Queries of Agricultural Areas Falling into Cadastral Parcels and Organizing and Analyzing Them with Python Programming Language

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Keywords: Geographic Information Systems, Hazelnut, Tea, Python, Cadastre

SUMMARY

Turkey is the largest hazelnut producer and exporter in the world with approximately 79% of worldwide production. Turkey also takes the fifth place in production of tea after China, Kenya, India and Sri Lanka. Most of Turkish hazelnut and tea production comes from the eastern Black Sea region of Turkey, which has a mild climate with high precipitation and fertile soil. In this study, hazelnut and tea plantation areas, which were determined previously with multispectral image classification of WorldView-2 image data, are queried and analyzed with ArcGIS 10.2 software to create a Geographic Information System (GIS). The tea and hazelnut cultivation areas are categorized according to the slope information of each cadastral parcel and quantitative results are obtained as the result of queries and spatial analysis are displayed as thematic maps. In addition, land use maps are created and intersected with up-to-date cadastral maps to determine the total area of each agricultural product in each cadastral block. It is observed that a specific agricultural product such as tea, may not cover the entire cadastral parcel, but it is scattered as small pieced polygons having different IDs over the cadastral parcel. An ArcGIS-ready Python script is written and executed to collect and retrieve the total area per agricultural product. Afterwards, the resultant maps are created and displayed.

1. INTRODUCTION

Trabzon is a major province in the Turkish Eastern Black Sea region. This region is the major production region for hazelnut (over 70%), and one of the major production regions for black tea, in the world (FAOSAT 2012). Using remote sensing classification methods, we have previously classified land use in an area around the city of Sürmene in Trabzon, with the classes 'orman', 'fındık', 'gölge', 'toprak', 'çay', 'kentsel yapı1', and 'kentsel yapı2' (forest, hazelnut, shadow, soil, tea, urban structure 1, and urban structure 2, respectively). We have digitized the cadastre maps of the Kuleli-Kumru district in the region, and matched parcels with the classification results. We have produced maps and analyzed them, for the land use for parcels, and the relation to the slope. For this purpose, we extended ArcGIS using Python programming language (CPython).

2. BACKGROUND

2.1. Geographic Information Systems Queries

Geographic Information Systems (GIS) are information systems that handle geospatial data. Geospatial data are collected, analyzed, managed, and queried using GIS. We can use GIS to answer the following questions and more.

- Which agricultural products are presently cultivated in the parts of the given region where the slope is less than 52%?
- What is the area of the region with tea in island 115, parcel 5?
- Which regions are better suited for hazelnut/tea production?
- Which present tea plantations should be moved to have more suitable conditions for tea production?

2.2. Python

Python is a widely used, efficient, highly extensible, high level, cross-platform programming language with a high level of readability, also supporting multiple paradigms including object-oriented programming. Partly because of Python modules such as numpy and scipy, Python programming language is quite popular in scientific circles.

2.3. Universal Transverse Mercator System

Universal Transverse Mercator System (UTM) is a popular, ellipsoidal, cylindrical projection system adopted by NATO countries for two dimensional presentation of Earth's surface. It relies on the (transverse) Mercator system that is conformal, but distorts distances and areas. To reduce the distortion, the Earth surface is divided in 60 zones, each a band of longitudes of 6°. Trabzon lies in Zone 37.

3. CASE STUDY

3.1. Data Acquisition and Preparation for the Case Study

The cadastral data was acquired from the public and private institutions in the region for the project. We digitized a 1/25000 scale cadastral map on paper, and obtained a GIS ready digital map for the region, containing geospatial data with attributes, as seen in Figure 1. We have corrected the topological errors. The expected level of accuracy is 5m. The coordinate system is UTM (Universal Transverse Mercator System), zone 37. Also, we purchased a WorldView-2 image for the region. We classified this remote sensing image after converting the coordinate system. The result can be seen in Figure 2. Further information is given in section 3.2.

