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DRAWING UP MAPS OF INFERTILE SOIL PLOTS USING GEOGRAPHIC INFORMATION SYSTEMS

Rimvydas GAUDĖŠIUS

Aleksandras Stulginskis University, Studentų g. 11, LT-53361 Akademija, Kauno r., Lithuania
E-mail: rimvydas.gaudesius@asu.lt

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Abstract. There are quite a lot of unused plots of lands that are suitable for agriculture or other business in the territory of Lithuania. This has happened because of various social, natural and economic reasons. Scientists emphasize that all intensity of agricultural production is determined by different conditions of development of agricultural activities. Productivity of soil is highly significant in this case.

Big farmers control vast territories in which natural conditions are different. Some farmers engage in one type of activities in their farms, whereas others develop different business. Using the territory used for agriculture to engage in different activities is more efficient economically because different crops need different conditions to grow; therefore, it is possible to obtain higher economic efficiency taking into account the characteristics of soil.

Taking into account the relevance of such a map in practice, it was decided to try to draw it up using geographic information systems. The biggest problem while performing this task is the fact that initial information is saved in different formats. The article also describes the capacities of software. It is noteworthy that the situation is analyzed in respect of drawing up a map of individual holdings not a mass map of unproductive land. The article is more of practical nature; therefore, the results reflect program capacities and theoretical ideas more that could be useful in business and expand the capabilities of land management officers' activities.

Keywords: land plot, infertile soils, GIS, economic efficiency.

Introduction

There were approx 537 thousand ha of unused land in the territory of Lithuania according to the data of 2013 (Aleknavičius, P., Aleknavičius, M. 2014). This has happened because of various social, natural and economic reasons. In the opinion of Prof. P. Aleknavičius, the land reform being implemented in Lithuania may be called one of them. Ownership of land plots was restored to persons during the land reform irrespective of the fact whether the said persons engage in active agriculture; also most of the owners live far away from the land plot owned (in another district) now; therefore, engaging in agriculture is inconvenient.

Another significant natural reason due to which land plots are not used for active agriculture must also be named, i.e. low productivity score of the land plot due to which farming is unprofitable. Of course, farmers may expect support from the European Union (hereinafter – "the EU") because of mass maps of unproductive lands drawn up in respective wards. Such maps must be updated in Lithuania before 2018 pursuant to the requirements of the EU. However, there is no official information concerning the methodology that will be used to update the said maps yet. It is doubtful whether the wards which were characterized by unproductive lands before due to unclear economic factors will not become territories with fertile lands and vice versa (Tavorienė 2016). Since drawing up of individual not mass maps is analyzed in the article, the methodology used to draw them up an informational materials is set out clearly and available to everyone.

In his scientific article, G. Ribokas (2013). maintains that the intensity of agricultural production in Lithuania is determined by different conditions for developing agricultural activities. Land was divided into several categories by productivity in the Soviet time and prices of buying agricultural products depended on the said categories. They were abolished

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after Restoration of Independence and owners of unproductive lands faced huge problems because they were forced to compete with the subjects whose farming conditions were better. Income from agricultural activities was several times lower in unproductive territories than in fertile ones. Therefore, agricultural activities became unprofitable in some regions of Lithuania, agricultural land was neglected and rapid renaturalization processes of land started.

However, this does not mean that infertile land plots must be unused and kept neglected. Such low-productivity (up to 30 points) land plots can be used for other, unconventional business, e.g. to forest them, engage in unconventional agriculture, livestock farming, horticulture or rural tourism in them (Ozolinčius 2005).

Taking all these causes listed into account, it is useful for specialists of respective areas and/or farmers to know low-productivity plots and specific layout thereof in a respective territory. However, there is currently no information space where in this information would be systematized and presented to the user concerned (Gaudėšius 2014). This article will be aimed namely at achieving this relevant objective by using geographic information systems (hereinafter – "GIS").

Also, according to a famous land management officer (Aleknavičius, A., Aleknavičius, P. 2016), further designing tasks must be found for land management officers because of the land reform implementation of which is almost completed in the Republic of Lithuania.

