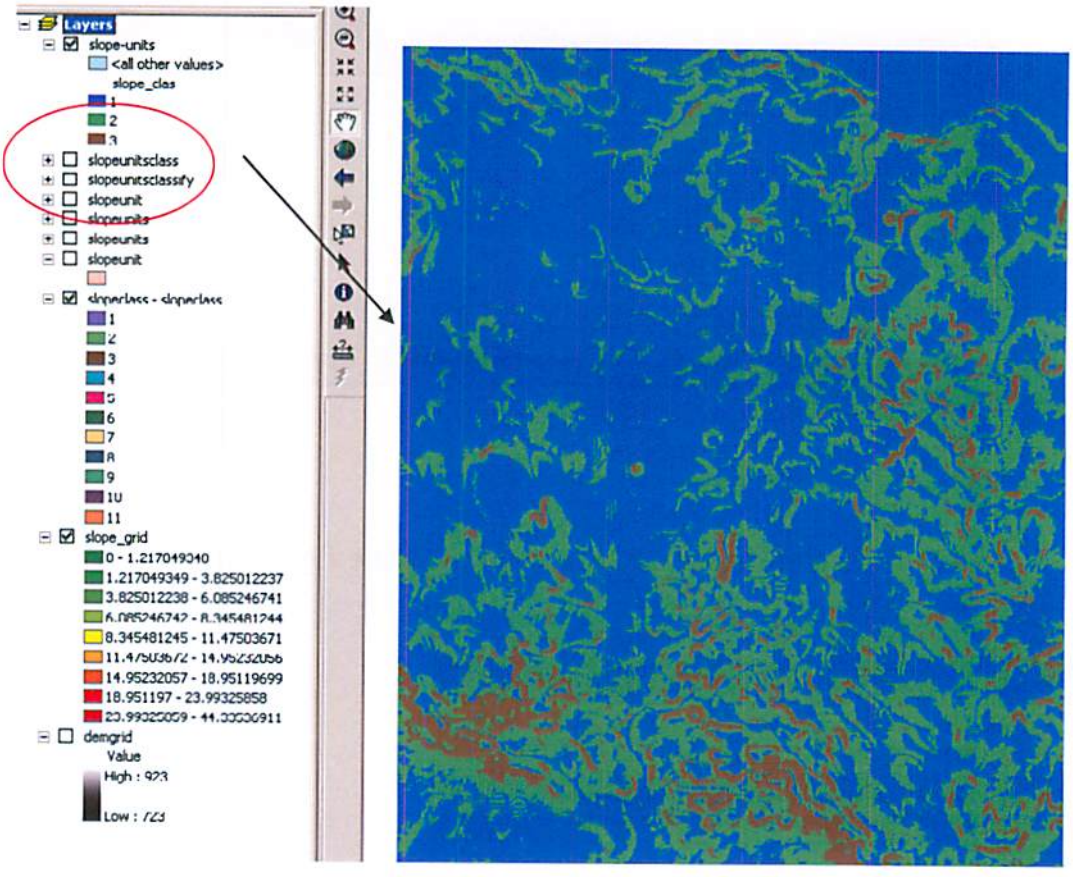
10- Repeat the steps (11 and 12) for the other two slope classes:

Slope class (3, 4, 5, 6) = class 2.

Slope class (7, 8, 9, 10, 11) = class 3.

11- Display slope units.shp according to the slope class (field)-using symbology.

The output as figure below:



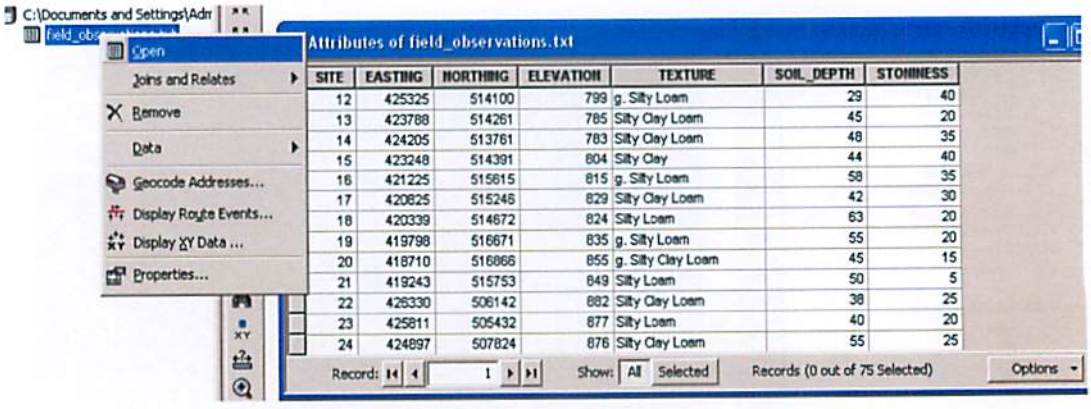
B. Preparing field observations for analysis:

These points were collected from the field and need to be prepared for the analysis. The coordinates attached to each point was collected using the GPS.

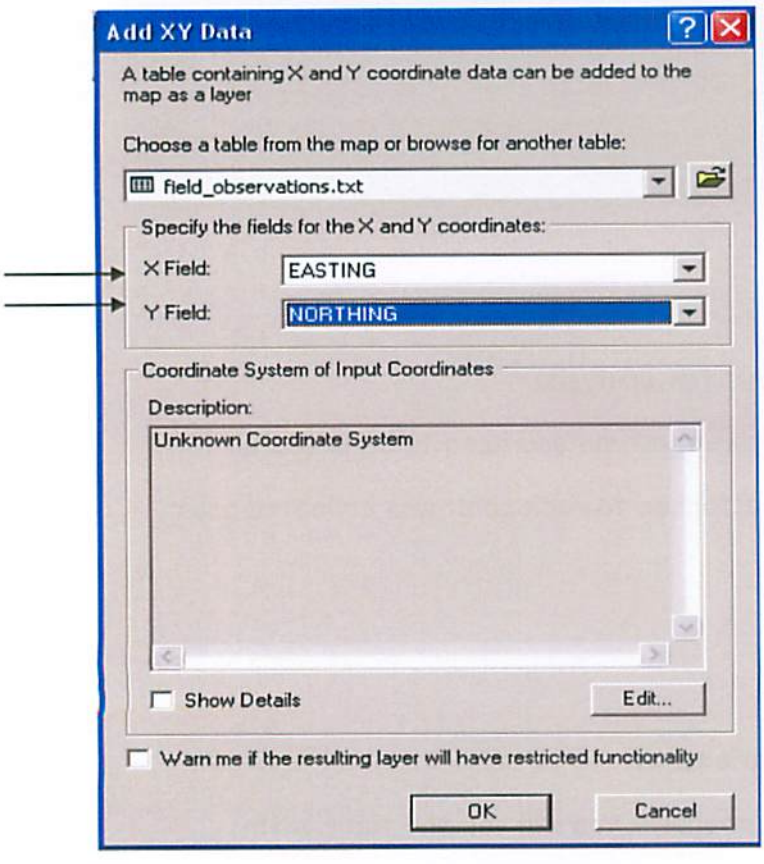
Steps:

1. Add the table field_observations.txt

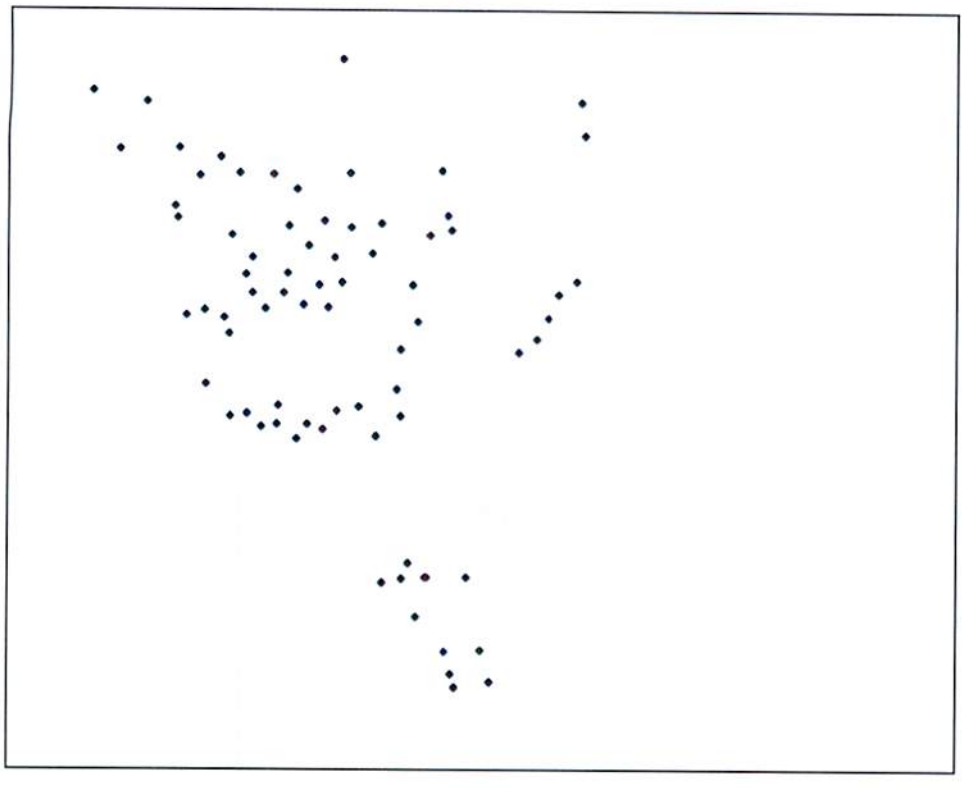
2- R.click the table and open as follows, you will see the table with information for each point and the coordinates: easting and northing



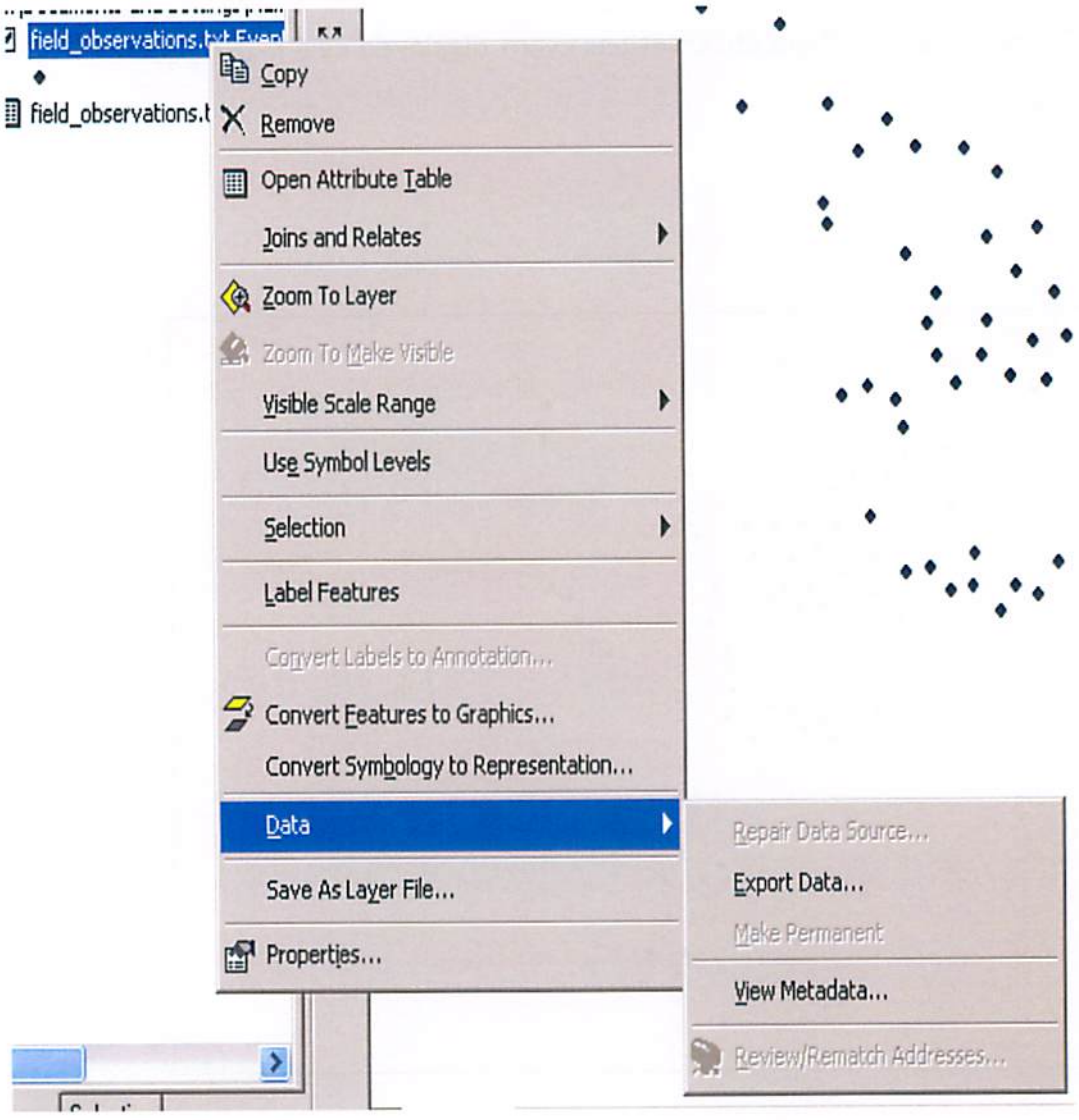
3. Select tools and choose add x, y and follow the figure below



4- You will see all field observations event displayed as a map as shown below:



5. R.click the "field_observations.txt event and select export - data export as shown below and save it as observations.shp


field_observations.txt Event
field_observations.t
Copy
Remove
Open Attribute Table
Joins and Relates
Zoom To Layer
Zoom To Make Visible
Visible Scale Range
Use Symbol Levels
Selection
Label Features
Convert Labels to Annotation...
Convert Features to Graphics...
Convert Symbology to Representation...
Data
Save As Layer File...
Properties...
Repair Data Source...
Export Data...
Make Permanent
View Metadata...
Review/Rematch Addresses...

C. suitability map based on slope units:

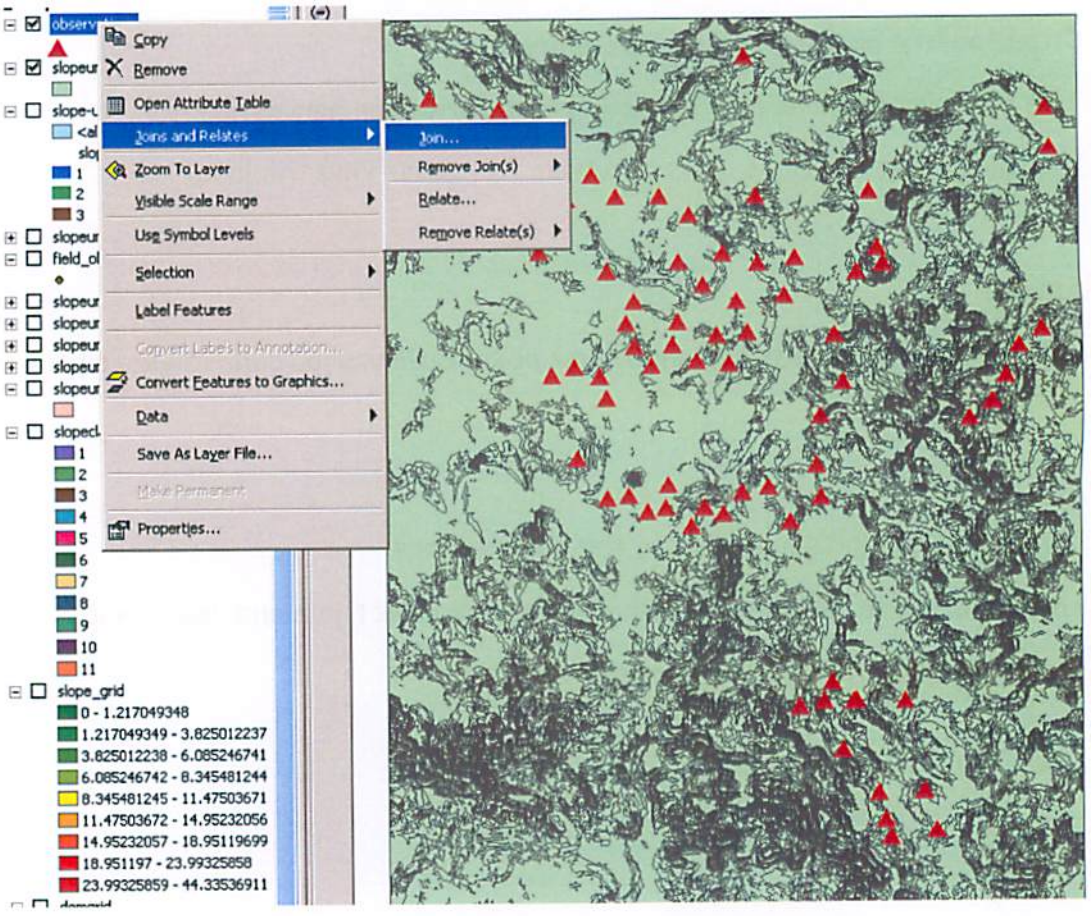
This exercise explains how suitability map for water harvesting is prepared using the slope units as a base for classifying the land.