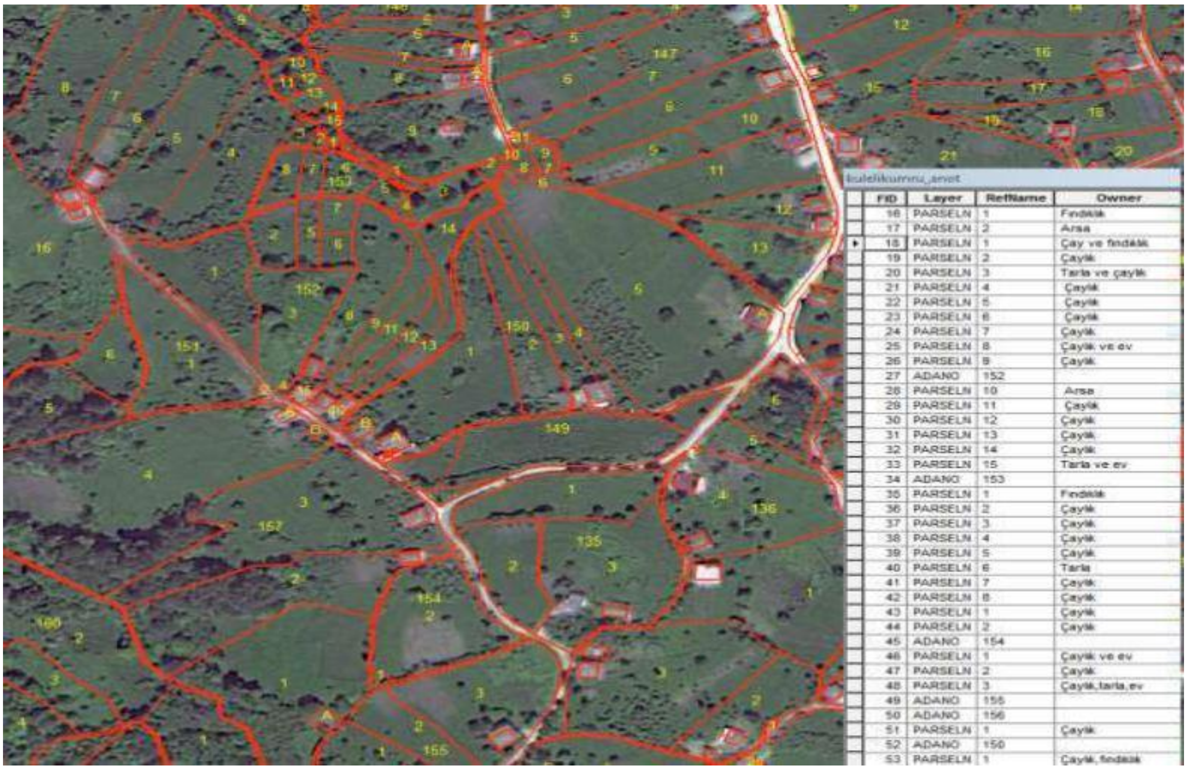

Fig 1. Cadastral map (digitized)