Objective: identify unproductive land plots and picture spatial layout thereof on the basis of available cartographic data using GIS tools.

Tasks: analyze the concepts, capacities and usage of GIS, form a geographical data base using available data, formulate queries and select desired (infertile) land plots as well as draw up a representative map of the solutions obtained.

Object: a single territory area of which is 600 ha was randomly selected in Kretingalė Ward, Klaipėda District Municipality.

Methods: analysis, synthesis, graphic modelling, abstraction. ArcGIS (10.2) program was used to process data and draw up the map.

1. Review of literature

Geographic information systems, geoinformation systems – a computerized system for collection, management, processing, storage, search and presentation of information on geographic objects, their characteristics and other information concerning land designed to solve designing, modelling, analysis, scientific and other geographic spatial problems (Rekus *et al.* 2008).

Geographic data – data regarding objects and phenomena knowing their spatial position and state. It must answer the main question: "What is where?" To put it in other words, geographic data must provide information where an object is located and what kind of an object it is.

Maps are a significant cultural heritage of human kind that shows the position and change of various objects and phenomena in space. First maps were topographic; they pictured the surface of the land and more prominent objects located on it as well as served traveling and military purposes. As science and comprehension of the environment surrounding us developed, the amounts of information that had to be pictured in topographic maps increased as well. Picturing a lot of different information in one topographic map became more and more complicated. Therefore, thematic maps are produced in the base of topographic maps today. Thematic maps are divided by types of information: natural phenomena, inhabitants, cultural, political-administrative, historical, economic, tourist, etc. (Gurklys 2007a).

Data collection is one of the most expensive and time-consuming GIS processes. Sometimes data collection amounts to even 85% of the whole price of a GIS project whereas the prices of computer equipment and software often become irrelevant. In general, GIS data is obtained by collecting it directly or transferring it from other systems. The sources of geographic data are divided into primary and secondary ones in this respect. Primary data is data collected by performing direct measurements of the object. They are direct measurements of the object using various measures, methods and instruments, photographs including aerial photographs and satellite images. Sources of secondary data are digital and analog sets of data collected for other purposes and converted to a form suitable for use in GIS. Sources of secondary data are characterized by quite quick and inexpensive collection of geographic data; however, increasing the accuracy of spatial data and completing the attributes with new characteristics of the objects is often impossible without any additional measurements or investigations (Gurklys 2007b).

Data is stored in four main formats: vector, raster, triangular irregular network (TIN) and tables. Vector data is constructed of points. Up to three coordinates:

x, y and z are used to describe the location of these points. Raster data model pictures data on a surface divided by a grid of the same size. Triangular irregular network (TIN) data model is perfect for picturing surface, e.g. relief. Data is pictured as a set of non-overlapping triangles drawn between points located at irregular distances. Table data is used for attributes – storing descriptive information of spatial data (Blyth *et al.* 2008).

In practice, the data collected by various bodies for different purposes and using different methods is stored in different digital formats.

Spatial data can be stored in one of the following types of formats:

- Vector formats: *DWG* ("AutoCAD" format), *SHX, SHP* (Shape file), *EMF, EPS, PDF*, etc.;
- Raster formats: *TIFF* (complemented with geographic reference metadata), *SID* (compressed format, data losses are incurred quite often), *BMP, JPEG, GIF, PNG*, etc. (Rusonytė 2013; Geografinės... 2016).

However, GIS is also useful because it enables working with digitalized data in various formats. Its format simply must be changed to a format suitable for every user or a tier of necessary information must be created using available data.

Quite a lot of scientific research of usage of GIS in various fields has been performed demonstrating vast capacities of this system. For example, GIS can be used in order to create a map of crimes committed in the city (Acus 2014), select a location for construction of commercial objects (Ustinovičius, Stasiulionis 2001), picture the spread of morbidity with respective diseases (Shirayama *et al.* 2009), as an educational measure (Bodzin, Anastasio 2006), etc. *Ž. Stankevičius* who analyzed the model of calculation of the value of land and the free land area model has written about usage of the capacities of GIS in land management (Stankevičius 1996). Soil erosion is described the most extensively in international literature analyzing usage of GIS in soil investigations (Zhu *et al.* 2001; Lufafa *et al.* 2003); however, no articles on drawing up maps of unproductive land plots were found.