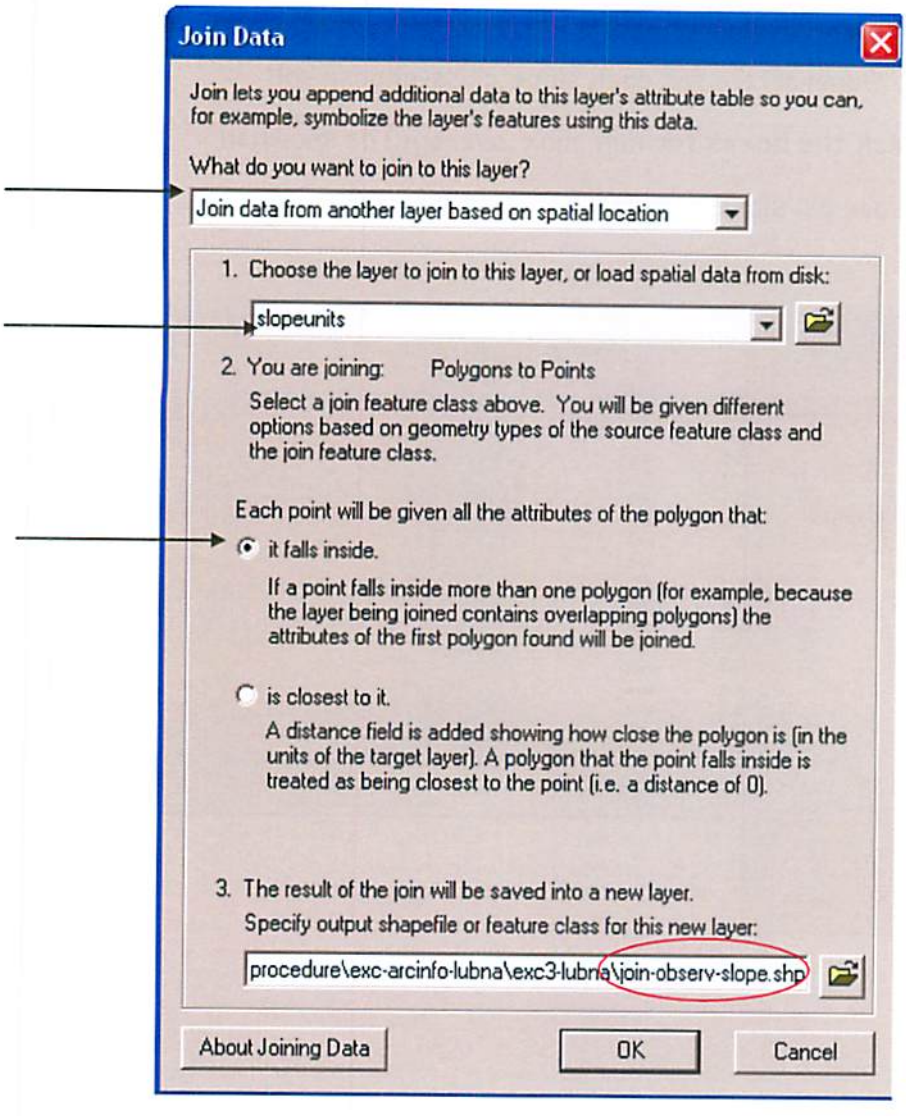
Steps:

1. Add theme slopeunits.shp and theme observations.shp (done in exercise B).

2. Attach slopeunits (number) to the observations:

- activate theme "obsertations.shp"and r.click select join and relate and choose join and follow the figures.

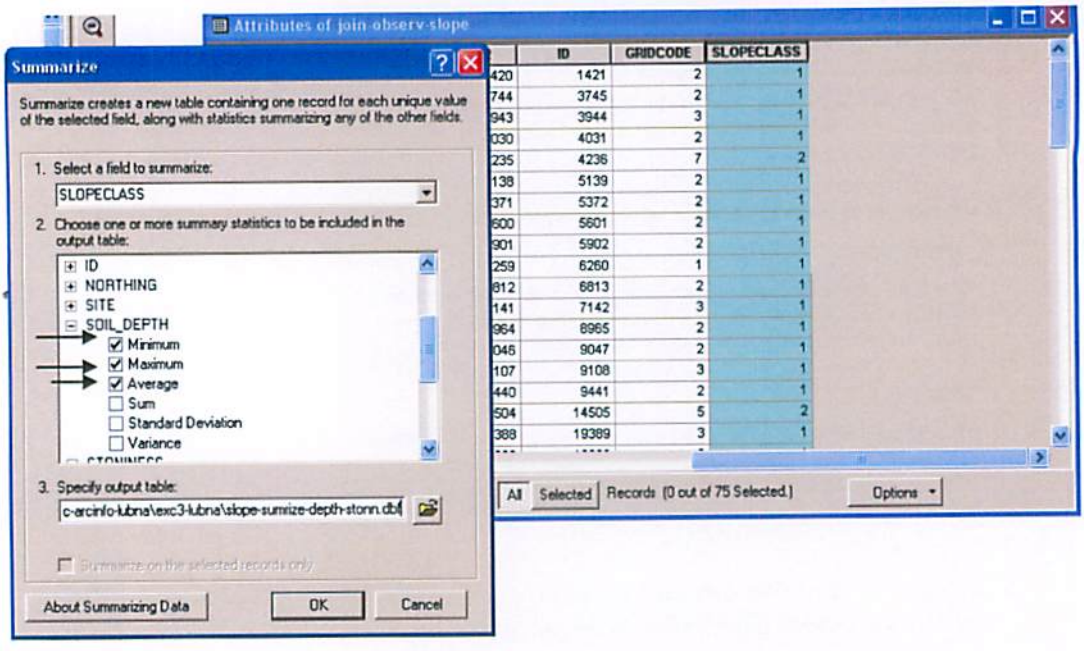

Copy
Remove
Open Attribute Table
Joins and Relates
Zoom To Layer
Visible Scale Range
Use Symbol Levels
Selection
Label Features
Convert Labels to Annotation...
Convert Features to Graphics...
Data
Save As Layer File...
Make Permanent
Properties...
Join...
Remove Join(s)
Relate...
Remove Relate(s)
slope_grid
0 - 1.217049348
1.217049349 - 3.825012237
3.825012238 - 6.085246741
6.085246742 - 8.345481244
8.345481245 - 11.47503671
11.47503672 - 14.95232056
14.95232057 - 18.95119699
18.951197 - 23.99325858
23.99325859 - 44.33536911

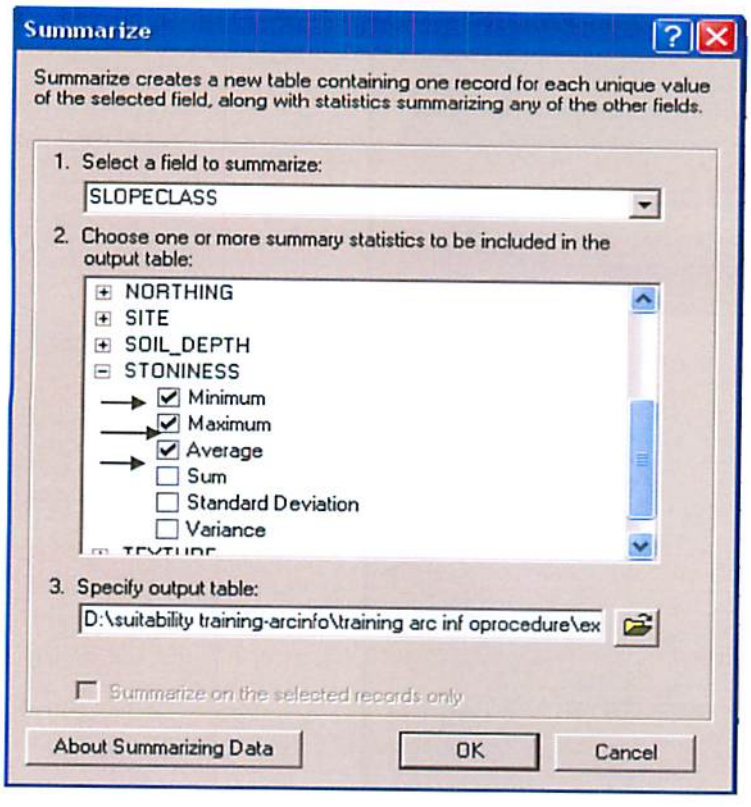


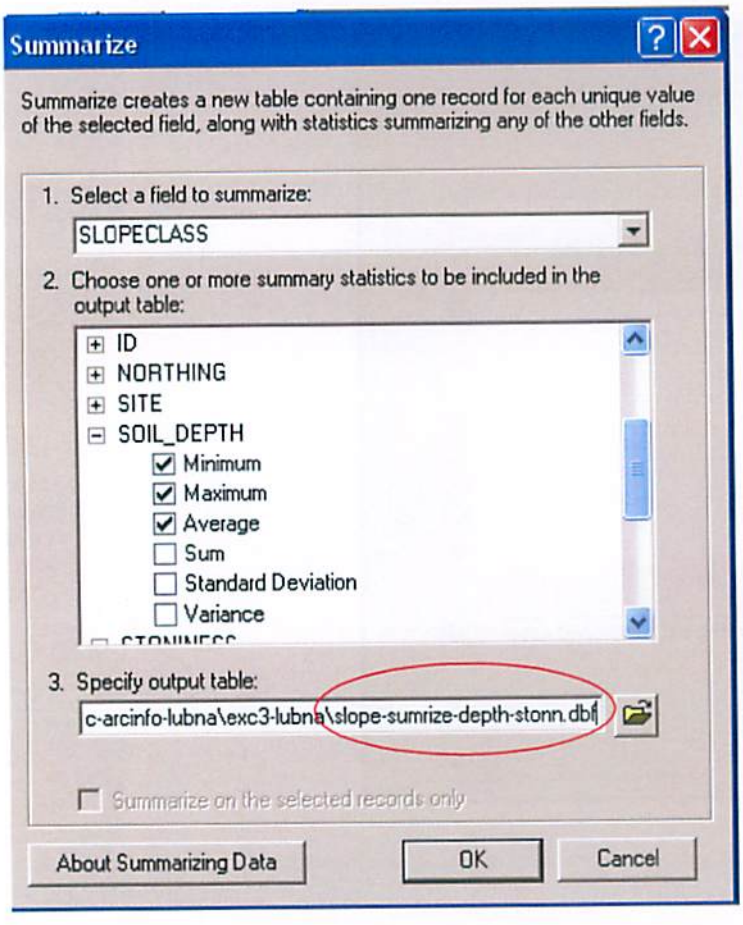
-The result is shapefile name: join-observ-slope.shp -open attribute table

- sees the result (each observation has attached slope class value).

3. Activate join-observ-slope.shp -r.click -open the attribute table-select slope class field- r.click- Summarize- for each slope class-choose soil depth and stoniness (check the boxes for min, max, average) as shown in the figures below , and save as: slope-sumrize-depth-stonn.dbf:




Summarize
Summarize creates a new table containing one record for each unique value of the selected field, along with statistics summarizing any of the other fields.
1. Select a field to summarize:
SLOPECLASS
2. Choose one or more summary statistics to be included in the output table:
NORTHING
SITE
SOIL_DEPTH
STONINESS
Minimum
Maximum
Average
Sum
Standard Deviation
Variance
3. Specify output table:
D:\suitability training-arcinfo\training arc inf oprocedure\ex
Summarize on the selected records only
About Summarizing Data
OK
Cancel

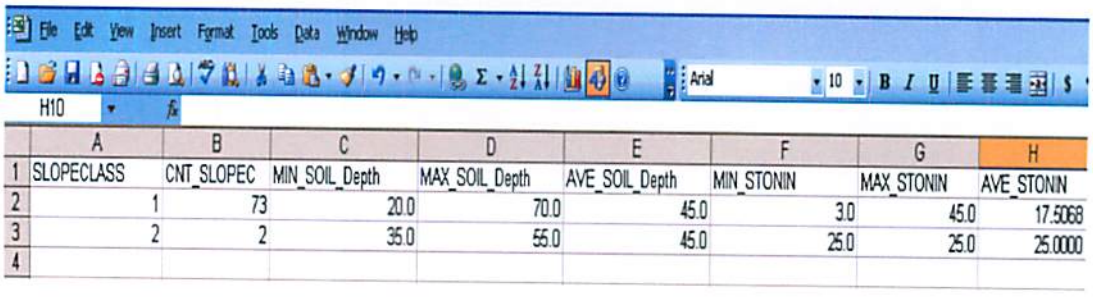


Note: texture is classified" med" for all slope classes.

4. Compare the values for each slope unit with the criteria for each water harvesting system. (See attached W.H table criteria).

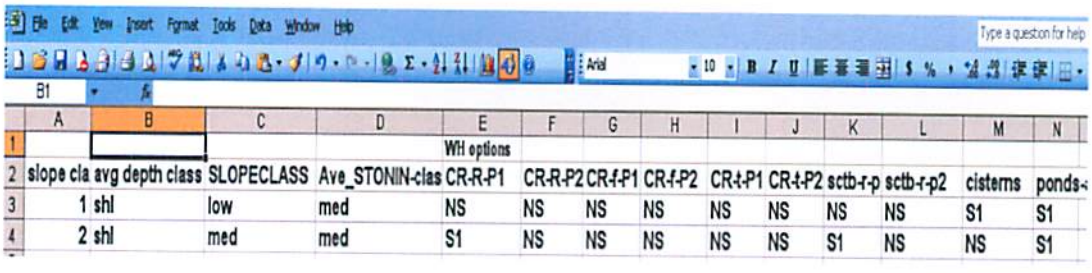
5- Open the table slope-sumrize-depth-stonn.dbf r.click-export-data-wh-options.dbf.

6- Open excel sheet and reopen the wh-options .dbf file



	A	B	C	D	E	F	G	H
1	SLOPECLASS	CNT_SLOPEC	MIN_SOIL_Depth	MAX_SOIL_Depth	AVE_SOIL_Depth	MIN_STONIN	MAX_STONIN	AVE_STONIN
2	1	73	20.0	70.0	45.0	3.0	45.0	17.5068
3	2	2	35.0	55.0	45.0	25.0	25.0	25.0000
4								

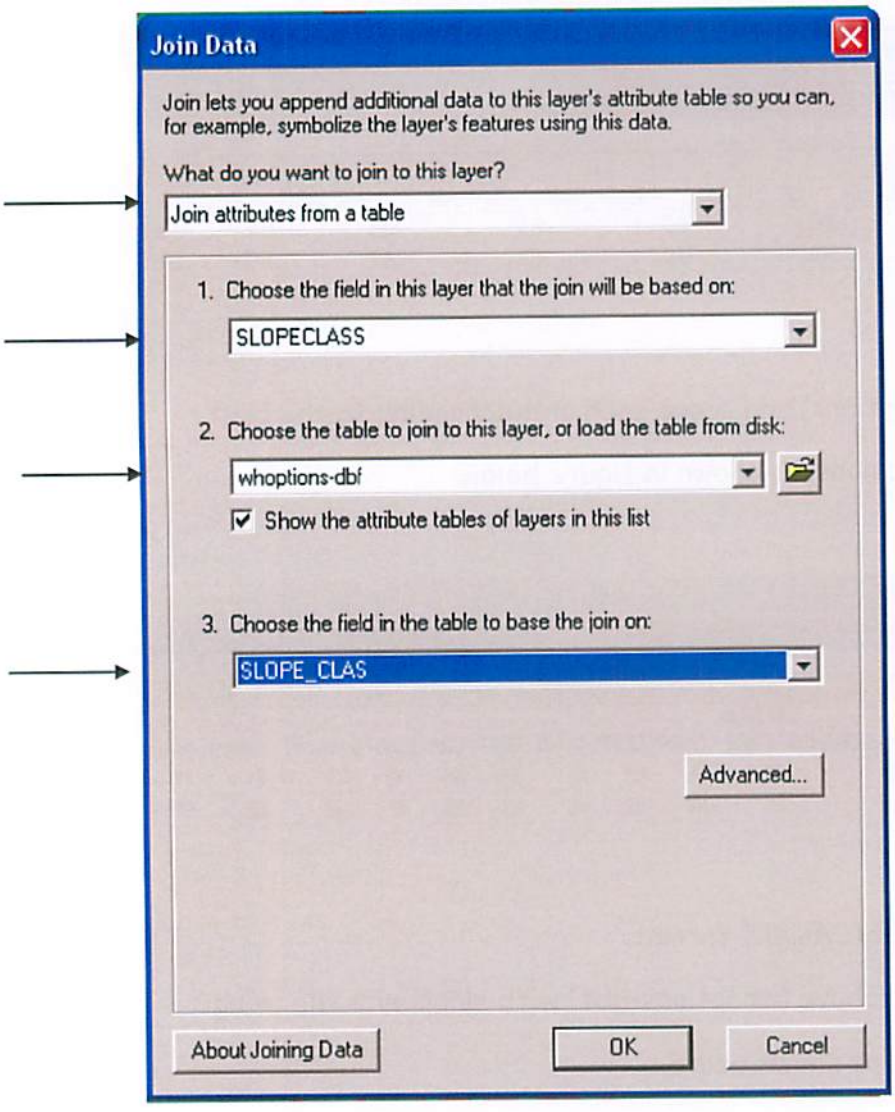
7- Edit excel file (wh-options) and score each unit according to the best two water harvesting options, as shown in figure below:



	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1					WH options									
2	slope cla	avg depth class	SLOPECLASS	Ave_STONIN-clas	CR-R-P1	CR-R-P2	CR-f-P1	CR-f-P2	CR-t-P1	CR-t-P2	sctb-r-p	sctb-r-p2	cisterns	ponds-r
3	1	shl	low	med	NS	NS	NS	NS	NS	NS	NS	NS	S1	S1
4	2	shl	med	med	S1	NS	NS	NS	NS	NS	S1	NS	NS	S1

8. Save as Wh-options-dbf. As dbf format.

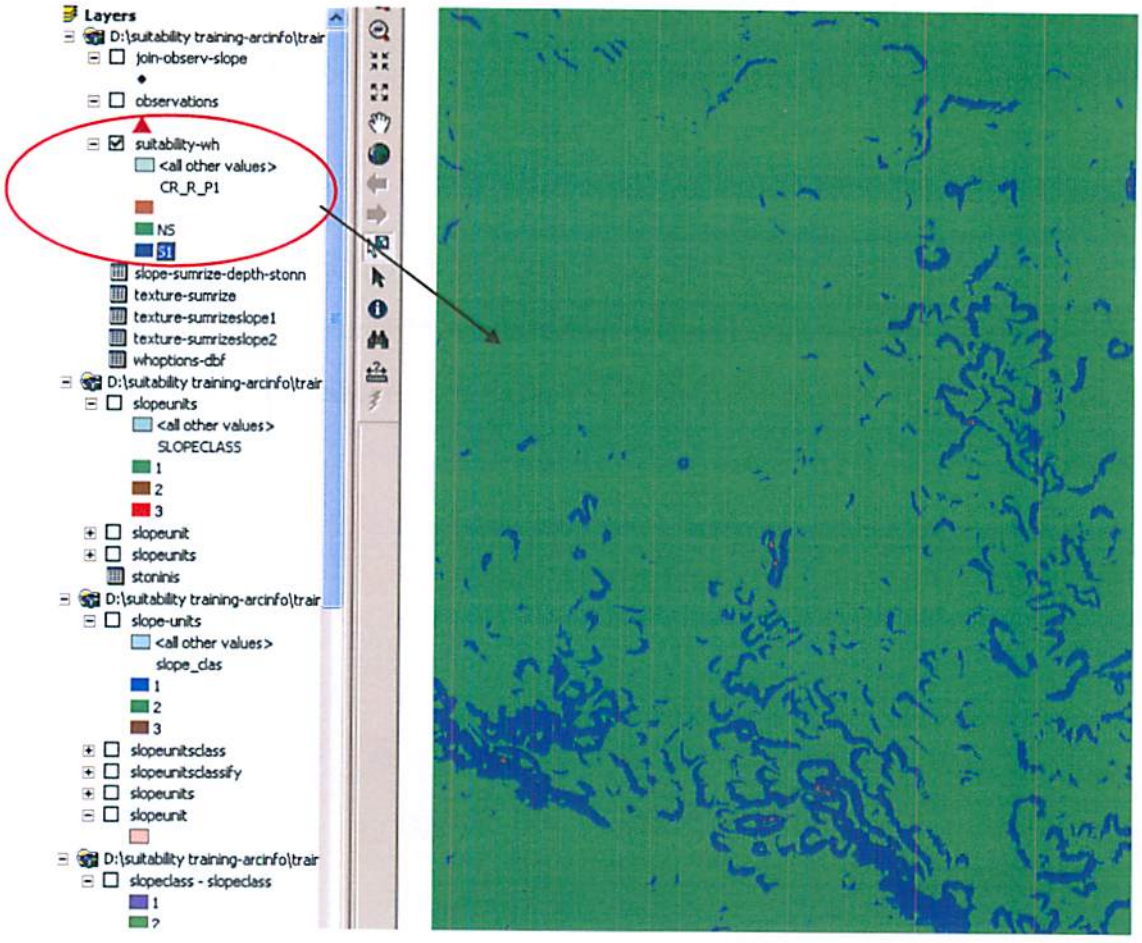
9. Join the table named above (whoptions-dbf) with slopeunits.shp using the values of slope class as shown below.