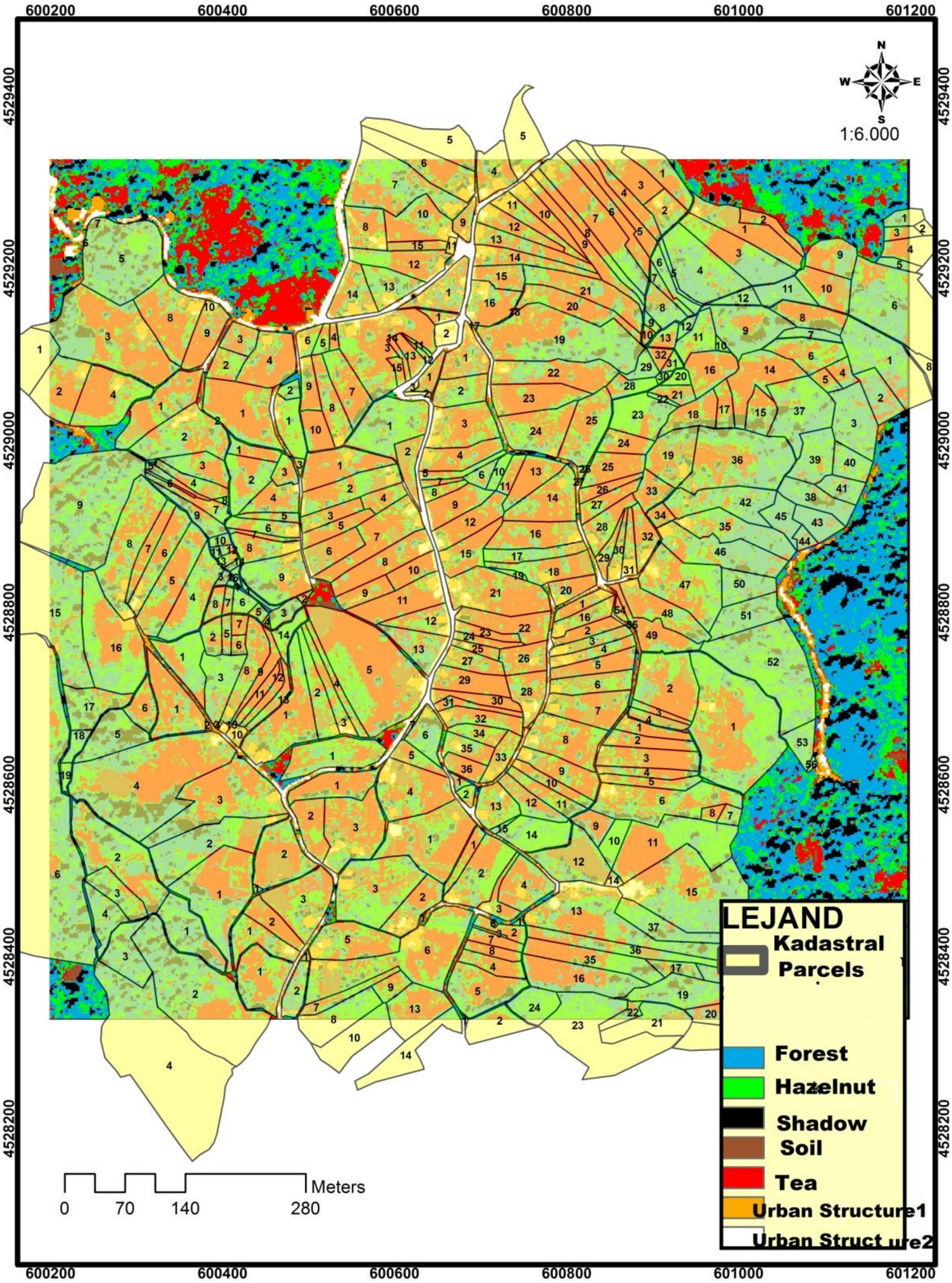

Figure 2. Classified WorldView-2 image

3.2. Map Production

We used the contour lines for the third dimension during digitization, and created a three dimensional model for the region. We produced the aspect and slope maps. Afterwards, we reclassified the slope map for different ranges. We intersected this slope map with the cadastre map to obtain the slope map in Figure 3. Similarly, we obtained the aspect map in Figure 3. Afterwards, we analyzed the relation with the classified image.

