A Pilot Project for GIS Application in Soil Management Planning

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1. Abstract

The objective of the project is to create a soil data base, to carry out soil management plans at regional and national level and to analyse fertilizer use and prospective fertilizer consumption. The project region is located south-east of Ankara and comprisis an area of approximately 260 000 ha. The innitial 1:25 000 semi-detailed soil maps were reduced to 1: 100 000 scale. Mapping units are great soil groups and their phases. Each unit specifies the great soil group; soil depth; slope gradient; erosion degree; drainage, salinity-alkalinity class; stoniness; rockiness; land use capability class and subclass and land use. In addition to these data , each unit was examined separately for the purpose of establishing the general NPK and pH status.

To begin with the 1:100 000 scale map was digitized so that polygons were formed. A total of 427 polygons were identified and tagged. Then, attribute tables were created as Microsoft Excel files. Queries were based on the above-mentioned soil characteristics. At the end of each query layers were formed for each characteristic and a map of each layer was created.

Calibrated fertilizer values for certain crops gathered by means of experiments and the amount of nutrients (NPK) available in the soil were combined to find out about nutrient deficiency in each unit and the whole area for specific crops. Thus, we are able to estimate the amount of fertilizer to be given to the soil for specific crops within the framework of our management plans.

2. Study Area

The study region is situated southeast of Ankara and covers an area of 260 000 hectares around the Golba i and Haymana townships and lakes Mogan and Eymir.

Figure 1. Location Map.

3. Method

GenaMAP (GIS software), on a Silicon Graphics Workstation and 1:100 000 scale soil map and fertilizer calibration data were used in the study. The base map was prepared by reducing the 1:25 000 scale soil and fertility maps to 1:100 000 scale. Queries were based on graphical data (mapping units) and non-graphical data (great soil group, slope, erosion degree, drainage, salinity–alkalinity, stoniness, rockiness, land use capability class – subclass, land use, NPK and pH status specified for each polygon.

The method is illustrated schematically in Figure 2. The aforementioned attribute data are displayed in tables 1-14. The tables follow the National Database Legend and apply to Turkey.

Table 1. Great Soil Groups

P	Red – Yellow Podzolic Soils
G	Gray – Brown Podzolic Soils
M	Brown Forest Soils
N	Noncalcic Brown Forest Soils
C	Chestnut Soils
D	Reddish Chestnut Soils
T	Red Mediterranean Solis
E	Reddish – Brown Mediterranean Soils
B	Brown Soils
U	Noncalcic Brown Soils
F	Reddish – Brown Soils
R	Rendzina Soils
V	Vertisols
Z	Sierozems
L	Regosols
Y	Alpine Meadow Soils
A	Alluvial Soils
H	Hydromorfic Alluvial Soils
S	Alluvial Coastal Swamps
K	Kolluvial Soils
C	Solonchak –Solonetz Soils
O	Organic Soils

Table 2. Combination of Great Soil Groups (H, S) And Soil Properties

Great Soil Group		**Drainage – Salt – Alkali Combination**							
H	Hydromorfic Alluvial Soils	Textur e	Drainage	Salt - Alkali					
				Free	Sligthly salty	Salty	Alkali	Slightly Salty-Alkali	Salty-Alkali
		Mixed	Very Poorly Drained in natural condition	H	Hh	Hs	Ha	Hk	Hv
			Improved, but still imperfectly drained	Hy	Hhy	Hsy	Hay	Hky	Hyy
			Improved, but still very poorly drained	Hf	Hhf	Hsf	Haf	Hkf	Hyf
S	Alluvial Coastal Swamps		Very poorly drained	S	Sh	Ss	Sa	Sk	Sy