10- Export the slopeunits.shp to suitability-wh.shp.

11- Display the suitability-wh.shp using different wh options using symbology.

Example as below (suitability for CR.R.P1)



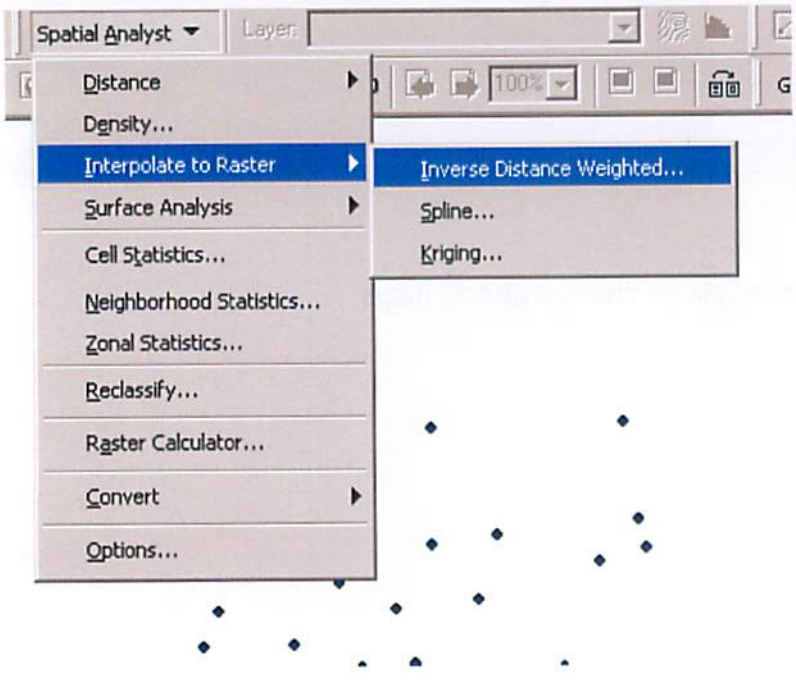
10- Prepare another example of the suitability maps.

D. Suitability map based on field observations:

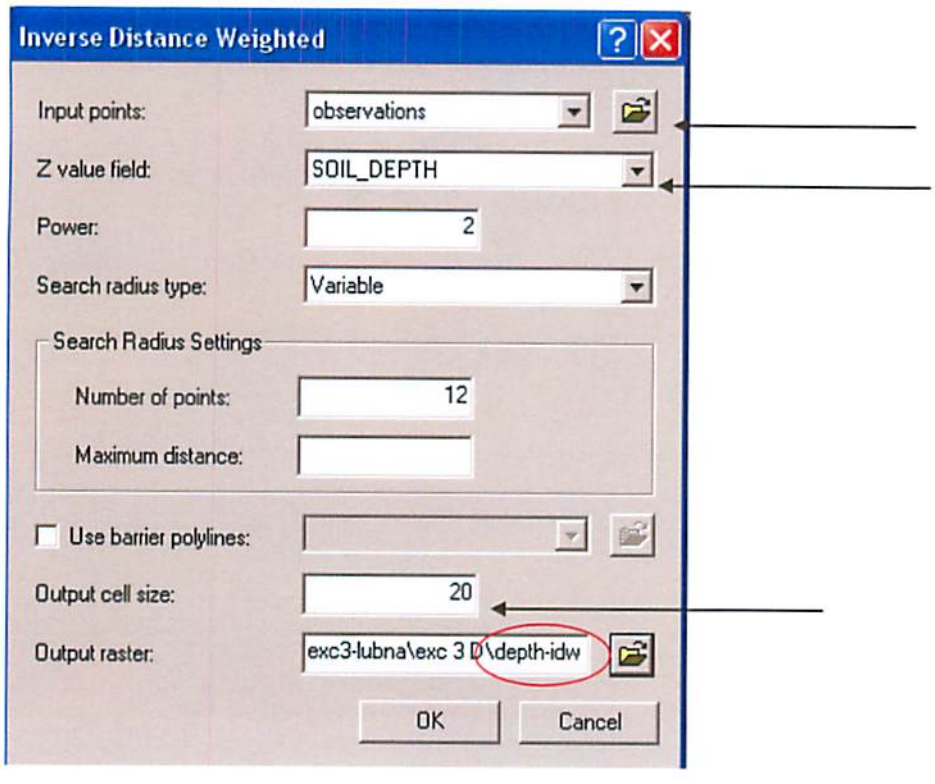
This exercise explains how suitability map for water harvesting is prepared using the field observations.

Steps

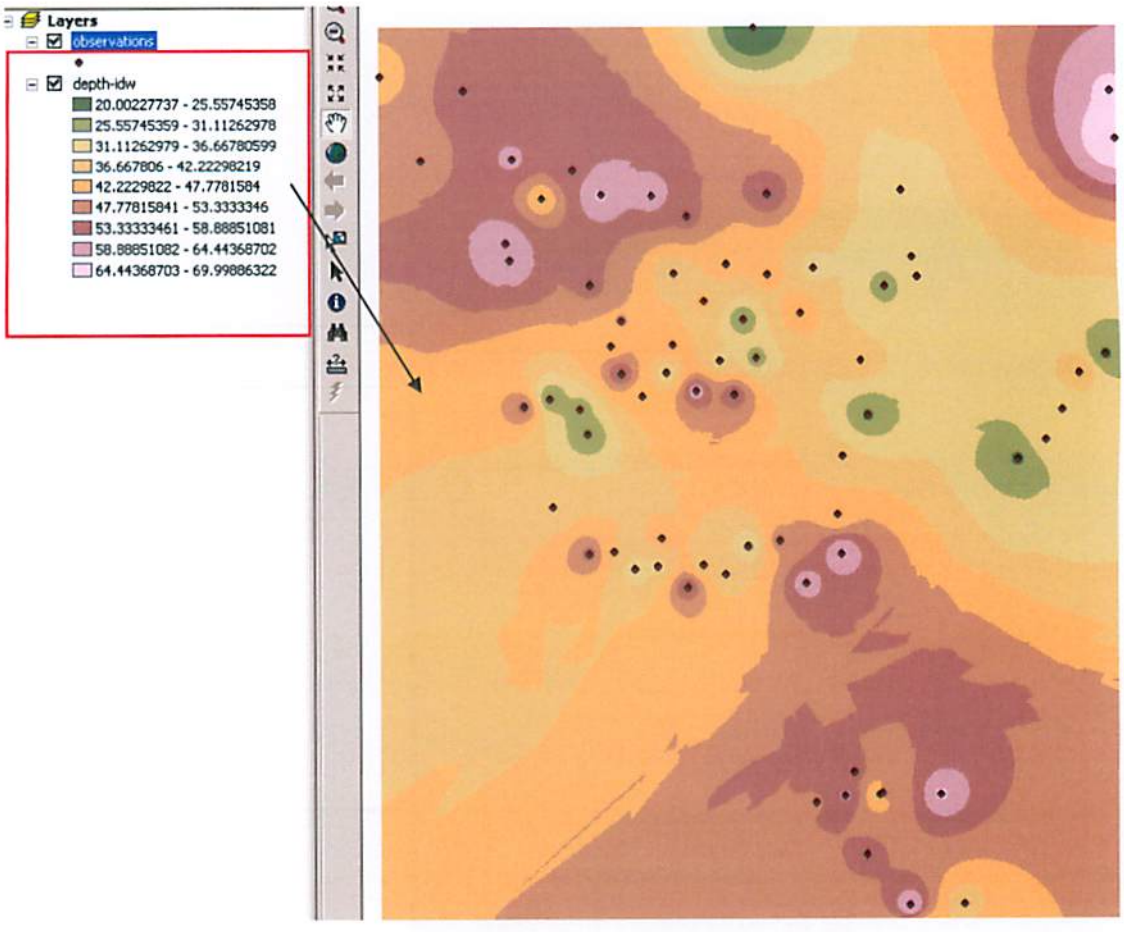
1. Add the theme observations.shp containing the field points.
2. From tools - extensions, click the spatial analyst (if not activated)
3. Spatial analyst - select interpolate to raster and choose IDW as shown below



4- Follow the figure below:



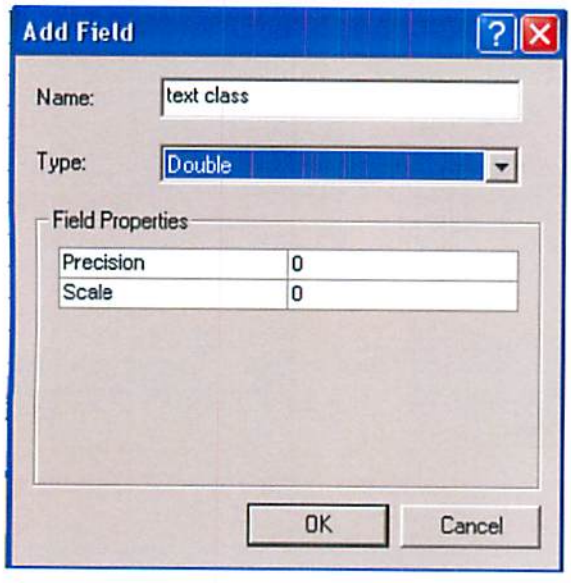
5- The output (depth-idw (raster) with actual field values for depth.



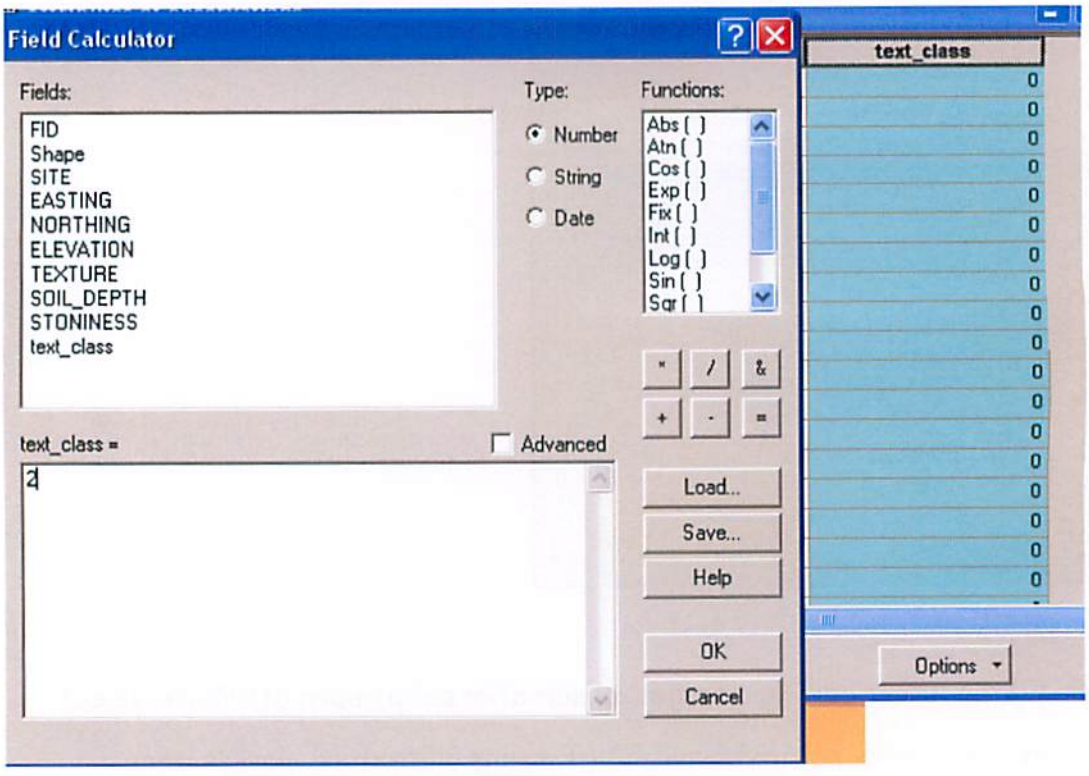
6- Repeat steps (3, 4, and 5) for stoniness and name the output raster as (stone-idw).

7- For texture interpolation the field should be as number not text.

8- r.click- observations.shp -open attribute -options- add field as below::

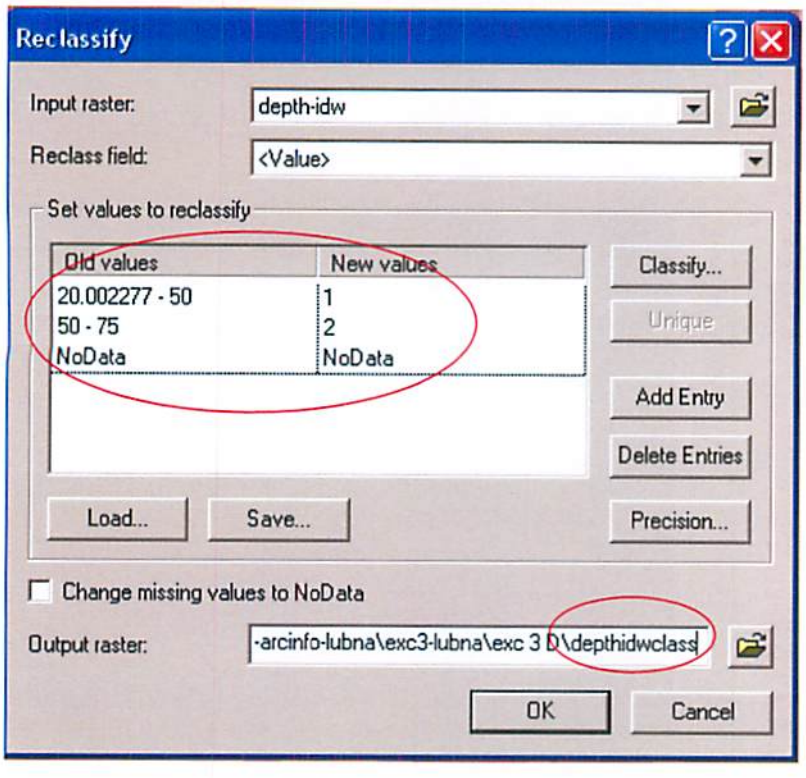


9- Editor- start editing- (target: observations.shp)-open attribute-select field text_class- calculate value=2 (it means all texture classes were classified as medium) as shown below:

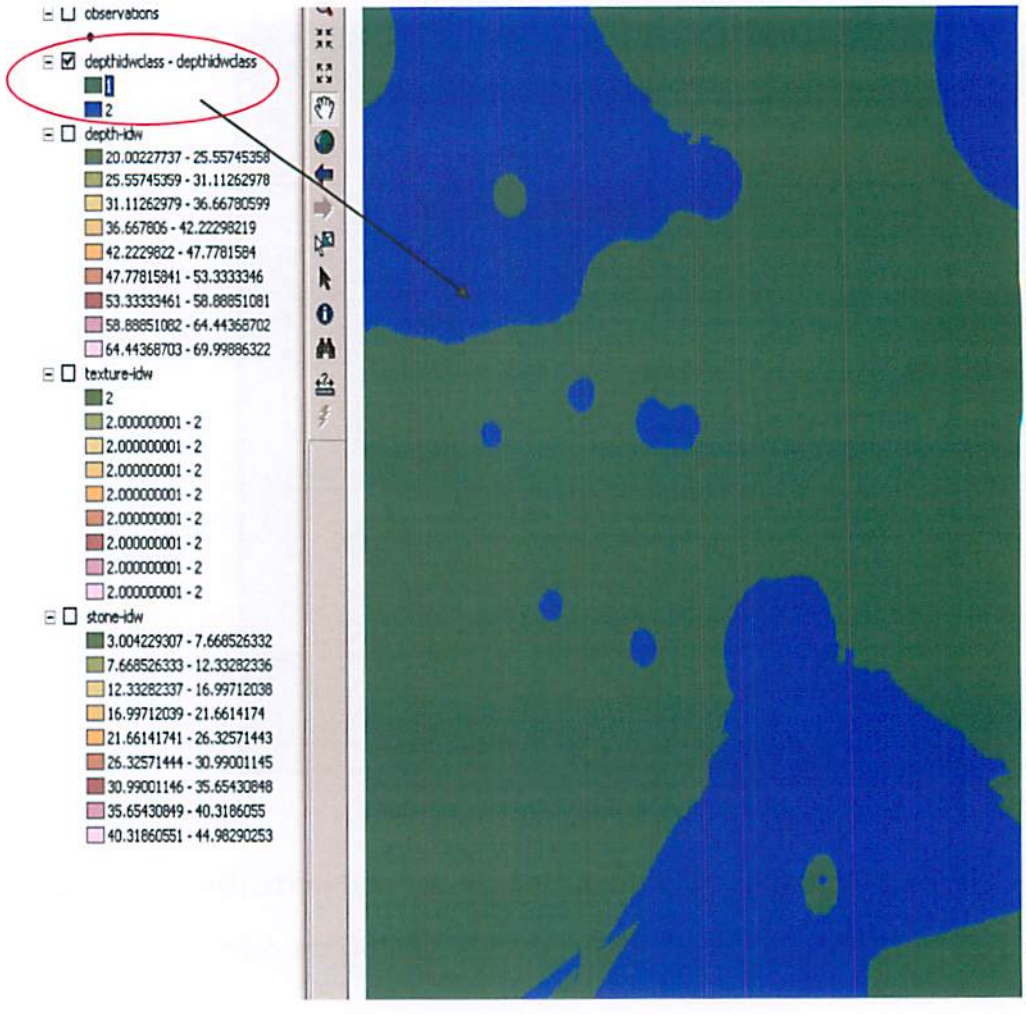


10- Repeat steps (3, 4, and 5) for text_class. Named output (texture-idw).