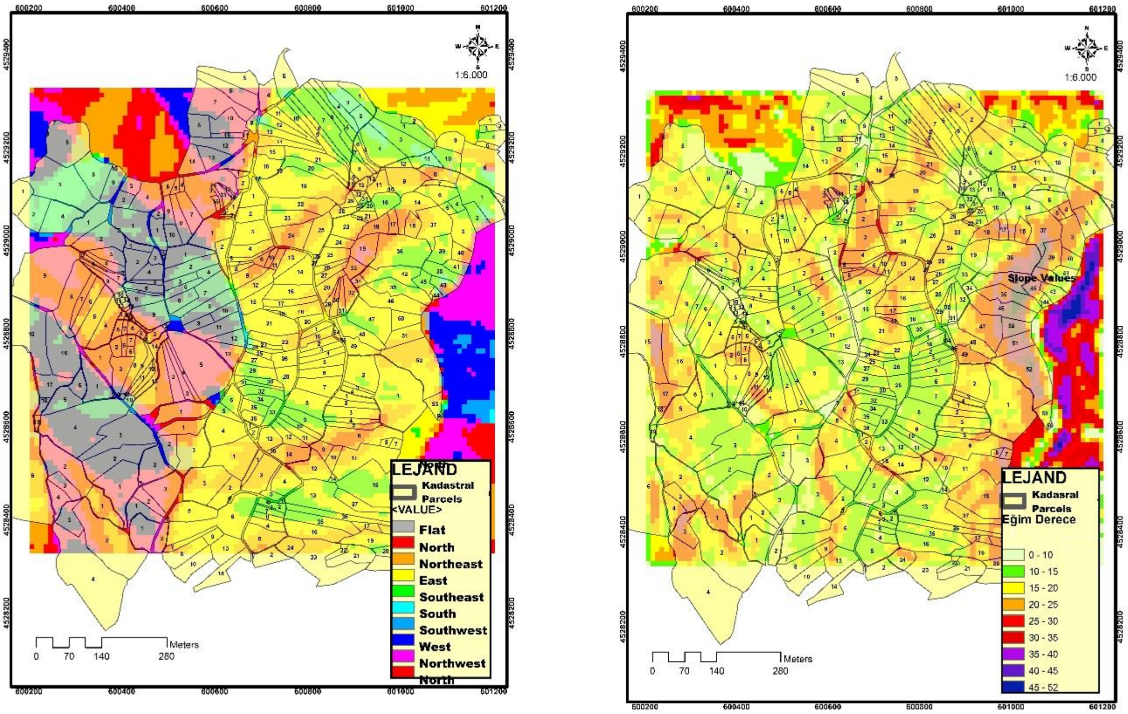

Figure 3. Aspect (left) and Slope (right) Maps

3.3. Queries and Analysis

We used ArcGIS intersection analysis on the digital cadastre map and the classified World-View-2 image. The attribute table can be seen in Table 1. Using queries, we obtained classes in each parcel, and their areas are calculated, as can be seen under the field 'Alan_1' in Table 2. Table 3. shows the result of a query. We observed and analyzed the relation with the slopes.

Table 1. Attribute table before queries .

FID	Shape *	ADA	PARSEL	GRIDCODE	ALAN
3145	Polygon	115	5	2	0,265
3145	Polygon	115	5	2	0,160
3145	Polygon	115	5	2	0,587
3146	Polygon	115	5	2	0,341
3146	Polygon	115	5	2	4,628
3146	Polygon	115	5	2	0,594
3146	Polygon	115	5	1	6
3146	Polygon	115	5	4	0,000
3146	Polygon	115	5	5	0,171
3146	Polygon	115	5	1	4
3146	Polygon	115	5	5	1,135
3146	Polygon	115	5	2	13,67
3146	Polygon	115	5	2	5,781
3147	Polygon	115	5	5	0,631
3147	Polygon	115	5	1	12
3147	Polygon	115	5	2	0,290
3147	Polygon	115	5	3	36,98
3147	Polygon	115	5	4	6,642
3147	Polygon	115	5	1	6,180
3147	Polygon	115	5	2	10,74

Table

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(3 out of 39115 Selected)

Table 2. Attribute table after queries.

Table

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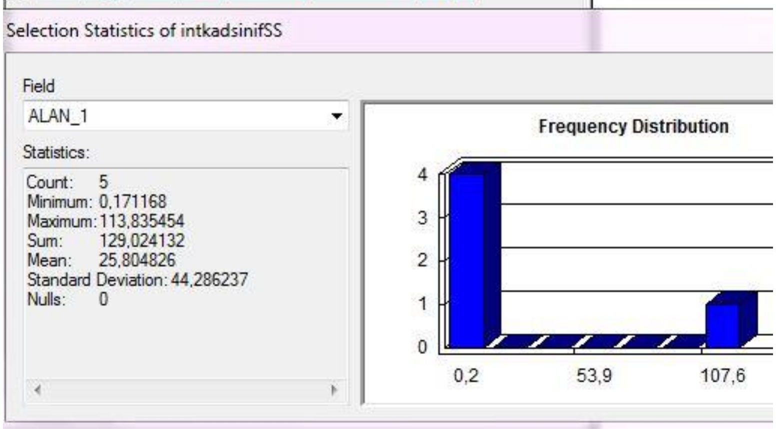
FID	Shape *	ADA	PARSEL	GRIDCODE	ALAN
3146	Polygon	115	5	5	0,171
3146	Polygon	115	5	5	1,135
3147	Polygon	115	5	5	0,631
3148	Polygon	115	5	5	13,25
3148	Polygon	115	5	5	113,8