Table 3. Combination of Great Soil Groups(P-Y) And Soil Properties

Great Soil Group		Slope – Depth Combination					
P G M N C D T E B U F R V Z L Y	Red- Yellow Podzolic Soils Gray-Brown Podzolic Soils Brown Forest Soils Noncalcic Brown Forest Soils Chestnut Soils Reddish Chestnut Soils Red Mediterranean Soils Reddish-Brown Mediterranean soils Brown Soils Noncalcic Brown Soils Reddish-Brown Soils Rendzina Soils Vertisols Sierozems Regosols Alpine Meadow Soils	Slope (%)	Depth (cm)				
			Deep 90+	Moderately Deep (90-50)	Shallow (50-20)	Very Shallow (20-0)	Lithosolic
		A-Flat-Almost Flat (0-2)	1	2	3	4	25
		B-Gently Sloping (2-6)	5	6	7	8	26
		C- Sloping (6-12)	9	10	11	12	27
		D- Moderately steep (12-20)	13	14	15	16	28
		E- Steep (20-30)	17	18	19	20	29
		F-Very Steep (30+)	21	22	23	24	30

Table 4. Combination of Great Soil Group (A) and Soil Properties

Great Soil Group		Drainage –Texture Combination				
A	Alluvial Soils	Drainage	Texture			
			Fine	Medium	Coarse	Very Coarse
		Well Drained	1	2	3	
		Imperfectly Drained	4	5	6	
		Poorly Drained	7	8	9	
		Excessively Drained				10

Table 5. Combination of Great Soil Group (K) and Soil Properties

Great Soil Group		Slope – Texture – Depth Combination						
K	Kolluvial Soils	Slope (%)	Texture	Depth (cm)				
				Deep	Moderately Deep	Shallow	Very Shallow	Litosolic
		Flat- Almost Flat (0-2)	Fine	1	2	3		32
			Medium	4	5	6		
			Coarse	7	8	9		
		Gently Sloping (2-6)	Fine	10	11	12		33
			Medium	13	14	15		
			Coarse	16	17	18		
		Sloping (6-12)	Fine	19	20	21		34
			Medium	22	23	24		
			Coarse	25	26	27		
		Moderately steep (12-20)	Assorted	28	29	30	31	35

Table 6. Combination of Great Soil Group (C) And Soil Properties

Great Soil Group		Salt- Alkali & Texture Combination			
C	Solonchak-Solonetz Soils	Salt- Alkali	Texture		
			Fine	Medium	Coarse
		Salty	1	2	3
		Alkali	4	5	6
		Salty-Alkali	7	8	9

Table 7. Combination of Great Soil Group (O) and Soil Properties

Great Soil Group		Texture & Units		
O	Organic Soils	Muck	Peat	Mixed
		m	p	r

Table 8. Other Soil Properties

h	Slightly salty
s	Salty
a	Alkali
k	Slightly salty –Alkali
v	Salty alkali
t	Stony
r	Rocky
y	Imperfect Drainage
f	Poor Drainage