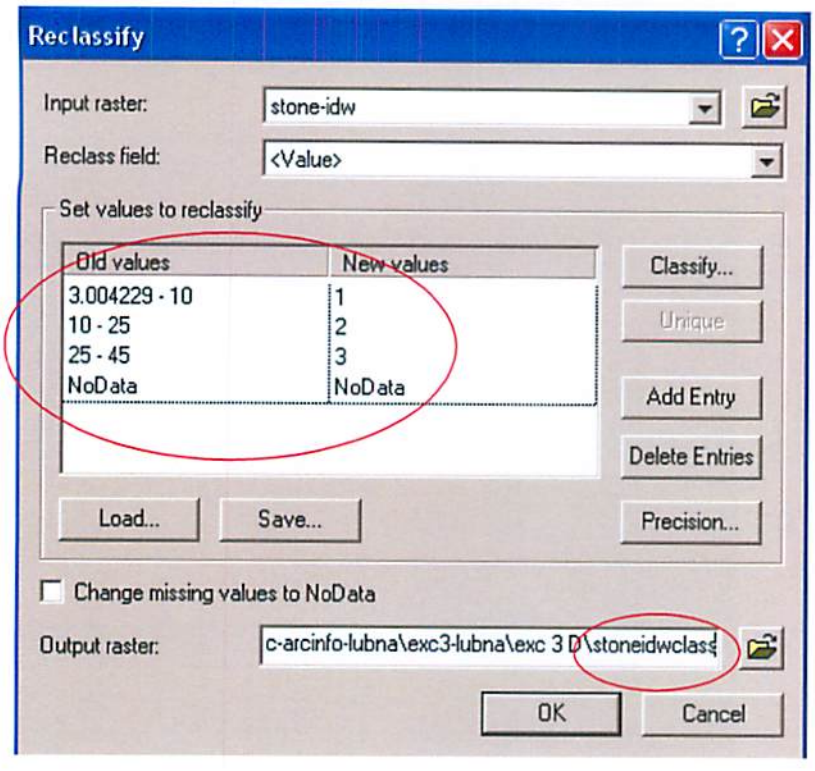
11- Spatial analyst – select reclassify- depth-idw, and choose two classes (according to the WH criteria for depth: <50 cm, 50-100, >100) but in our case only two classes as shown below: and save the output depthidwclass.



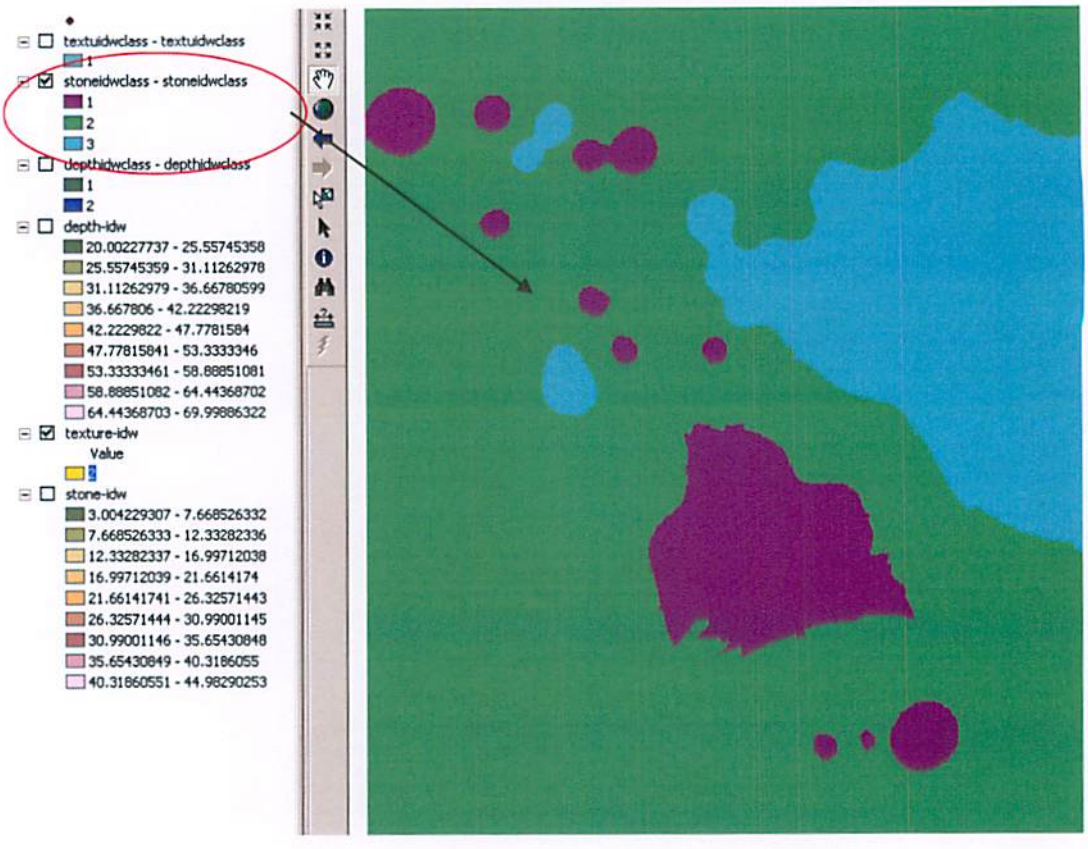
- See the output as below with 2 classes and write down in your book that (class1= <50 cm depth, class2= 50-100 cm depth.


observations
depthidwclass - depthidwclass
1
2
depth-idw
20.00227737 - 25.55745358
25.55745359 - 31.11262978
31.11262979 - 36.66780599
36.667806 - 42.22298219
42.2229822 - 47.7781584
47.77815841 - 53.3333346
53.33333461 - 58.88851081
58.88851082 - 64.44368702
64.44368703 - 69.99886322
texture-idw
2
2.000000001 - 2
2.000000001 - 2
2.000000001 - 2
2.000000001 - 2
2.000000001 - 2
2.000000001 - 2
2.000000001 - 2
2.000000001 - 2
stone-idw
3.004229307 - 7.668526332
7.668526333 - 12.33282336
12.33282337 - 16.99712038
16.99712039 - 21.6614174
21.66141741 - 26.32571443
26.32571444 - 30.99001145
30.99001146 - 35.65430848
35.65430849 - 40.3186055
40.31860551 - 44.98290253

12- Repeat step 11 for stoniness (three classes and write down the actual classes meaning) and follow the figure below



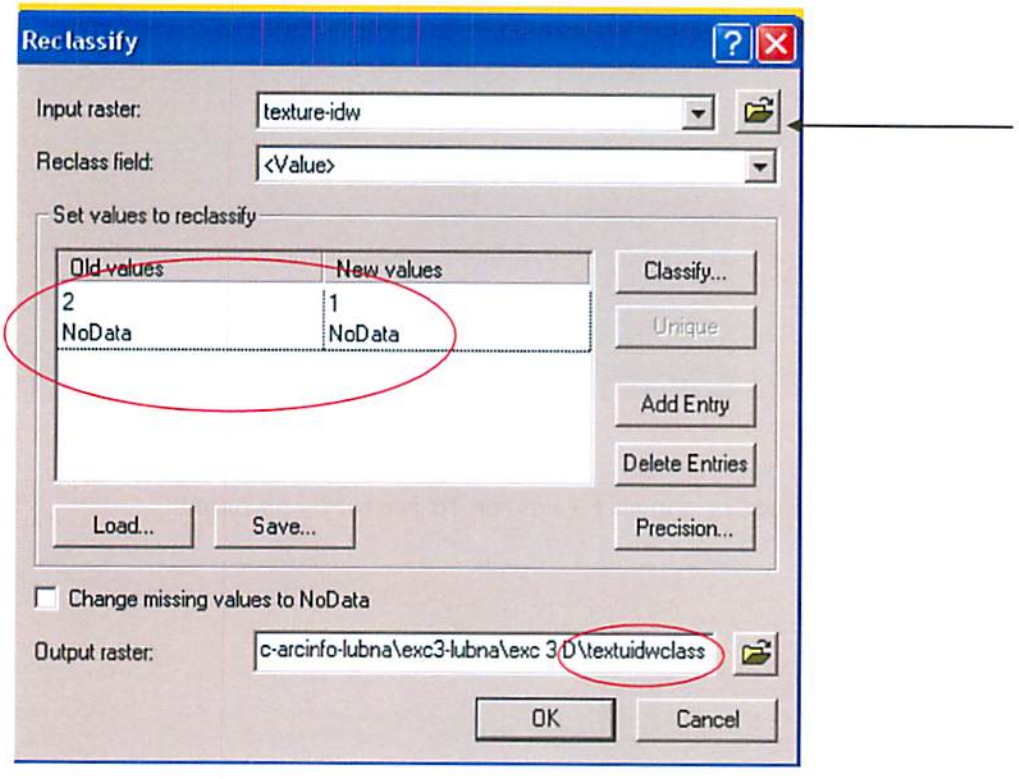
- The output as below:



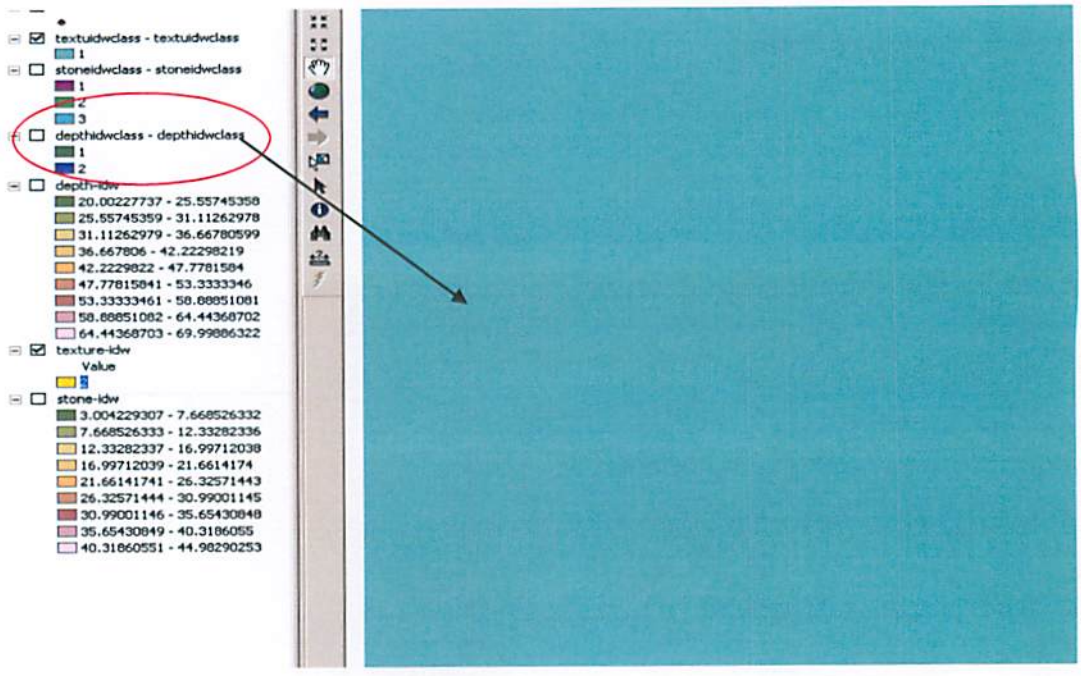
13- Symbology the textureidw to unique value as one class.

14- Repeat step 11 for texture (one class) and

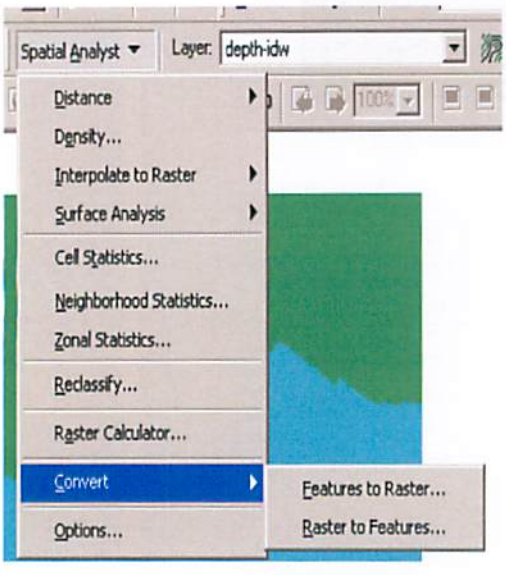
Follow the figure below:



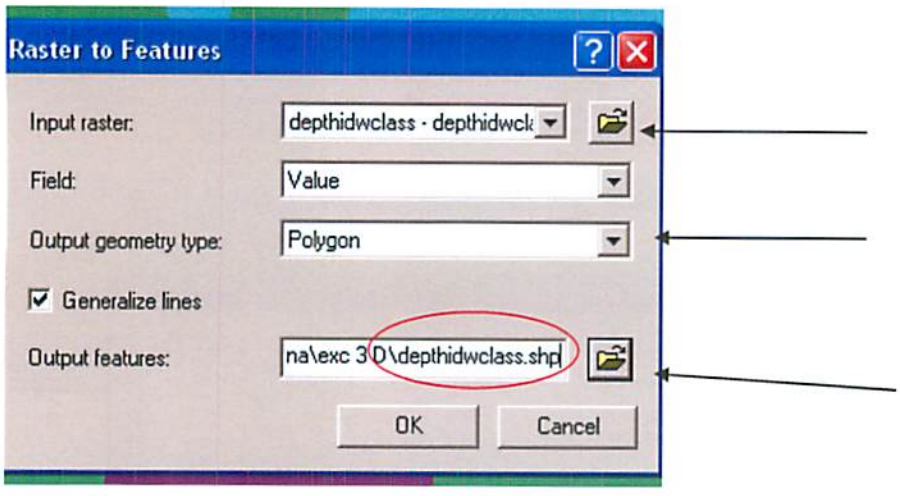
- The output as below:



15- Spatial analyst- chooses convert – raster to features as below:



- choose depthidwclass (raster) and follow the figure below:



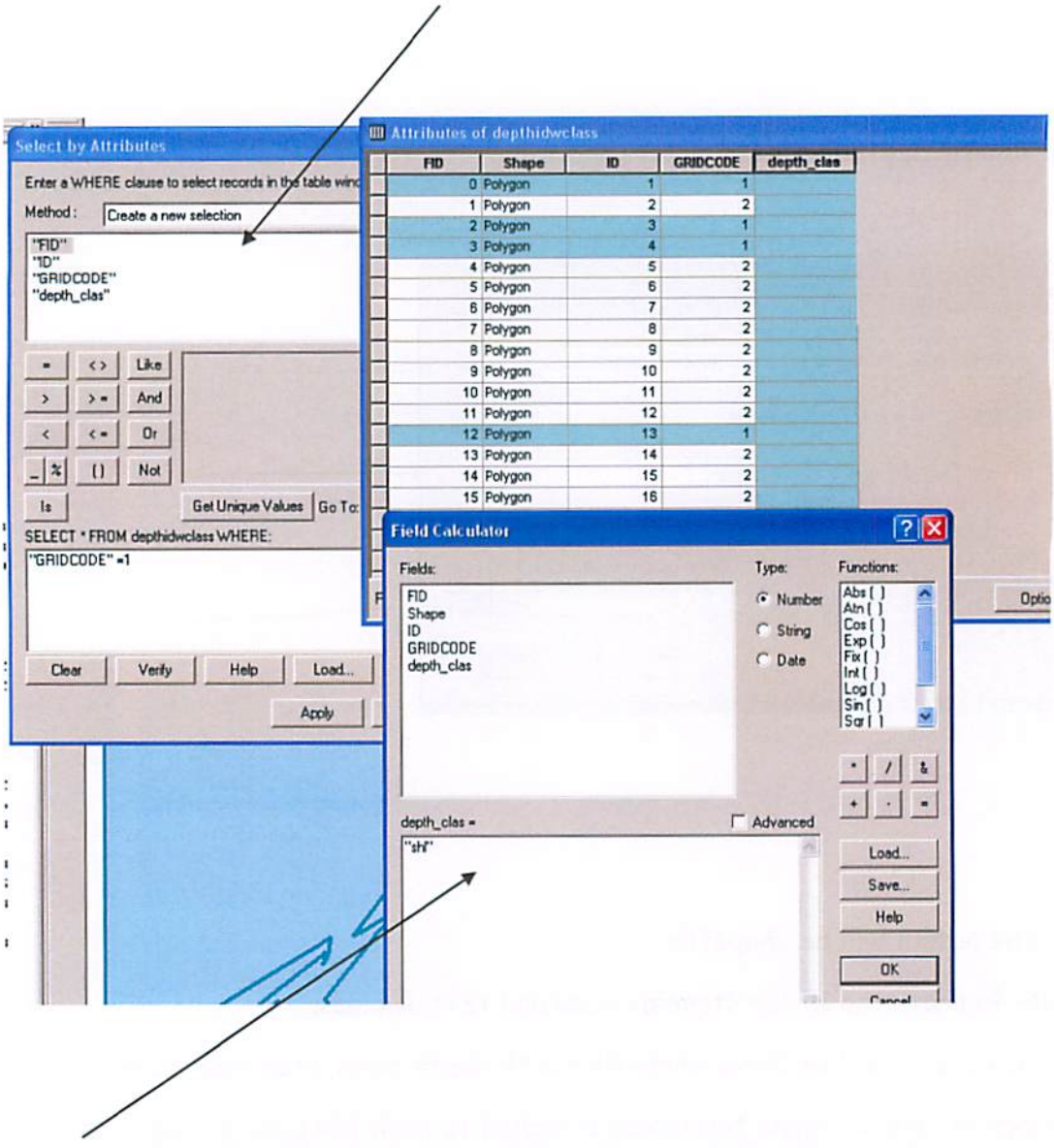
-The output will be shapefile.

16- Repeat step 15 for stoneidwclass and textidwclass.