Generalizing the literature collected, it may be concluded that GIS is the most suitable measure for solving the problems useful to land management because data can be generalized when digital information in various formats is available and thematic models of maps can be drawn up analyzing the data.

2. Practical experience

The data collected by different bodies and stored in different digital formats must be used in order to achieve the objective. The available orthophotographic material (Fig. 1) is stored in *SID* format; the information of the productivity score of soils is stored in this format as well (Fig. 2).

The information on roads (Fig. 3), buildings (Fig. 4) and forests (Fig. 5) is stored in *SHAPE* format in this case. One source of geographic information – boundaries of land lots (Fig. 6) – is also stored in *DWG* format.

It goes without saying that analyzing information accurately, interrelating it, etc. is complicated when it is stored in different formats; therefore, it is more beneficial to convert it to another digital format, i.e. to unify formats for the sake of further analysis. Doing this is not easy either; however, this can be done quite accurately and conveniently using ArcGIS software. In this case, data on the boundaries of land plots registered in the Real Estate Register are converted from *DWG* to *SHAPE* format in order to be able to work with the table of attributes conveniently.

Fig. 1. Orthophotographic map
(source: prepared by the author)

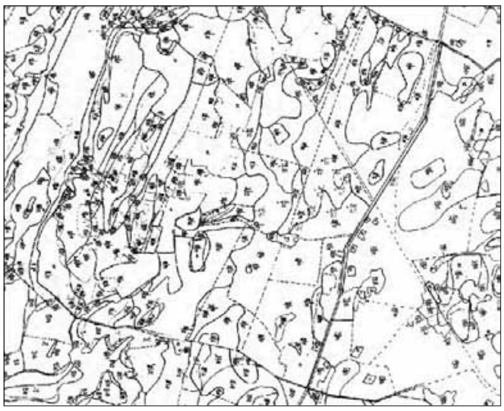

Fig. 2. Productivity score of soils
(source: prepared by the author)

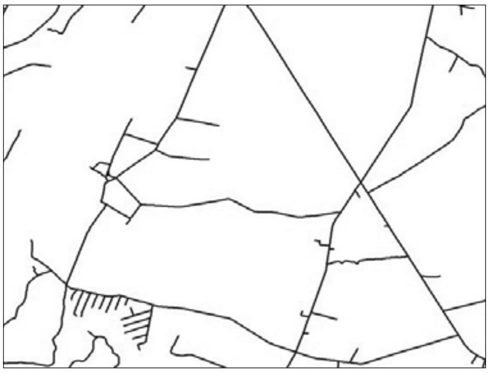

Fig. 3. The information about roads
(source: prepared by the author)

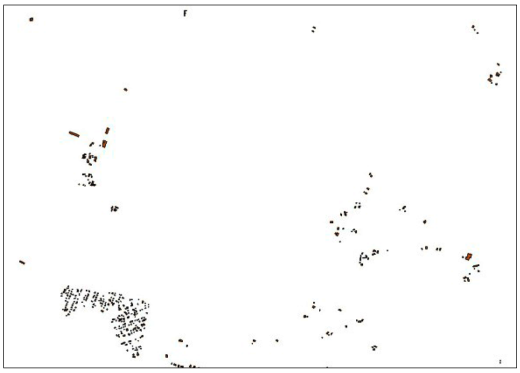

Fig. 4. The information about buildings
(source: prepared by the author)

Fig. 5. The information about forests
(source: prepared by the author)

Fig. 6. Boundaries of land lots
(source: prepared by the author)

After data tiers are uploaded to ArcGIS program, the colours of data tiers are selected automatically; those colours do not always correspond to the established mapping standards. The names of tiers were changed to clearer ones, the road line was drawn thicker and the colours of tiers were changed (forest – green, road – brown, etc.) in order to be able to work with the data and analyze the elements of the situation more conveniently.