Table 9. Erosion Degree

1	Nil- Slight
2	Moderate
3	Severe
4	Very Severe

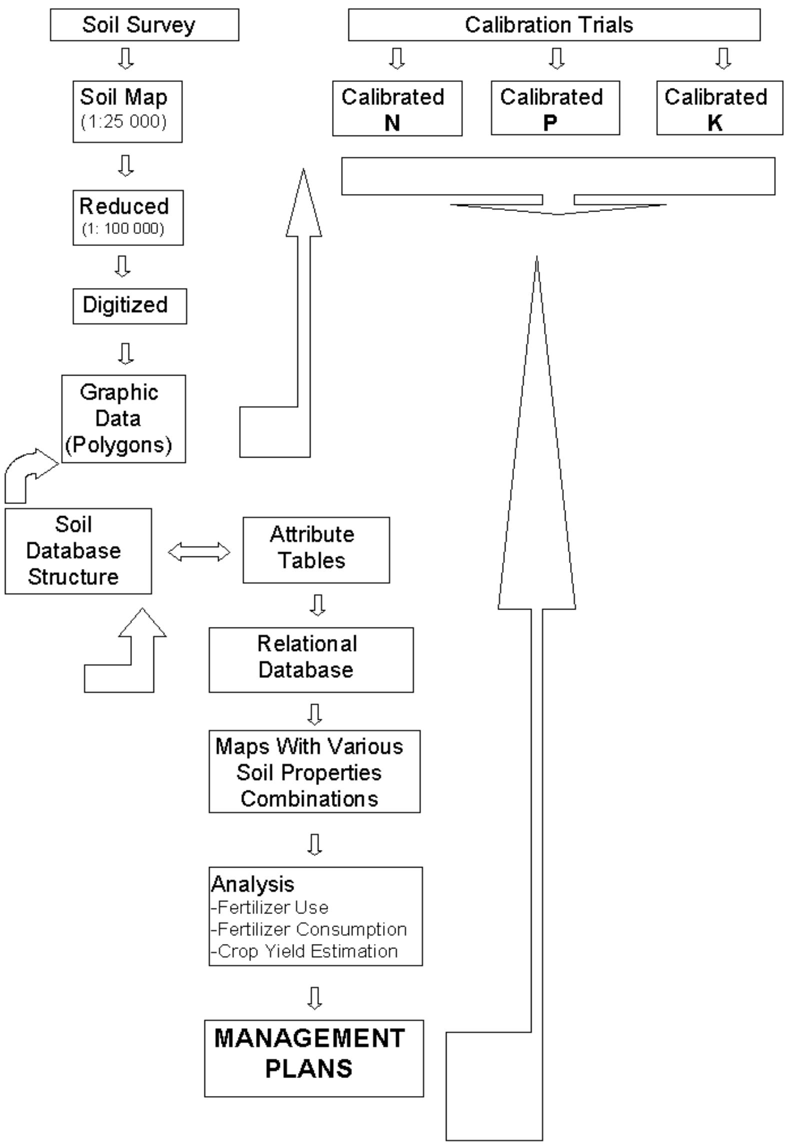


Figure 2. Flowchart of the methodology followed.

Table 10. Present Land Use

K	Rainfed Agriculture (fallow)
N	Rainfed Agriculture (non Fallow)
S	Irrigated Agriculture
B	Vineyard- Tree Crop Cultivation
Z	Special Crops (Zç:tea,Zt:Citrus,Za:pistachio,Zi:fig,Zk:Chestnut,Zf:Hazelnut,Zp:Peanut

Table 11. Miscellaneous Land Types

CK	Bare Rocks, Outcrops &Debris
IY	Overflow Mantle
SK	Coastal Dunes
KK	Sand Dunes
SB	Marsh & Swamps
DK	Lands Covered by Permament Snow Canopy

Table 12. Key for Soil Fertility Assessment

Fertility Symbol	Nitrogen (N)	Phosphorus (P)	Potassium (K)
1	Low	Low	Low
2	Low	Low	Medium
3	Low	Low	High
4	Low	Medium	Low
5	Low	Medium	Medium
6	Low	Medium	High
7	Low	High	Low
8	Low	High	Medium
9	Low	High	High
10	Medium	Low	Low
11	Medium	Low	Medium
12	Medium	Low	High
13	Medium	Medium	Low
14	Medium	Medium	Medium
15	Medium	Medium	High
16	Medium	High	Low
17	Medium	High	Medium
18	Medium	High	High
19	High	Low	Low
20	High	Low	Medium
21	High	Low	High
22	High	Medium	Low
23	High	Medium	Medium
24	High	Medium	High
25	High	High	Low
26	High	High	Medium
27	High	High	High