The outputs will be three shapefiles with depth class, stoniness class and texture class examine the tables attached to each file (you will see the field "gridcode" represent the classes).

17- r.click- depthidwclass.shp. open attribute-options-add field : depth class (type:text , length=10) -ok.

18- options-select by attribute- follow the equation below:



19- after selected attribute – r.click- depth_class field –calculate values and type "shl") according to the WH criteria table.

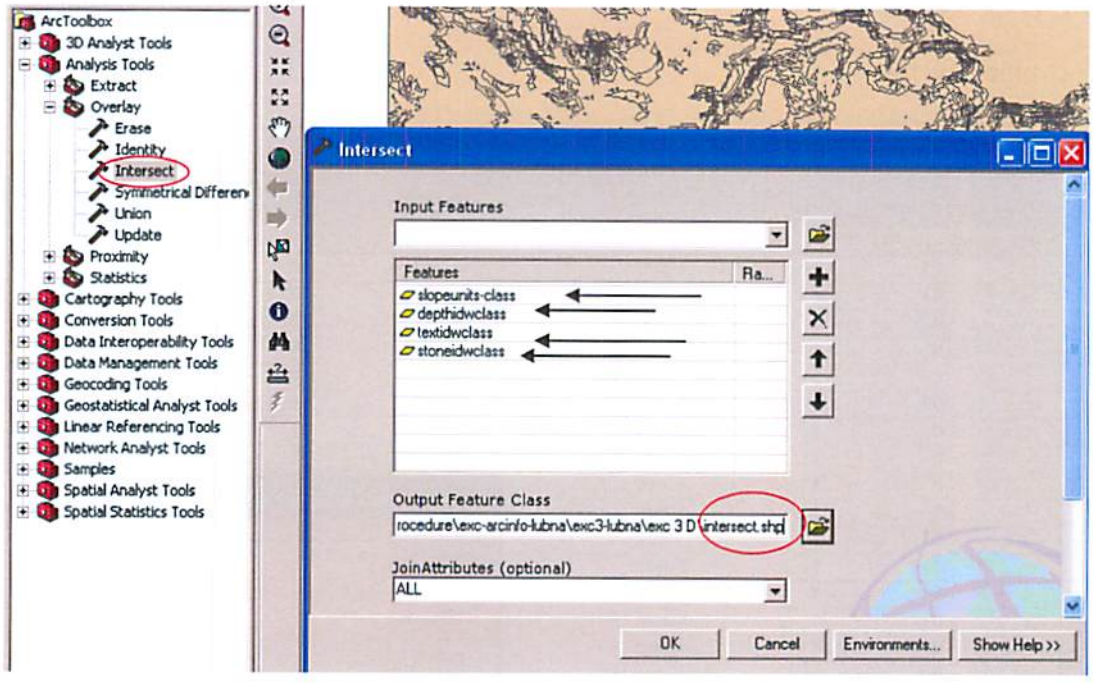
20- Repeat steps 18, 19 for other classes.(clear selection after each selection)

21- Repeat steps (17, 18, 19, 20) for stoneidwclass.shp and textidwclass.shp (use classes according to the WH criteria table).

22- Add slopeunits.shp and repeat steps (from 17 to 21) but use

(slopeclass field). Use classess from WH criteria table:low, med, steep.

23- Activate Arctoolbox , analysis tools, overlay, choose intersect as shown below. Input features: four shapefiles see below and the output is intersect.shp and click ok.



As a result a lot of polygons are produced from intersection command.

- Open attribute table of intersect.shp, you will see all classes of slope, depth, texture and stoniness.

Applying the WH techniques criteria from attached paper:

24- r. clicks intersect.shp; add fields as shown in figure below. (Example):

cr-r-p1, cr-r-p2, cr-f-p1, cr-f-p2, cr-t-p1, cr-t-p2: means

Cr: contour ridges

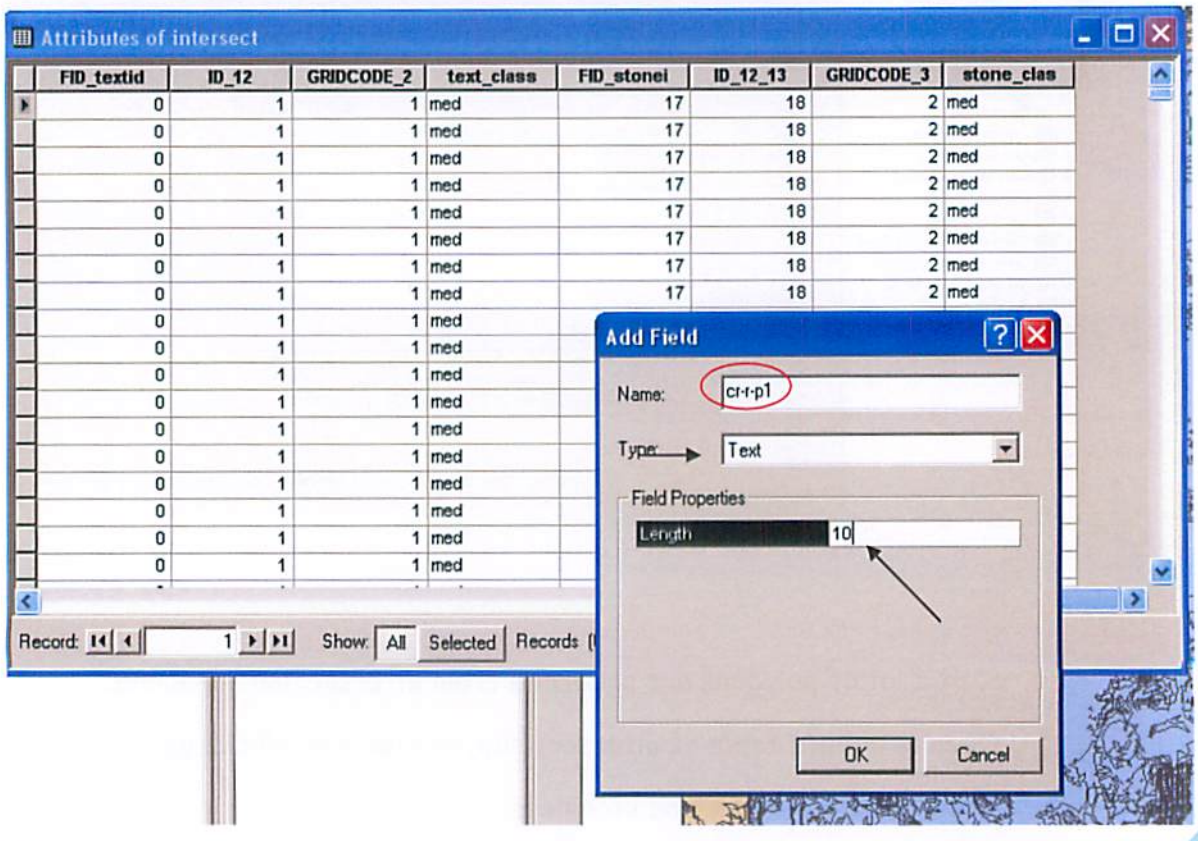
R: range

F: field crops

T: trees

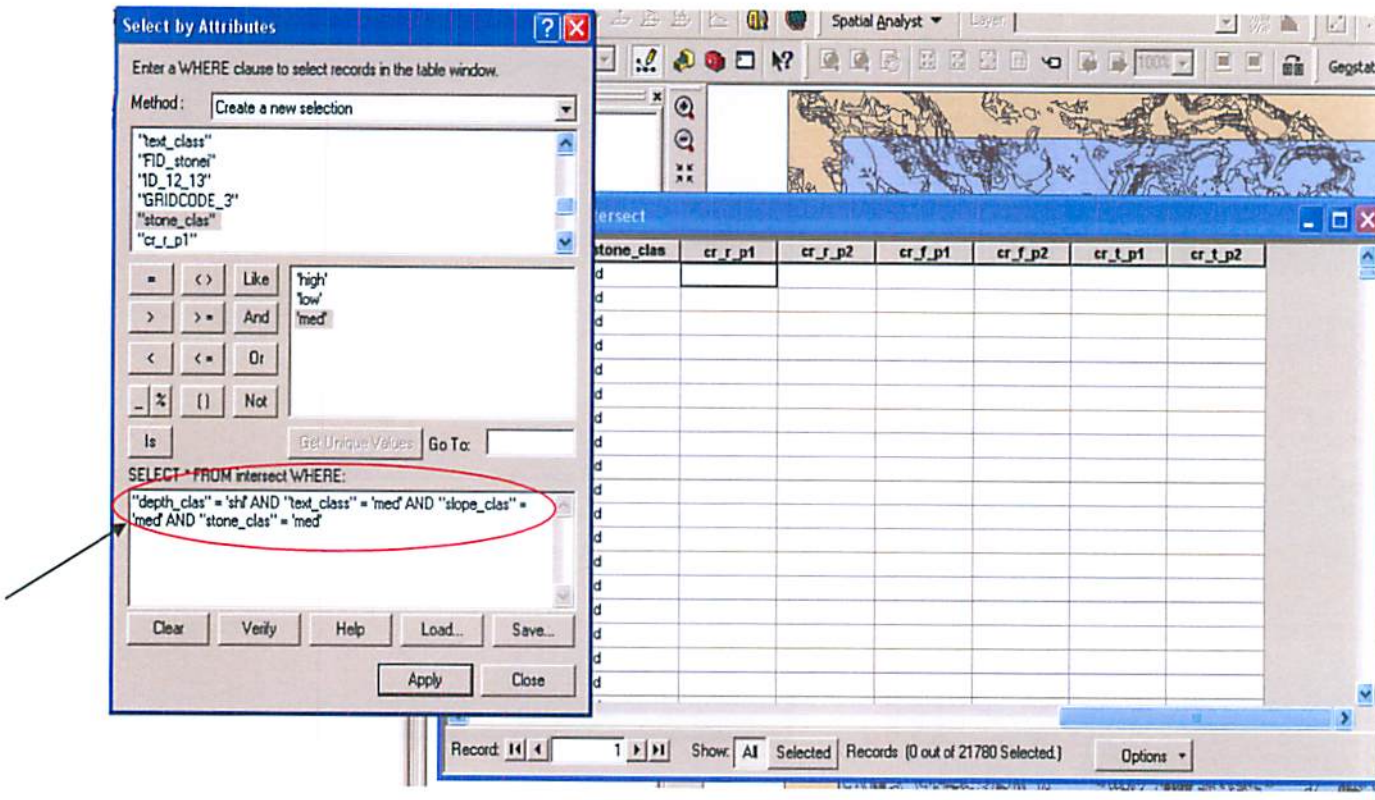
P1: priority one

P2: priority two

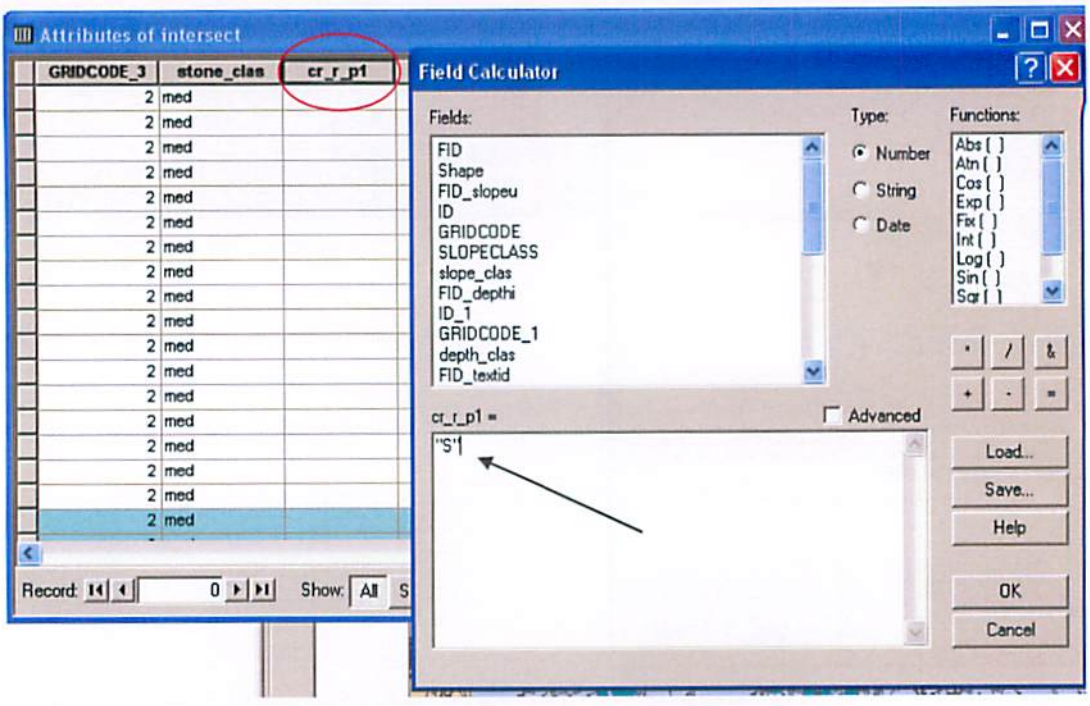


25- r. click intersect.shp, open attribute table, options - select by

attribute and follow the equation below and click apply. You will see many polygons selected that satisfy the condition written below (equation).



26- r. click field cr-r-p1, and choose calculate and type "S" which means suitable for this WH technique as following figure.

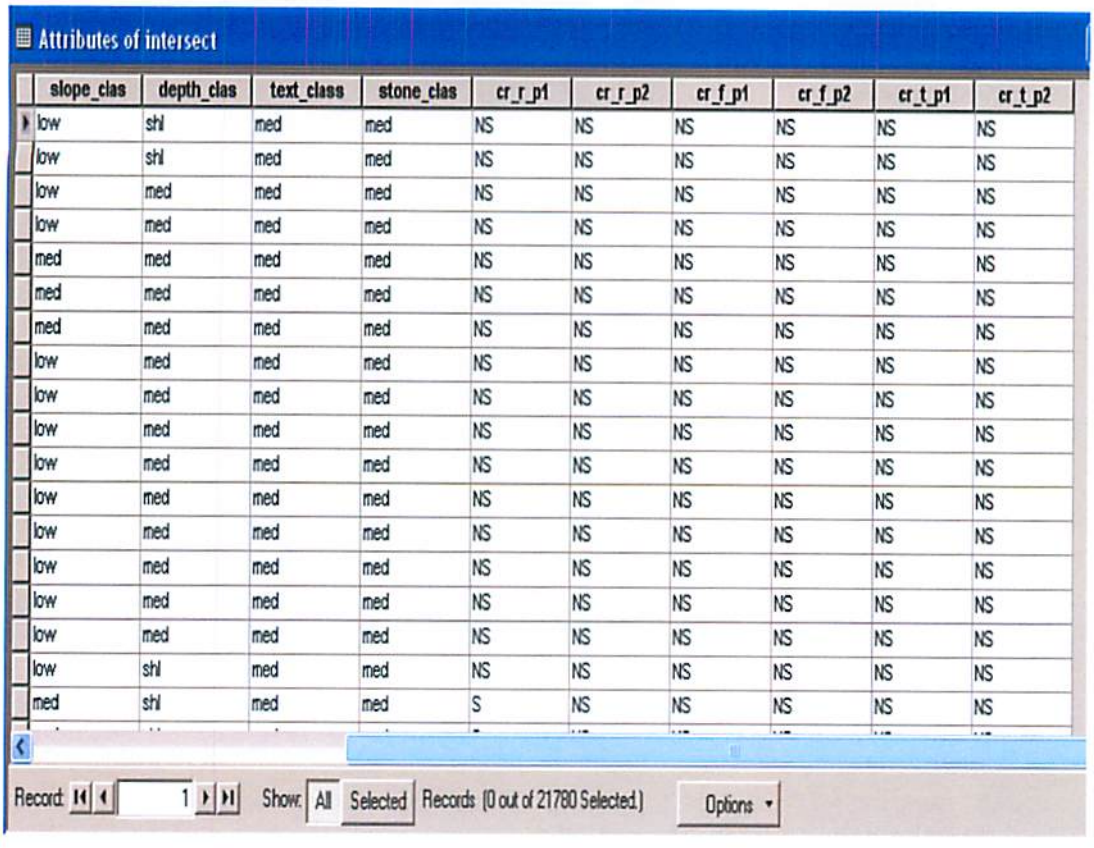


-switch selection, field calculator and type "NS" mean not suitable. And clear selection

27- Repeat step 25 and 26 for cr-r-p2, cr-f-p1, cr-f-p2, cr-t-p1, cr-t-p2

The output table of intersect.shp looks like figure below.

Continue for the rest of WH techniques.