Program capacities of ArcGIS enable stacking available data tiers onto each other and thus obtaining a solid informative view (Fig. 7). When data is staked onto each other, the plan (scheme) of the situation becomes clear picturing forests, roads, built-up territory, boundaries of formed land plots and land productivity scores in this case. It is noteworthy that arrangement of tiers in the program is important. If we place data in *SID* format (soil productivity) higher than data in *SHAPE* format (boundaries of land plots), we will not be able to see the latter data because raster view will cover vector data.

This available plan is not sufficiently convenient to identify the land plots characterized by low productivity score. The bigger the territory, the more impractical manual search of such plots and solution of the problems desired; therefore, performing a program analysis by formulating queries and thus identifying and marking the specifically required land lots is useful.

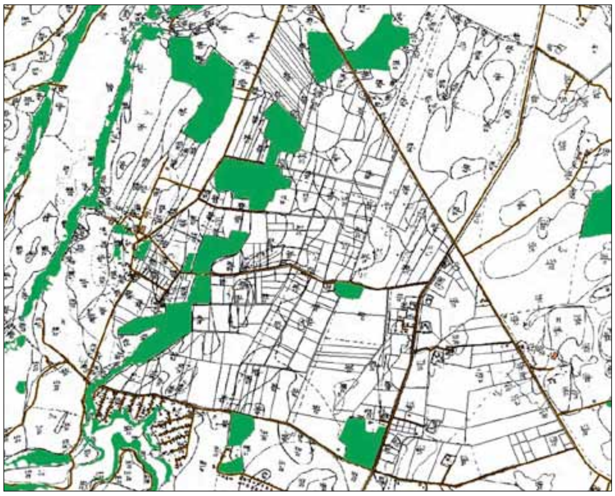

Fig. 7. Layers of all data at once
(source: prepared by the author)

The productivity score of each land plot must be determined in order to identify infertile land plots. Such information could be obtained from the certificates of the Real Estate Register as well but this service is expensive and this data will not be presented graphically; therefore, orienting in a location and planning further activities according to available certificates of the Centre of Registers would be complicated. There is no unanimous information in this case either. Individual data files are presented, i.e. one tier contains the boundaries of land plots, while another one – the land productivity score. Data tier containing productivity of land stored in *SID* format cannot be edited (supplemented); however, data in *SHAPE* format can be edited (the boundaries of land plots). Therefore, a table of attributes is supplemented here manually by specifying land productivity scores (Fig. 8). It was also decided to supplement the attributes right away by stating which land plot is built up and which – forested.

Naturally, such work is highly time-consuming and that depends on the size of the territory being analyzed. However, the table of attributes supplemented by such information becomes extremely valuable and useful for solving various further problems.

Desired selection by desired geographical characteristics of land lots can be performed after the table of attributes of the tier of land lots is supplemented. The following conditions were chosen for the selection performed:

1. Productivity score of a land plot not higher than 30 (inclusive);
2. The land plot is not forested;
3. The land plot is not built up.

Since the activities for which the land plots found will be used were not planned, other selection criteria were not used in selection, e.g. determining the distance from the land plot to a road, the distance to a forest or any territorial planning solutions.