Table 13. Key for Assessment of Available Nutrients

Quantity	N	P_2O_5	K_2O
Low	0-2	0-6	0-20
Medium	2-3	6-9	20-30
High	3+	9+	30+

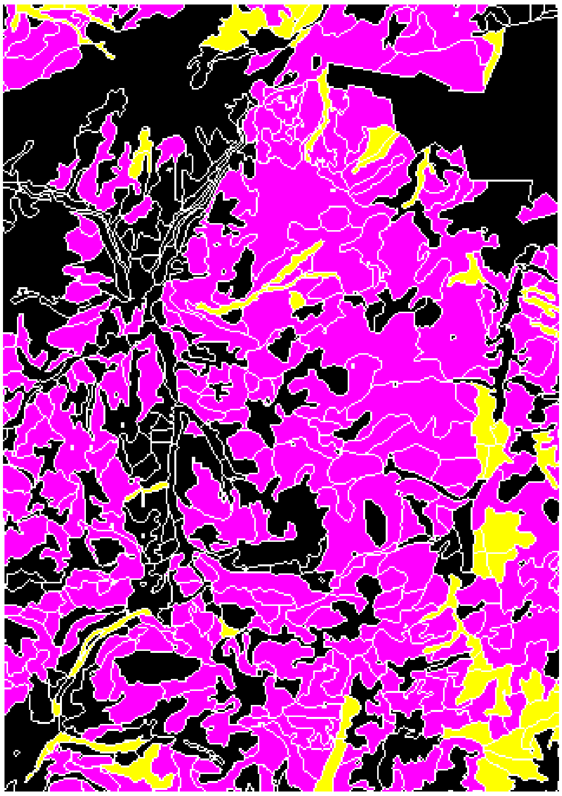
Table 14. Soil reaction (pH)

1	pH= 6.50
2	pH = 6.51 – 7.50
3	pH= 7.51

4. Data Processing (Queries in the Soil Data Base)

Within the context of the study, several maps of the area were prepared. The range of maps created included:

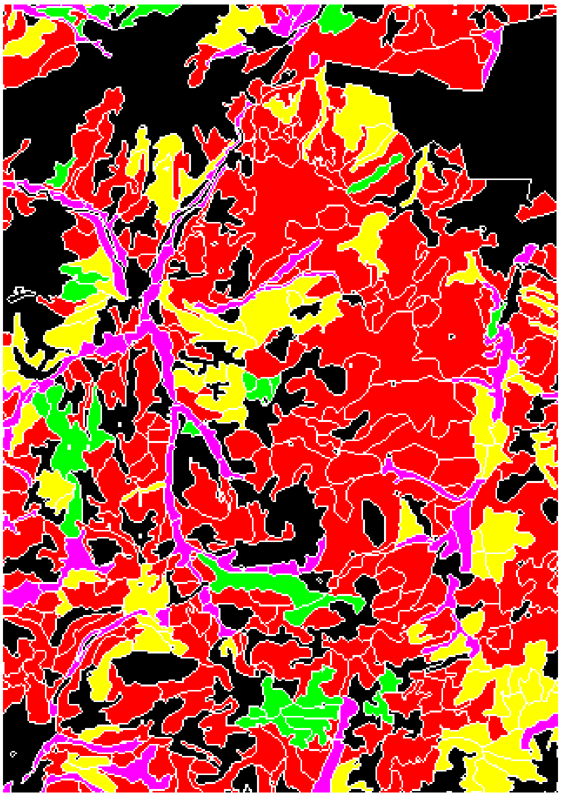
- A map showing the general N, P and K status
- Maps showing Great Soil Groups with different soil properties combinations (Figure 3)
- An erosion map (Figure 4)
- Maps with different N,P,K combinations (Figure 5)



Brown soils (219 475 ha)

Moderately deep areas in Brown Soils (27 397 ha)

Figure 3. Depth and slope combination by Great Soil Group



1 Nil-Slight (2 871 ha)

Moderate (5 149 ha)

Severe (204 050 ha)

Very Severe (17 164 ha)

Figure 4. Erosion map.

5. Soil Data Base Analysis

5.1 Analysis of Fertilizer Consumption

The aim of this analysis is to determine the amount of fertilizer we need, in case we wish to put land in the study area under a certain crop. The amounts of nitrogen (N), phosphorus (P_2O_5) and potassium (K_2O) fertilizers required for crops mostly grown in Central Anatolia were defined by means of soil test calibration trials. Tables 15, 16 and 17 present the non–graphical data used for the analysis.