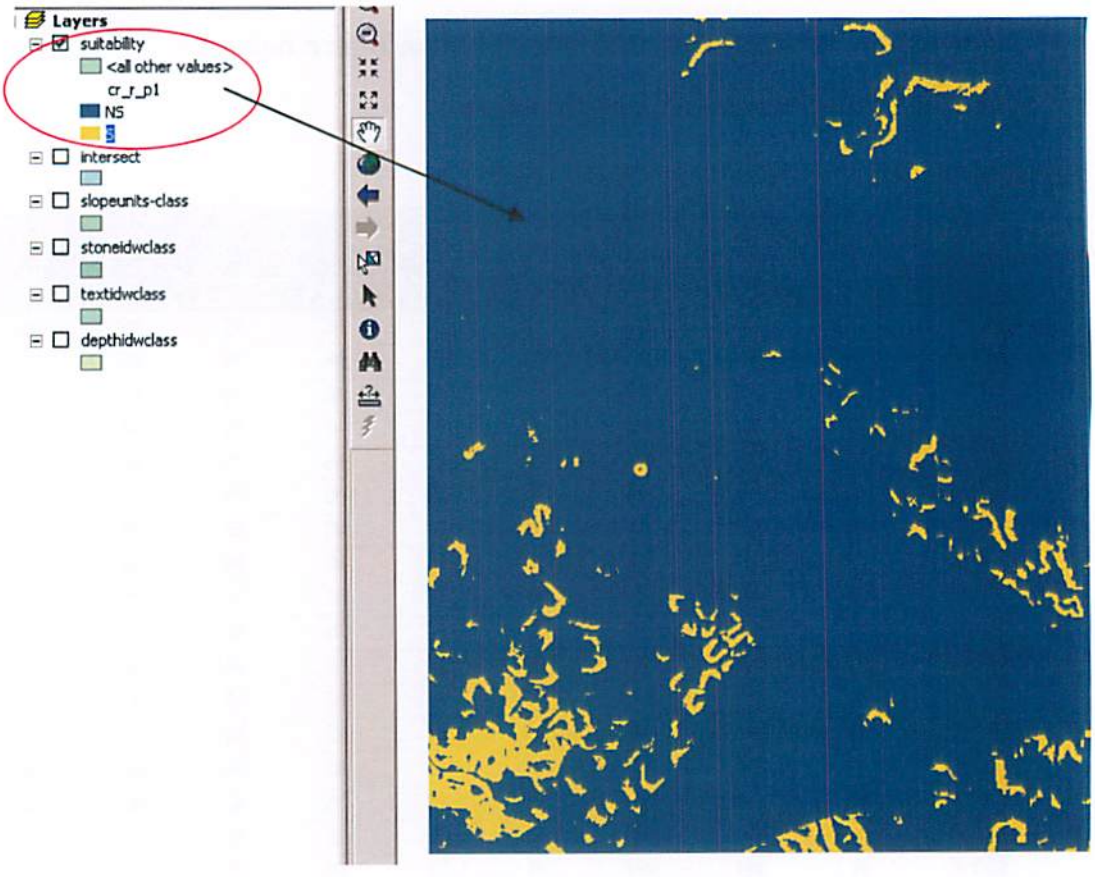
Attributes of intersect

slope_clas	depth_clas	text_class	stone_clas	cr_r_p1	cr_r_p2	cr_f_p1	cr_f_p2	cr_t_p1	cr_t_p2
low	shl	med	med	NS	NS	NS	NS	NS	NS
low	shl	med	med	NS	NS	NS	NS	NS	NS
low	med	med	med	NS	NS	NS	NS	NS	NS
low	med	med	med	NS	NS	NS	NS	NS	NS
med	med	med	med	NS	NS	NS	NS	NS	NS
med	med	med	med	NS	NS	NS	NS	NS	NS
med	med	med	med	NS	NS	NS	NS	NS	NS
low	med	med	med	NS	NS	NS	NS	NS	NS
low	med	med	med	NS	NS	NS	NS	NS	NS
low	med	med	med	NS	NS	NS	NS	NS	NS
low	med	med	med	NS	NS	NS	NS	NS	NS
low	med	med	med	NS	NS	NS	NS	NS	NS
low	med	med	med	NS	NS	NS	NS	NS	NS
low	med	med	med	NS	NS	NS	NS	NS	NS
low	med	med	med	NS	NS	NS	NS	NS	NS
low	med	med	med	NS	NS	NS	NS	NS	NS
low	shl	med	med	NS	NS	NS	NS	NS	NS
med	shl	med	med	S	NS	NS	NS	NS	NS

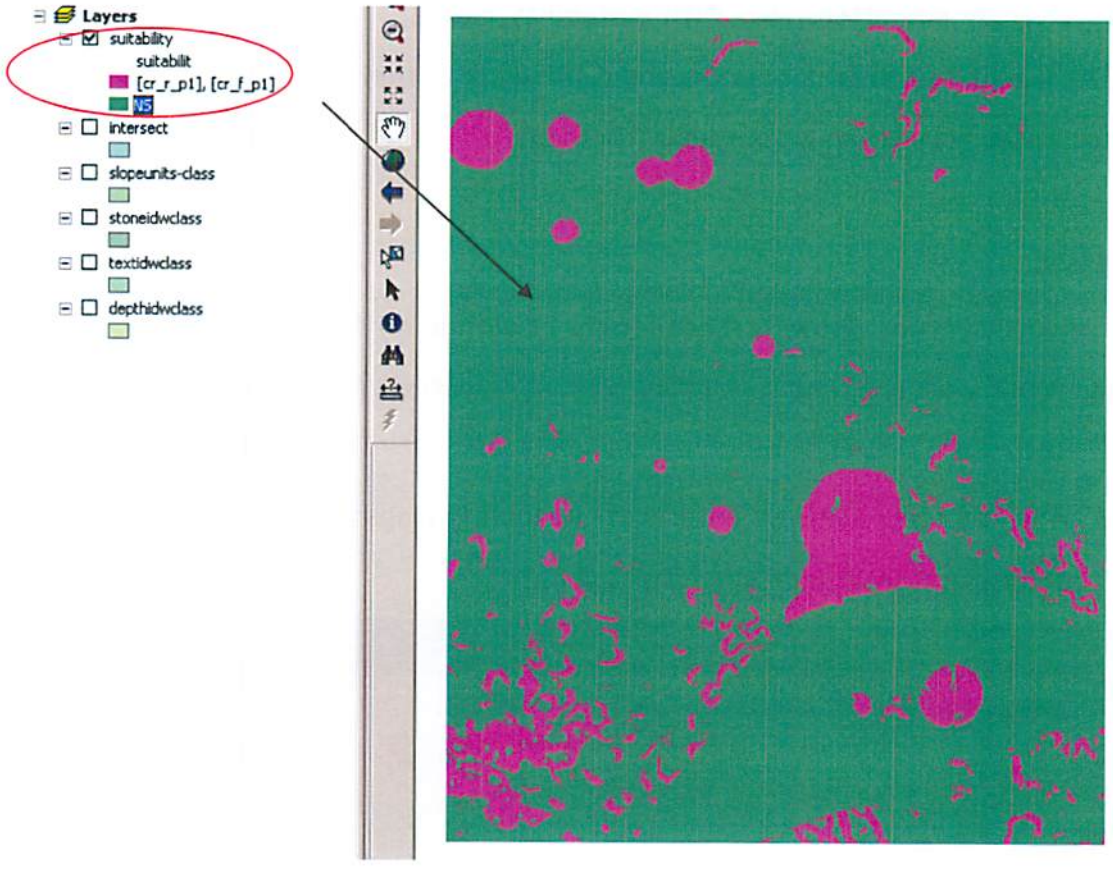
Record: 1 Show: All Selected Records (0 out of 21780 Selected.) Options

28- r. clicks intersect.shp and exports it to suitability.shp

29- Display the suitability map for cr-r-p1 using symbology. The output is shown below



- try the other suitability options
- for combination suitability see figure below:


Layers
suitability
suitabilit
[cr_r_p1], [cr_f_p1]
NS
intersect
slopeunits-class
stoneidwclass
textidwclass
depthidwclass

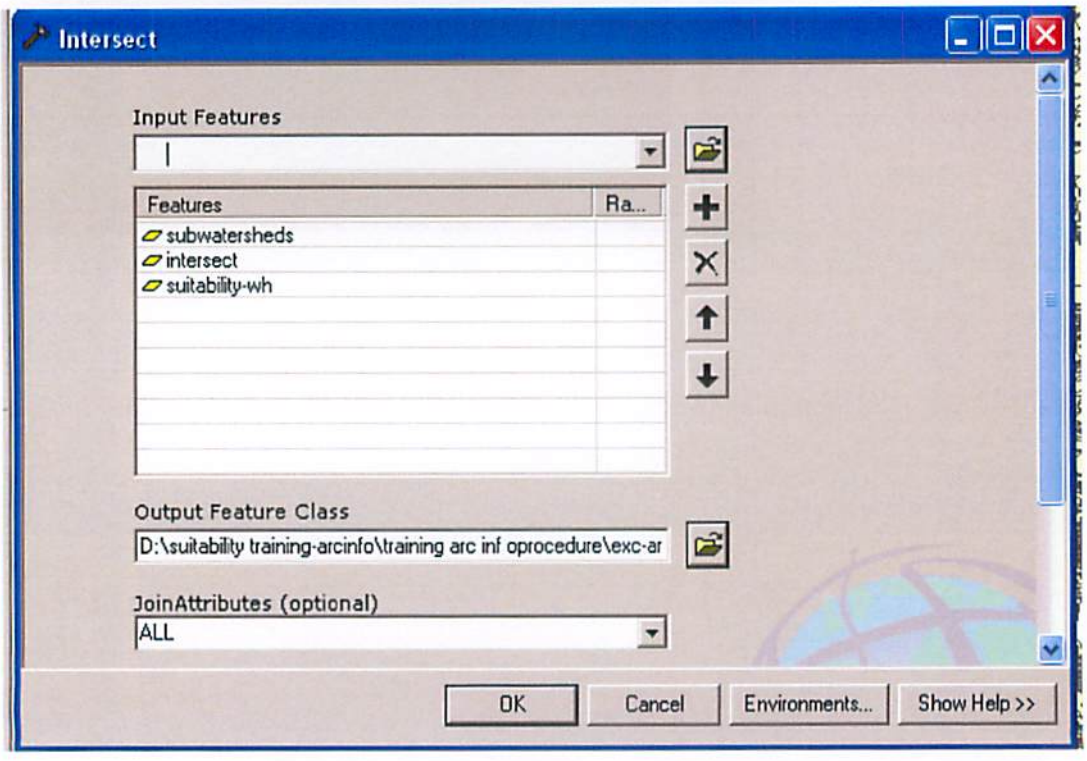
F. Overlay subwatersheds with suitability maps

The aim of this step is to understand the distribution of suitable areas for water harvesting within subwatersheds.

Steps:

1. Add shapefiles: subwatersheds (data 1), suitability from slope units(C) (suitability-wh.shp) and suitability from observations (D) (intersect.shp).

2. Analysis tools-overlay- Intersect- suitability maps with subwatershed and name it intersect-shed_suit1.shp.



Thin click ok.

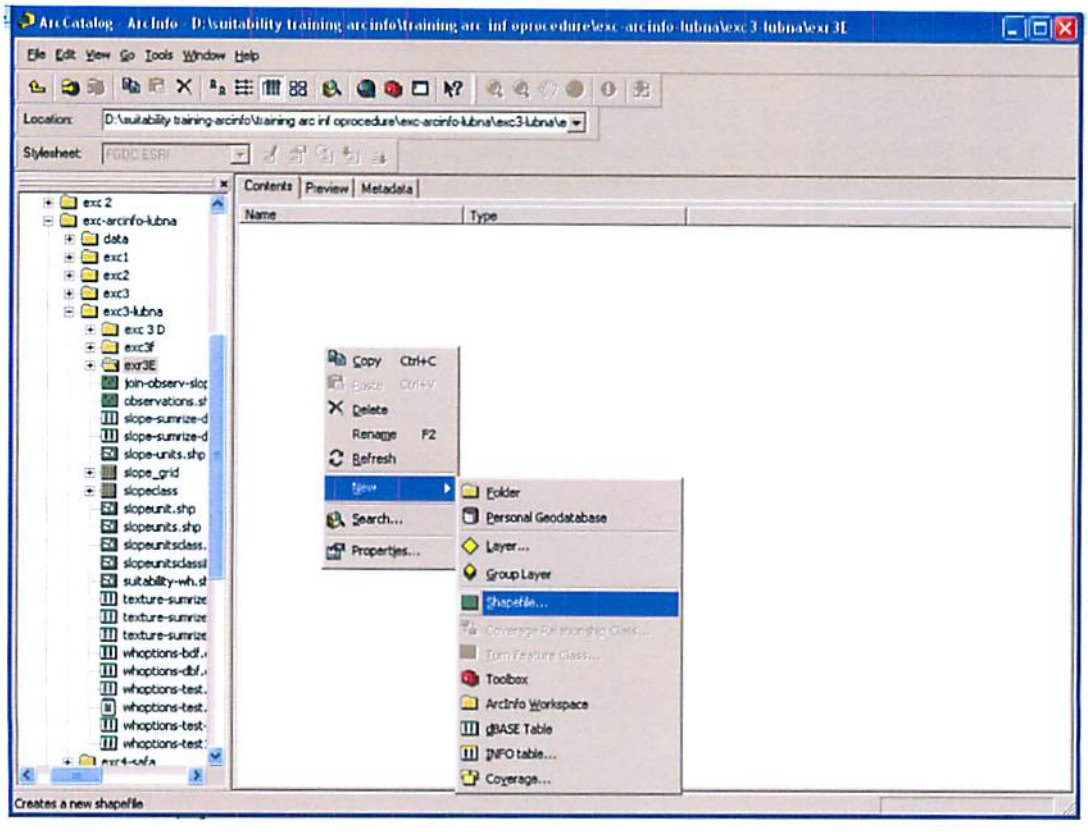
3. Summarize the suitability for each watershed, using both method.

E. Watershed delineation

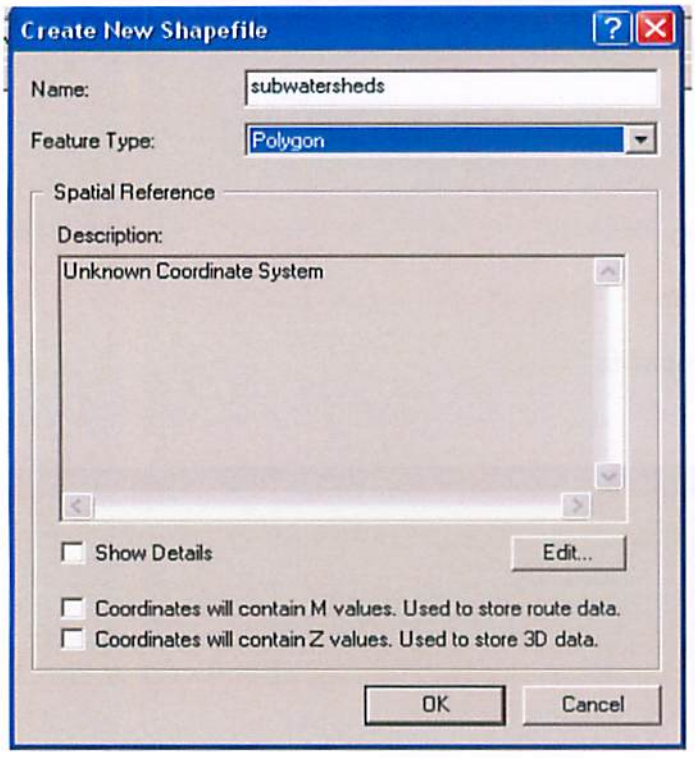
This exercise explains the procedure to derive watershed boundaries using contour lines and stream network.

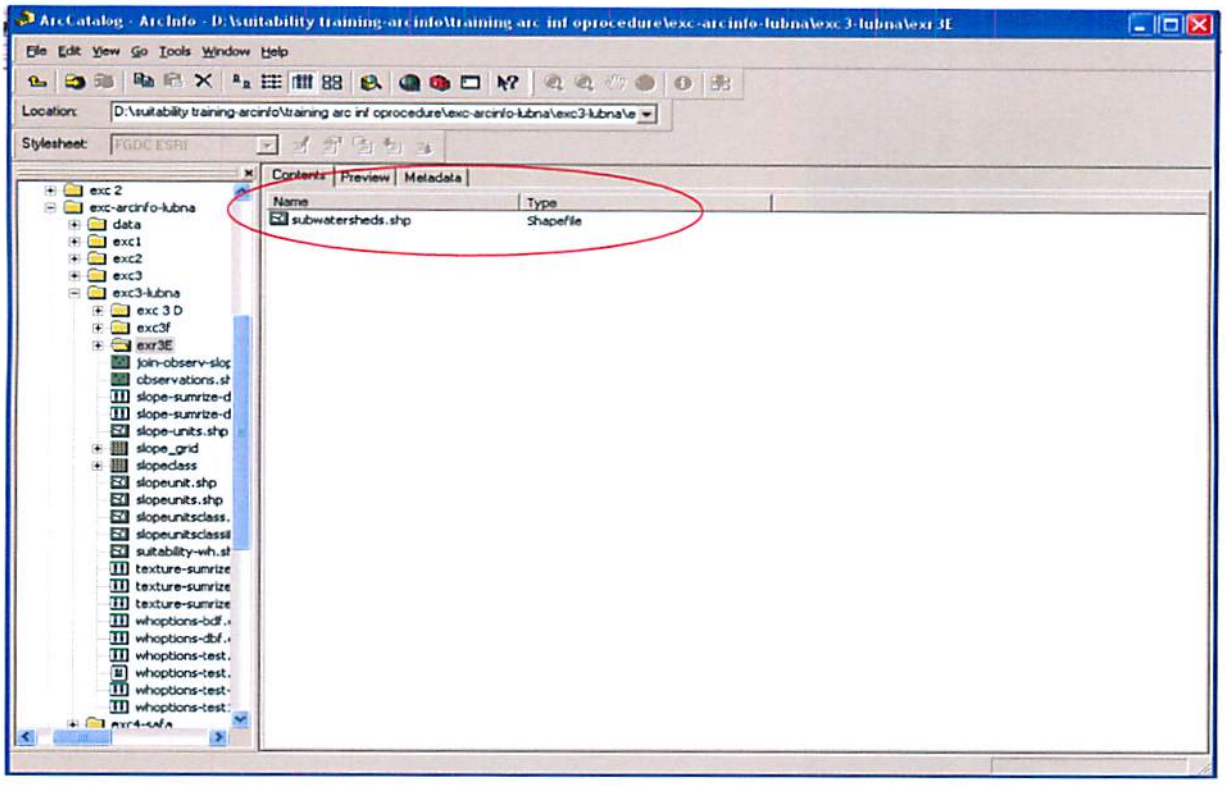
Steps

1. Add the theme streams.shp
2. Add the theme contours.shp
3. Arc catalog-select new shapefile



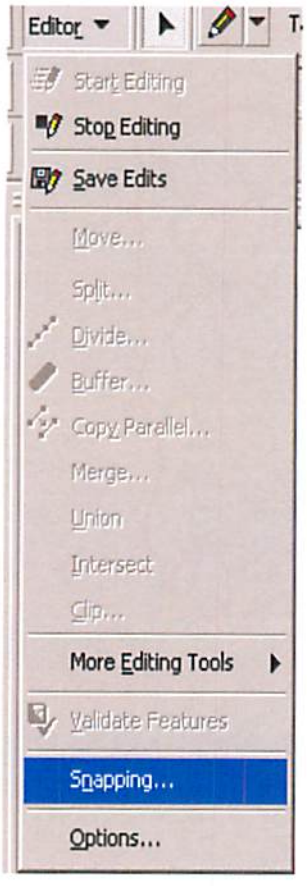
4. Choose feature type: polygon and name the file: subwatersheds.shp:




ArcCatalog - ArcInfo - D:\suitability training-arcinfo\training arc inf oprocedure\exc-arcinfo-lubna\exc3-lubna\exr3E
File Edit View Go Tools Window Help
Location: D:\suitability training-arcinfo\training arc inf oprocedure\exc-arcinfo-lubna\exc3-lubna\e
Stylesheet: FGDC ESRI
Contents Preview Metadata
Name
Type
subwatersheds.shp
Shapefile
exc 2
exc-arcinfo-lubna
data
exc1
exc2
exc3
exc3-lubna
exc 3 D
exc3f
exr3E
slope-units.shp
slope_grid
slopeclass
slopeunit.shp
slopeunits.shp
texture-sumrize
texture-sumrize
texture-sumrize