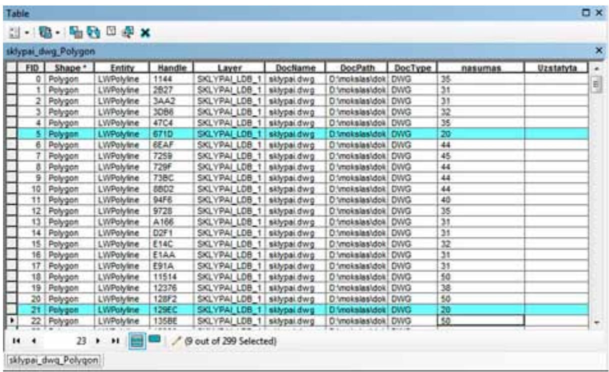
Table
sklypai_dwg_Polygon

FID	Shape *	Entity	Handle	Layer	DocName	DocPath	DocType	nasumas	Uzstatyta
0	Polygon	LWPolyline	1144	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	35	
1	Polygon	LWPolyline	2B27	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	31	
2	Polygon	LWPolyline	3AA2	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	31	
3	Polygon	LWPolyline	3DB6	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	32	
4	Polygon	LWPolyline	47C4	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	35	
5	Polygon	LWPolyline	671D	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	20	
6	Polygon	LWPolyline	6EAF	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	44	
7	Polygon	LWPolyline	7259	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	45	
8	Polygon	LWPolyline	729F	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	44	
9	Polygon	LWPolyline	73BC	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	44	
10	Polygon	LWPolyline	8BD2	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	44	
11	Polygon	LWPolyline	94F6	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	40	
12	Polygon	LWPolyline	9728	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	35	
13	Polygon	LWPolyline	A166	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	31	
14	Polygon	LWPolyline	D2F1	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	31	
15	Polygon	LWPolyline	E14C	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	32	
16	Polygon	LWPolyline	E1AA	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	31	
17	Polygon	LWPolyline	E91A	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	31	
18	Polygon	LWPolyline	11514	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	50	
19	Polygon	LWPolyline	12376	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	38	
20	Polygon	LWPolyline	128F2	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	50	
21	Polygon	LWPolyline	129EC	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	20	
22	Polygon	LWPolyline	135BE	SKLYPAI_LDB_1	sklypai.dwg	D:\mokslas\dok	DWG	50	

23 (9 out of 299 Selected)
sklypai_dwg_Polygon

Fig. 8. Table of land lots attributes
(source: prepared by the author)

The program selected and marked the land plots of interest in this case according to the queries presented (Fig. 8). A new tier consisting of marked land plots is created in order to be able to work with the results obtained more conveniently.

Final goal of the task is not only to select desired (low-productivity) land plots but also to draw up a map of representative solutions. An orthophotographic map is very convenient for orienting in a known or unknown location; however, neither the boundaries of land plots nor their productivity score can be seen in them if no additional information is inserted. Taking available data into account, another raster data tier (land productivity plan) could be used as the basis of the map; however, the data user will find it difficult to orient on the basis of it because stable elements of the location are not pictured clearly in such a map. Therefore, using an orthophotographic map as the basis in the final map and placing unproductive land plots and other significant elements onto it is expedient.

Conclusions

1. Generalizing the literature collected, it may be concluded that GIS is a truly multifunctional measure for solving various social, economic, environmental protection and other problems as well as picturing the results obtained in geographic space. It is a convenient measure for drawing up various maps related to geographic coordinates.
2. The fact that digital information stored in different formats can be coordinated using ArcGIS (10.2) program is a huge advantage. Therefore, a geographic data base was created using data stored in different formats while writing this paper and a unified plan containing all available information of interest was drawn up only after converting the data to one geographic system.
3. Data was analyzed and generalized using ArcGIS program and specific land plots with low fertility were selected while creating various query models. Setting the objects of interest, their coordinates and characteristics is convenient while creating query models. As was mentioned before, only specific land plots with low productivity score that are not built up or forested were found among the many land plots located in the 600 ha territory while writing the paper.
4. Having the results selected from the whole information of interest, it is possible to draw up a full-fledged map and thus present an aesthetically

orderly product to the user. It is recommended to inform farmers about the possibility to draw up such practically usable maps. Farmers would be able to plan their economic activities by the characteristics (fertility) of the soil of their land and thus use their land plot more economically efficiently based on such maps drawn up individually.

5. Maps of soil fertility may be used not only for more economically efficient farming but also in urbanization processes when planning land plots to be built up. There are no legal obligations to use maps of fertility of land; however, recommended usage thereof in the said activities and processes must be emphasized increasingly more often. It is also an excellent new field where the land management officers of Lithuania could expand their activities.

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Rimvydas GAUDĖŠIUS, MSc in Environmental Engineering and Land Management, Chief specialist in the National Land Service, under the Ministry of agriculture in Lithuania. Also, Rimvydas is a PhD student at the Institute of Land Use Planning and Geomatics, Faculty of Water and Land Management, Aleksandras Stulginskis University, Lithuania. Research interest: sustainable development, land use planning, geomatic and environmental engineering.