For example, let us select polygons with fertility symbol" 6 " (N: Low, P:Medium, K: High) from the NPK combination map and compute areas (da). Suppose that half of the area will be allocated for wheat cultivation under irrigated conditions, the other half for non- irrigated wheat. The required amount of fertilizers can be computed as follows.

Table 15. Nitrogen Fertilizer (N Kg /da) Recommended For Crops Grown in Central Anatolia

Crops	Practice	Low	Medium	High
Wheat	Irrigated	16	15	14
Wheat	Non irrigated	9	8	7
Barley	Irrigated	15	14	13
Barley	Non irrigated	8	7	6
Maize	Irrigated	17	16	14
Rice	Irrigated	19	18	16
Sun flower	Irrigated	13	11	9
Potato	Irrigated	16	15	14
Sugar beet	Irrigated	15	14	12
Vineyard	Irrigated	15	13	12
Vineyard	Non irrigated	10	8	7
Fruit	Irrigated	10	9	7
Vegetable	Irrigated	15	14	13
Watermelon	Irrigated	10	8	6
Watermelon	Non irrigated	7	6	5
Alfalfa	Irrigated	6	5	4
Bean	Irrigated	6	5	4
Chickpea	Non irrigated	5	4	3
Lentil	Non irrigated	5	4	3
Poppy	Irrigated	8	7	6
Poplar	Irrigated	14	13	12
Carrot	Irrigated	19	18	17
Cumin	Non irrigated	8	7	6

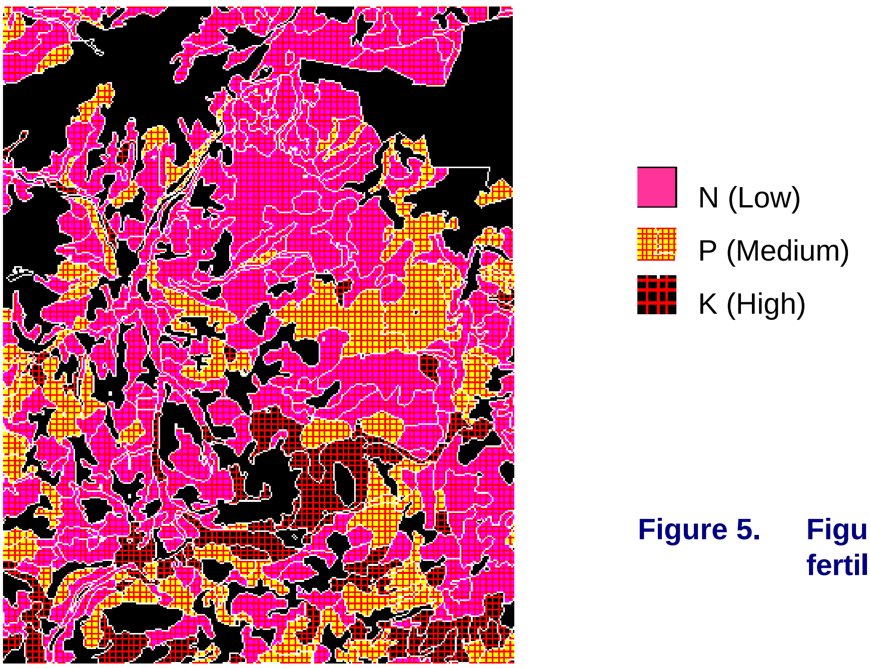


Figure 5. Figure 5 NPK status for fertility symbol "6".