3.4. Statistics, Analysis, Evaluation

The regulations handbook for hazelnut production lists favorable soil and weather related conditions for hazelnut production (TTB 2014). The handbook also emphasizes that hazelnut production efficiency depends on the slope, and precautions need to be taken according to slope conditions. Table 3 needs to be rearranged as in Section 3.5.

Table 3. Query result before rearrangements.

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FID	Shape *	FID_kadast	ADA	PARCEL	FID_vsinif	ID_1	GRIDCODE	ALAN_1
31457	Polygon	317	115	5	13	14	2	0,27
31458	Polygon	317	115	5	14	15	2	0,16
31459	Polygon	317	115	5	65	66	2	0,59
31460	Polygon	317	115	5	126	127	2	0,34
31461	Polygon	317	115	5	127	128	2	4,63
31462	Polygon	317	115	5	173	174	2	0,59
31463	Polygon	317	115	5	174	175	1	6,00
31464	Polygon	317	115	5	175	176	4	0,00
31465	Polygon	317	115	5	275	276	5	0,17
31466	Polygon	317	115	5	366	367	1	4,00
31467	Polygon	317	115	5	367	368	5	1,14
31468	Polygon	317	115	5	368	369	2	13,67
31469	Polygon	317	115	5	369	370	2	5,78
31470	Polygon	317	115	5	461	462	5	0,63
31471	Polygon	317	115	5	462	463	1	12,00
31472	Polygon	317	115	5	568	569	2	0,29
31473	Polygon	317	115	5	621	622	3	36,98
31474	Polygon	317	115	5	622	623	4	6,64
31475	Polygon	317	115	5	623	624	1	6,18
31476	Polygon	317	115	5	721	722	2	10,75
31477	Polygon	317	115	5	800	801	1	1,81
31478	Polygon	317	115	5	801	802	2	0,45
31479	Polygon	317	115	5	1080	1081	4	5,66
31480	Polygon	317	115	5	1356	1357	5	13,25

3.5. Final modifications

The region within a given cadastral parcel (for instance 115-5) with the same gridcode (class, for instance 5, 'tea') comprises many polygons. They need to be collected. This can be done using Python. Table 4. shows total area of these polygons for a particular class in the same parcel, also simplifying the data. (Gridkod 1: 'orman' (forest), Gridkod 2: 'fındık' (hazelnut), Gridkod 3: 'gölge' (shadow), Gridkod 4: 'toprak' (soil), Gridkod 5: 'çay' (tea), Gridkod 6: 'kentselyapı1' (urban structure 1), Gridkod 7: 'kentselyapı2' (urban structure 2))
Final result is exported to MS Excel and shown in Table 5.

Table 4. Total areas.

ADA	PARCELS	GRİDKOD	ALAN(m2)
115	5	1	30,00
115	5	2	37,52
115	5	3	36,98
115	5	4	12,30
115	5	5	129,02
115	6	1	284,14
115	6	2	308,65
115	6	3	185,17
115	6	4	257,81
115	6	5	918,11
115	6	6	286,51
115	6	7	61,95
115	7	1	1652,74
115	7	2	1514,16
115	7	3	398,92
115	7	4	261,88
115	7	5	1400,08
115	7	6	266,36
115	7	7	93,94
115	8	1	325,36
115	8	2	337,19
115	8	3	39,64

The slope range intervals in Table 5 are (0°, 10°), (10°, 15°), (15°, 20°), (20°, 25°), (25°, 30°), (30°, 35°), (35°, 40°), (40°, 45°), and (45°, 52°) .