5. Select Editor -start editing

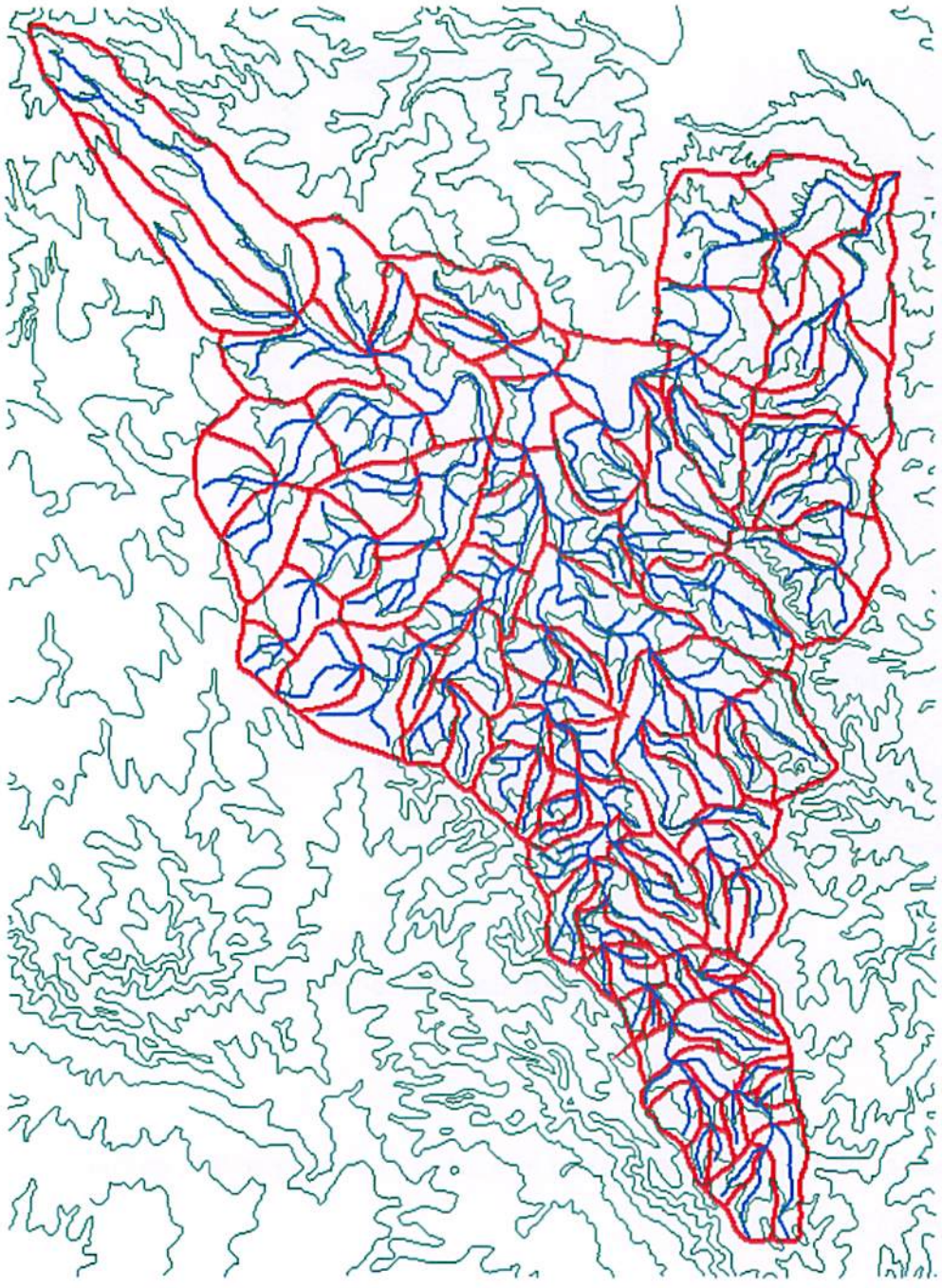
6. Select Editor- snapping-Use the snapping tolerance to insure the proper closing of polygons:



7. Start the delineation of watershed: use the contour line shape to draw the watershed devides.

-The outlet of the whole watershed is located at the upper left corner of the stream lines.

8. Start draws the subwatersheds using the streams lines:



9. Save the new shapefile when you finished the delineation

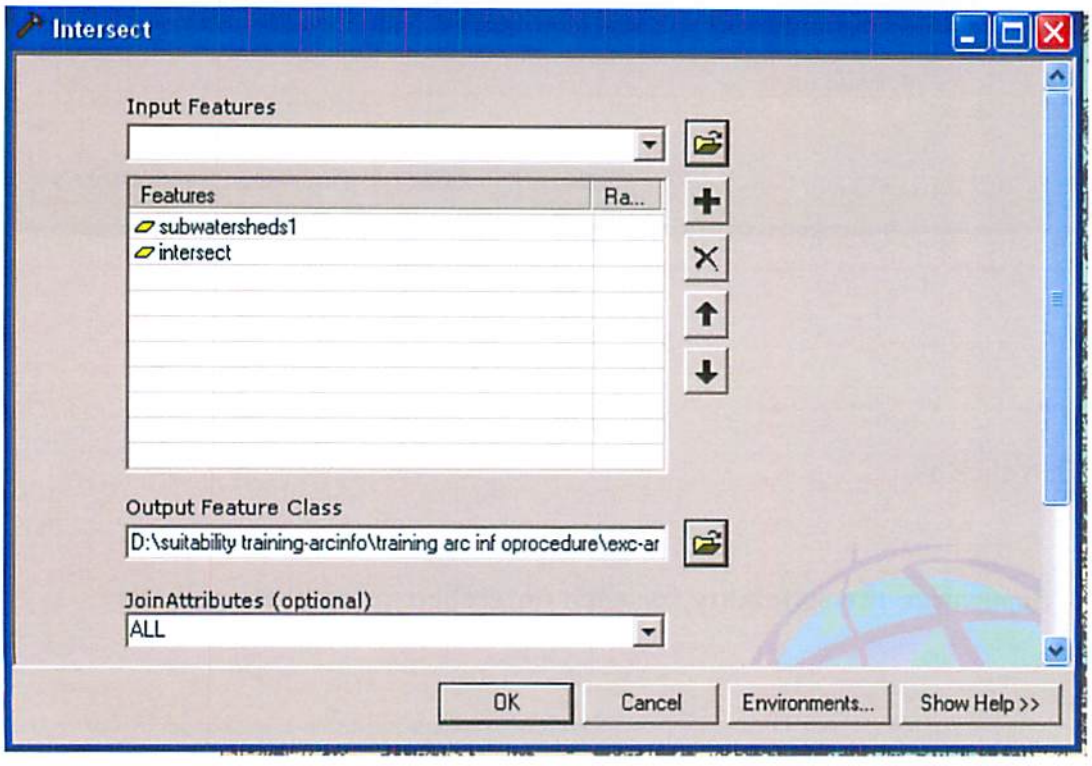
F. Overlay subwatersheds with suitability maps

The aim of this step is to understand the distribution of suitable areas for water harvesting within subwatersheds.

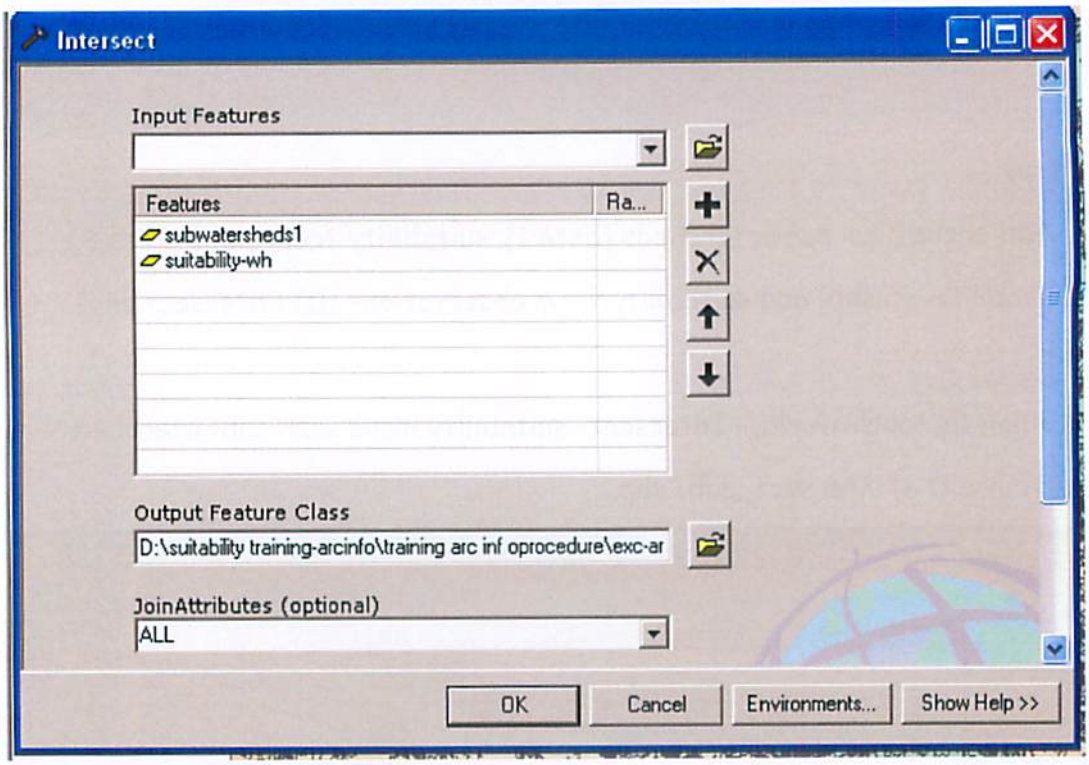
Steps:

1. Add shapefiles: subwatersheds (data 1), suitability from slope units(C) (suitability-wh.shp) and suitability from observations (D) (intersect.shp).

2. Analysis tools-overlay- Intersect- suitability maps with subwatershed and name it a) intersect_sub1.shp.



b) Suitability_sub1.shp



Thin click ok.

3. Summarize the suitability for each watershed, using both methods

Exercise 4:

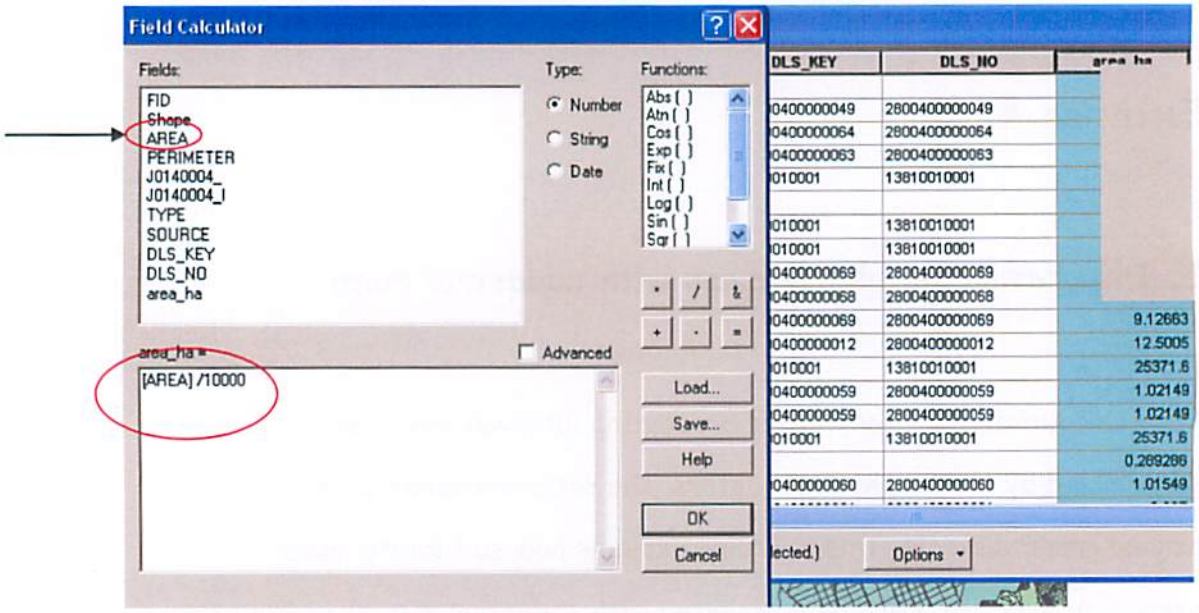
1. Integrating suitability maps with cadastral maps

The final suitability of any water harvesting intervention is not only determined by the biophysical factors, the socio-economic aspects also play an important role. This exercise explains how suitability maps derived in excerise 3 will be integrated with cadastral map to account for ownership aspects.

A. Use the ownership area as selection criteria

Steps

1. Add theme includes the suitability.shp map derived previously from exc 3
2. Add theme cadastral.shp
3. r. click cadastral.shp – open attribute table-options-add field name as area ha (area in hectar).
4. R.click field area ha, field calculator using equation as shown below. The output field is area in hectar calculated from area in m2



5- R. click cadastral.shp – open attribute table-options-add field name as area class

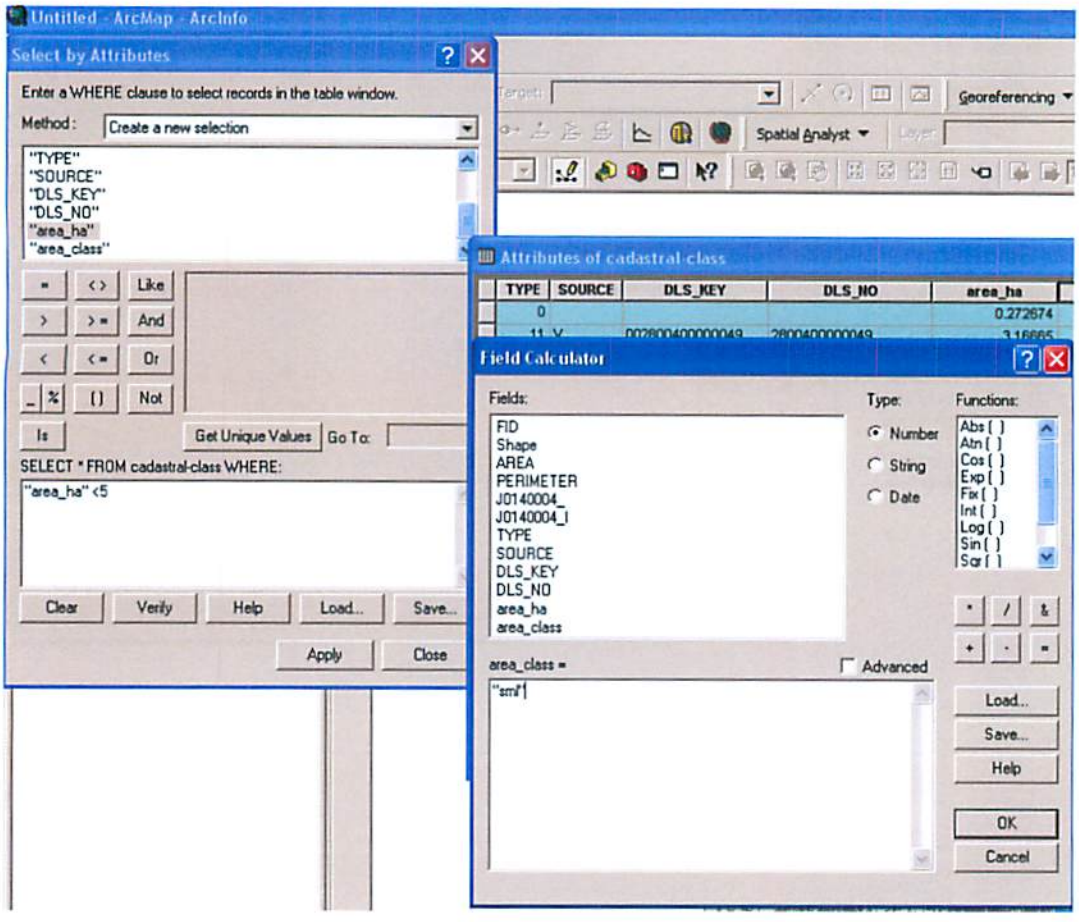
Classify the area according to WH criteria table:

Class 1= sml <5 ha, class 2= med 5-25 ha, class3= large >25 ha

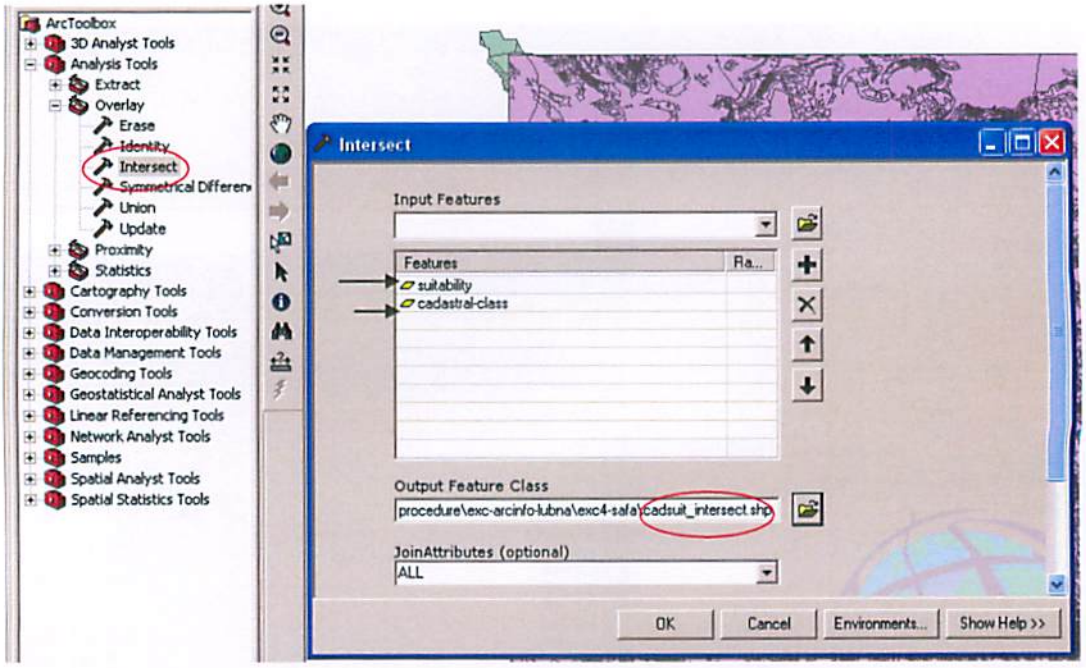
6-Options-select by attribute, write equation as below and click apply.