Fertilizer kg/ da =Area (da) X [16 kg/da nitrogen fertilizer (table 15)]+[5 kg/da phosphorus fertilizer (table17)]+ [4 kg/da potassium fertilizer (table 16)] X 50 % +[9 kg/da nitrogen fertilizer (table 15)]+ [4 kg/da phosphorus fertilizer (table 17)]+[potassium fertilizer is not required]X 50 %

Table 16. Potassium Fertilizer (K2O kg/da) Recommended for Crops Grown in Central Anatolia

Crops	Practice	Low	Medium	High
Wheat	Irrigated	11	8	4
Wheat	Non irrigated	8	6	-
Maize	Irrigated	13	10	5
Rice	Irrigated	12	10	4
Sun flower	Irrigated	14	12	5
Potato	Irrigated	15	12	6
Sugar beet	Irrigated	15	13	6
Vineyard	Irrigated	15	12	5
Vineyard	Non irrigated	12	9	4
Fruit	Irrigated	10	8	4
Vegatable	Irrigated	12	10	6
Watermelon	Non irrigated	10	8	-
Alfalfa	Irrigated	12	9	5

Table 17. Phosphorus Fertilizer (P_2O_5 kg/da) Recommended for Crops Grown in Central Anatolia

Crops	Practice	Low	Medium	High
Wheat	Irrigated	8	5	3
Wheat	Non irrigated	7	4	2
Barley	Irrigated	8	5	3
Barley	Non irrigated	6	3	-
Maize	Irrigated	6	3	-
Rice	Irrigated	9	5	3
Bean	Irrigated	8	5	-
Chickpea	Non irrigated	5	3	-
Lentil	Non irrigated	7	4	-
Sun flower	Irrigated	8	5	3
Potato	Irrigated	10	6	4
Potato	Non irrigated	8	5	3
Sugar beet	Irrigated	8	5	3
Vineyard	Irrigated	7	4	-
Vineyard	Non irrigated	6	4	-
Fruit	Irrigated	8	5	3
Vegetable	Irrigated	9	5	-
Onion	Irrigated	8	5	3
Watermelon	Non irrigated	5	3	-
Alfalfa	Irrigated	14	8	4
Carrot	Irrigated	11	7	5
Poplar	Irrigated	11	7	4
Cumin	Non irrigated	8	5	3

5.2 Analysis of estimated Yields

The study area varies in topography. Slope-depth combinations as in Table 3 (for great soil groups P to Y) help us to predict the likelihood of variations in expected yield in areas where the slope gradient is greater than that of a flat area and the soil depth is shallow than that of a deep area, and vice versa.

In table 18, depending on the slope-depth combination; the possible variations in the yield of five commonly grown crops in Central Anatolia are indicated.

Table 18. Estimated Yield Variation by Slope-Depth Combination (kg/da)

Slope-Depth Combination	Wheat	Barley	Lentil	Sugar beet	Chickpea
1	350	375	100	7000	95
2	332.5	356.5	95	6650	90.3
3	280	300	80	5600	76
4	245	262.5	70	4900	66.5
5	300	300	86	6100	82
6	285	285	81.7	5795	77.9
7	240	240	68.8	4880	65.6
8	210	210	60.2	4270	57.4
9	250	250	72	5200	69
10	237.5	237.5	68.4	4940	65.5
11	200	200	57.6	4160	55.2
12	175	175	50.4	3640	48.3
13	200	200	58	4300	56
14	190	190	55.1	4085	53.2
15	160	160	46.4	3440	44.8
16	140	140	40.6	3010	39.2
17-24 Not suitable for cultivation					

As an example, polygons with slope – depth combination “6” (gently sloping, moderately deep) are selected and areas are computed. Supposing that the areas selected will be cultivated with barley, we estimate the (predicted) yield as follows.

Barley (yield kg/da)= area (da) X (285 kg barley /da)

6. Conclusion

For a successful management plan for rational utilization of land resources, Geographic Information Systems are of great importance to planners. The use of GIS in management plans results in a sound implementation in which, accuracy, reliability and easy manipulation of huge quantities of data can be attained which makes it aqualified tool to be used in this field.

7. Acknowledgement

We would like to acknowledge to Ms. Özgün Canan from Middle East Technical University (METU) for her valuable assistance in conducting and finalizing this study

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