Tablo:5 Final results.

Eğim(Derece)	Nitelik	Alan(m2)		Eğim(Derece)	Gridkod	Alan(m2)
0-10	Orman	19305,93		30-35	Orman	11616,74
0-10	Fındık	14883,76		30-35	Fındık	7168,03
0-10	Gölge	4962,93		30-35	Gölge	1743,32
0-10	Toprak	7497,08		30-35	Toprak	456,39
0-10	Çay	18880,41		30-35	Çay	3430,19
0-10	Kentsel Yapı1	6014,01		30-35	Kentsel Yapı1	128,21
	Kentsel Yapı2	2381,29		30-35	Kentsel Yapı2	78,33
0-10						
10--15	Orman	43463,45		35-40	Orman	8892,41
10--15	Fındık	44886,19		35-40	Fındık	4753,54
10--15	Gölge	9658,45		35-40	Gölge	1203,44
10--15	Toprak	16665,32		35-40	Toprak	145,64
10--15	Çay	90561,84		35-40	Çay	1970,55
10--15	Kentsel Yapı1	8960,56		35-40	Kentsel Yapı1	3,34
10--15	Kentsel Yapı2	2993,58		35-40	Kentsel Yapı2	0,00
15-20	Orman	50680,80		40-45	Orman	4496,63
15-20	Fındık	53535,72		40-45	Fındık	1381,62
15-20	Gölge	10853,19		40-45	Gölge	659,71
15-20	Toprak	15084,81		40-45	Toprak	0,00
15-20	Çay	83694,53		40-45	Çay	134,55
15-20	Kentsel Yapı1	6687,82		40-45	Kentsel Yapı1	0,00
15-20	Kentsel Yapı2	2153,80		40-45	Kentsel Yapı2	0,00
20-25	Orman	40727,99		45-52	Orman	1410,67
20-25	Fındık	40583,51		45-52	Fındık	105,72
20-25	Gölge	8780,94		45-52	Gölge	78,28
20-25	Toprak	9829,17		45-52	Toprak	0,00
20-25	Çay	56740,83		45-52	Çay	42,32
20-25	Kentsel Yapı1	3919,10		45-52	Kentsel Yapı1	0,00
20-25	Kentsel Yapı2	1447,27		45-52	Kentsel Yapı2	0,00
25-30	Orman	19669,67				
25-30	Fındık	17243,74				
25-30	Gölge	4791,26				
25-30	Toprak	3012,02				
25-30	Çay	18776,87				
25-30	Kentsel Yapı1	1059,69				
25-30	Kentsel Yapı2	508,69				
			Nitelik	**Toplam Alan**		
			Orman	200264,29		
			Fındık	184541,85		
			Gölge	42731,53		
			Toprak	52690,44		
			Çay	274232,10		
			Kentsel Yapı1	26772,73		
			Kentsel Yapı2	9562,96		

4. RESULTS AND DISCUSSION

For more efficient production of agricultural products like hazelnut and tea, the dominant agricultural products in the Eastern Black Sea region of Turkey, the regulations should enforce geospatial criteria such as slope and aspect. We have examined the present situation in a district in the Eastern Black Sea region, a mountainous region. In the district, according to classification results, hazelnut is planted on a region with an area of 184541.85 m^2. 76.4% of this region has a preferable slope, a slope between 10 and 25 degrees. When the slope is over 40°, the total agricultural production is around 20%. With appropriate terracing, hazelnut can be planted when the slope is large, as well, increasing the overall production. Similarly, we see that tea is planted on an area of 274232.10m^2. 84.2% of this area has a slope between 10 and 25 degrees. This ratio is even higher than the one for hazelnut. With the right soil and weather conditions, and when the aspect is towards south, southeast or southwest, tea can be planted efficiently, even when the slope is a bit higher. One can do many more geospatial queries using GIS with remote sensing images. When the need arises to extract valuable information from the results of such queries, one can employ and execute a script. Python is our choice of programming language due to its qualities, and as one can extend ArcGIS with Python.

ACKNOWLEDGEMENTS

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