This will select all parcels that have area less than 5 hectars

7- Repeat step 5 for the rest of area classes



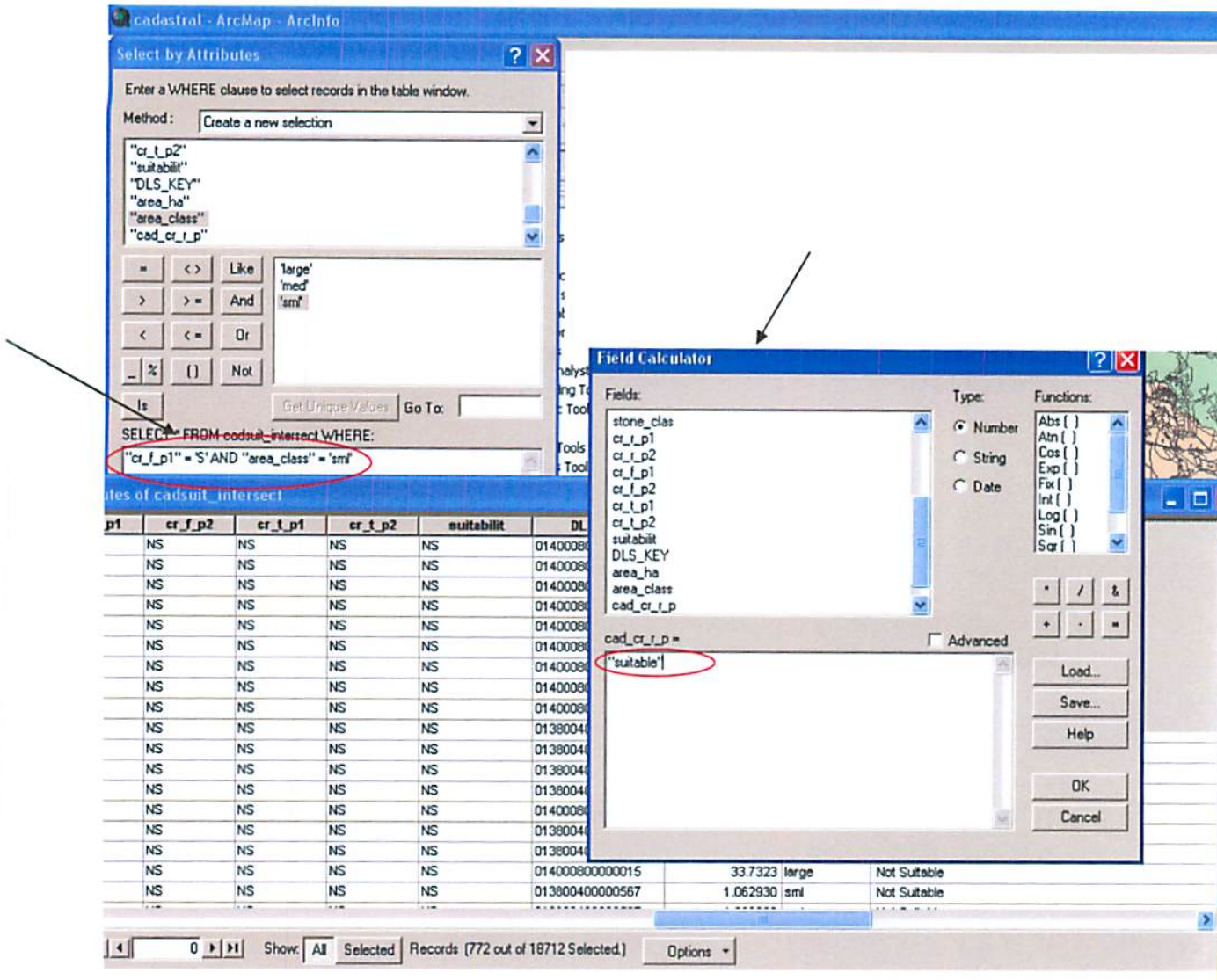
8. Intersect the suitability maps with the classified cadastral maps following the figure: the output is cadsuit_intersect.shp


ArcToolbox
3D Analyst Tools
Analysis Tools
Extract
Overlay
Erase
Identity
Intersect
Symmetrical Differen
Union
Update
Proximity
Statistics
Cartography Tools
Conversion Tools
Data Interoperability Tools
Data Management Tools
Geocoding Tools
Geostatistical Analyst Tools
Linear Referencing Tools
Network Analyst Tools
Samples
Spatial Analyst Tools
Spatial Statistics Tools
Intersect
Input Features
Features
Ra...
suitability
cadastral-class
Output Feature Class
procedure\exc-arcinfo-lubna\exc4-sala\cadsuit_intersect.shp
JoinAttributes (optional)
ALL
OK
Cancel
Environments...
Show Help >>

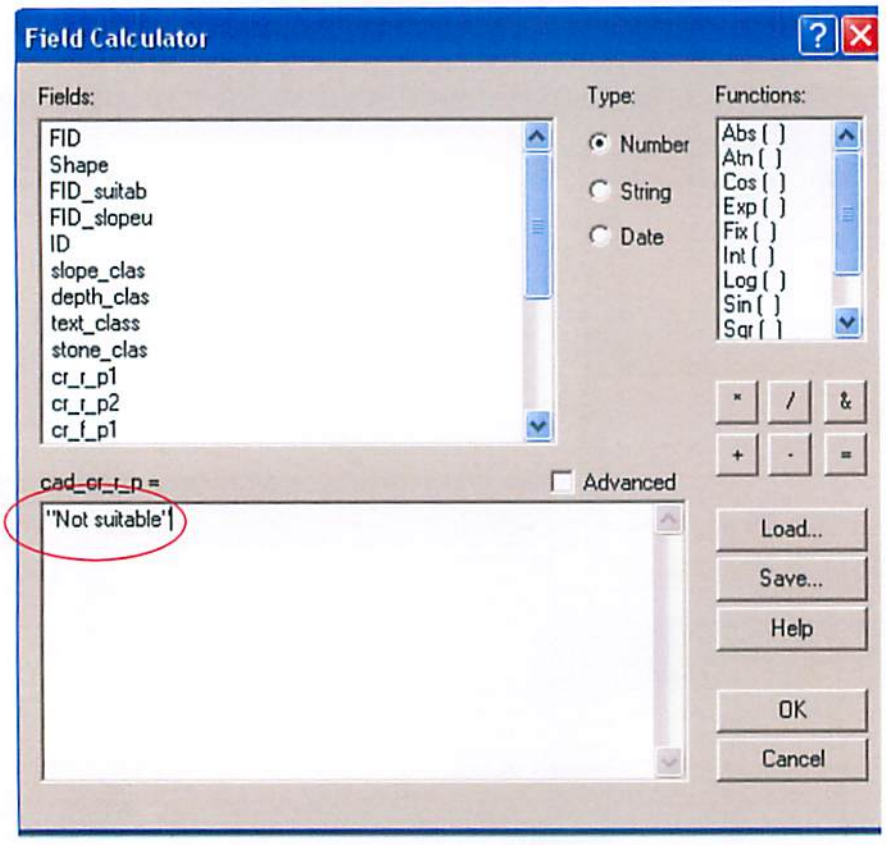
9. Update the suitability classes based on the cadastral map results

-r. clicks cadsuit_intersect.shp and add field Cad_cr-f-p1

- Options- select by attribute- follow the figure below and click ok



10- Options -switch selection-field calculator and type "not suitable" as following



11. Compare the suitability map before and after considering the area of the parcel.

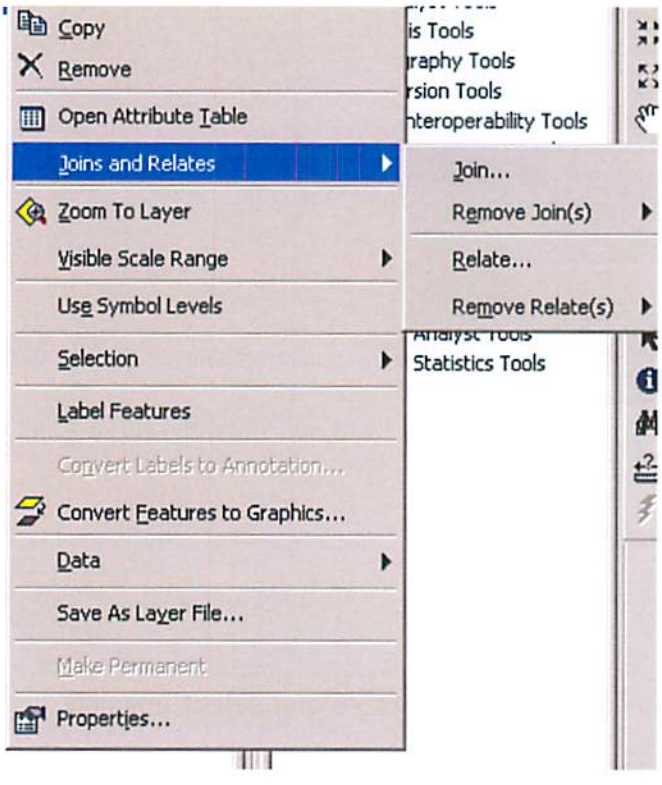
B. Use the cadastral maps to identify the land owners

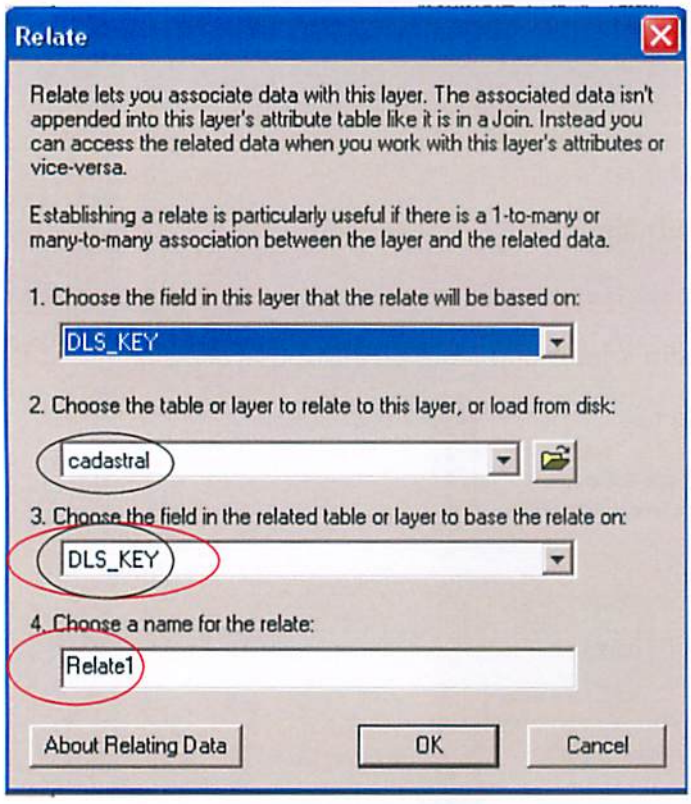
Steps

1. Add theme cadsuit_intersect.shp

2. Add theme cadastral.shp

3. r. click cadsuit_intersect.shp - joins and relate-relate as following

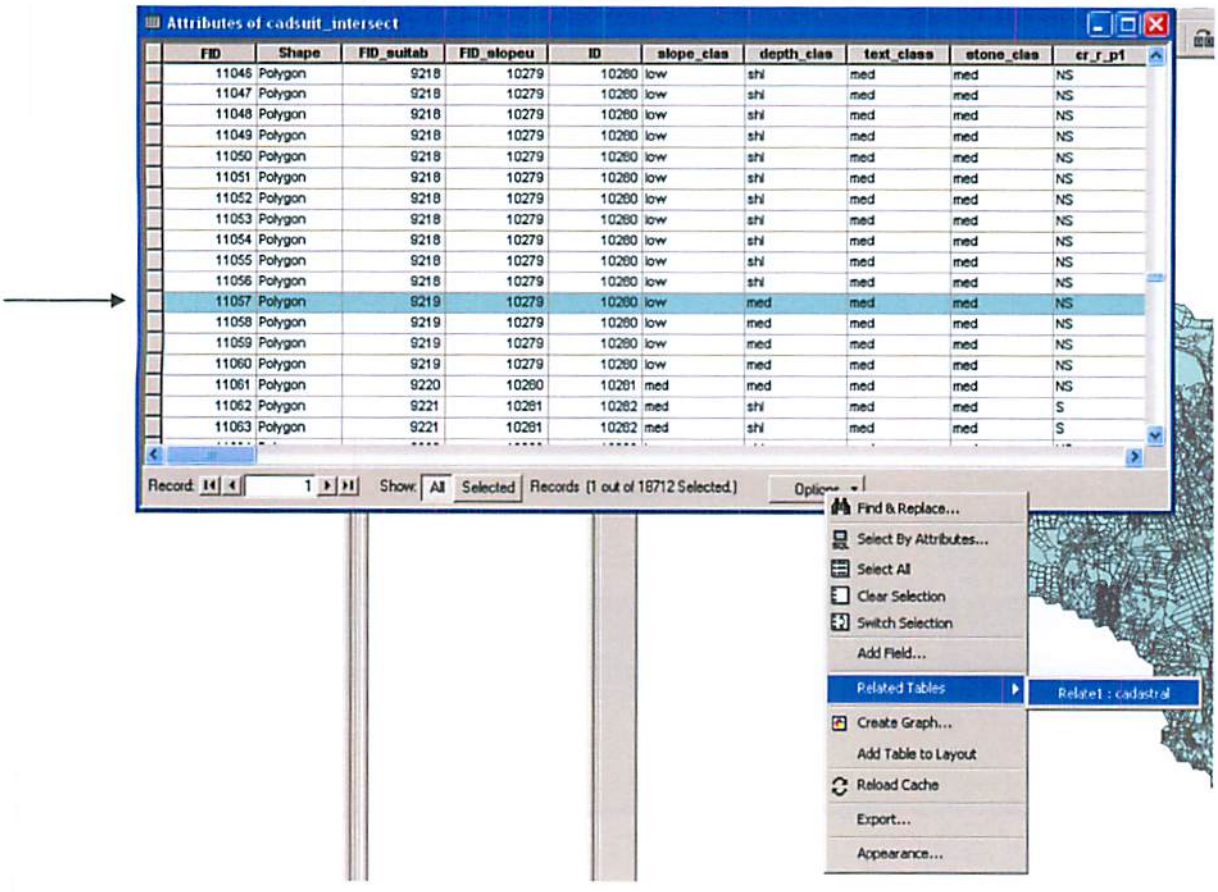




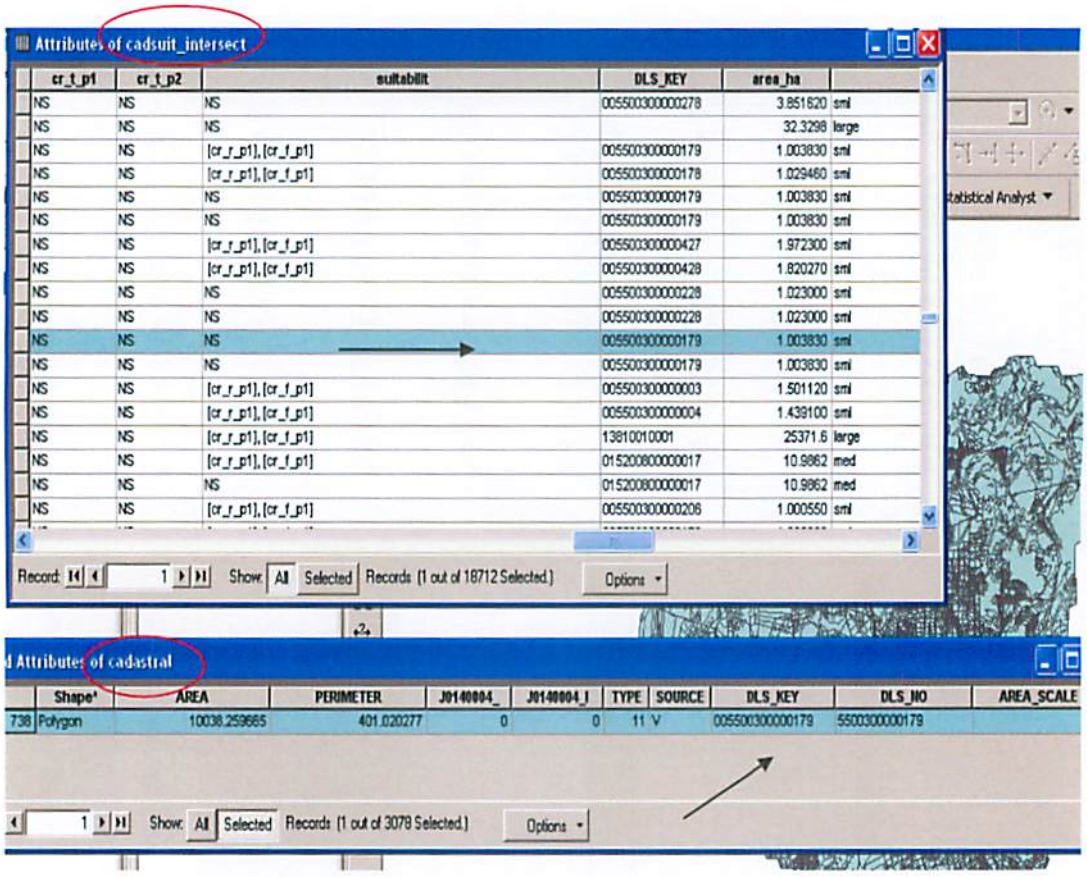
Click ok

4- r. click cadsuit_intersect.shp- open attribute table and select any row which includes DLS key to link between the two tables.

- Then -options-relate table-relate 1.



Now cadastral.shp table will open- and the row with the same DLS key will be highlighted in cadastal.shp table as shown



5. Identify some areas meeting the following criteria

    Within one of the best subwatersheds (exercise 3, F)

    Represent all water harvesting interventions

6. Select one of these areas

7. Select the theme cadastral.shp

8. From the theme menu, select "select by theme"

    This will select all parcels that intersect with the selected water harvesting areas

9. Record the name of the owners; you might export the owners in special table