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IMPACT OF NEW TECHNOLOGIES FOR SPATIAL DATA ACQUISITION AND MANAGEMENT ON LAND CONSOLIDATIONS IN SERBIA

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Summary: *Significant innovations and improvements in the technologies for spatial data acquisition and management data have emerged in the last few decades. Introduction of GPS and the technology of GIS and digital photogrammetry in surveying practice are definitely the most important ones. In spite of this, during the last few decades there were no actual projects of land consolidations in Serbia, so these advances in technology were not implemented within land consolidations and benefits were not obvious and quantified. However, in the last few years interest in land consolidations in Serbia has been intensified and a number of projects have been started and some were already finished using the latest technologies mentioned above. The role and impact of these technologies on all the relevant activities within major phases of land consolidation projects were analyzed and the resulting benefits were estimated and given in the paper. Improvements and benefits were estimated using data from a real land consolidation project. The benefits were expressed in terms of savings in time and costs and in terms of increased quality of the land consolidation results.*

Keywords: *Land consolidation, GPS, digital photogrammetry, GIS, surveying*

1. INTRODUCTION

Land consolidations have a long tradition in Serbia. Most of the projects were finished from sixties to eighties in the last century. Land consolidation was used to consolidate 1,700,000 ha of agricultural land. In the nineties, activities on land consolidations were almost stopped in Serbia. In the last few years there is an increased interest in land consolidations in Serbia and several projects were started. Some of these projects have been already finished successfully. Having in mind that surveying and IT technologies in general, have advanced significantly in the last two decades, it is obvious that the technology of land consolidation have to change radically as well. In other fields of geodesy and surveying these changes were implemented step by step, following advances in new technologies for spatial data acquisition and processing. Land consolidation is comprised of a set of different surveying activities and therefore it is to expect substantial changes of the land consolidation process itself and significant benefits from that. Since there were no land consolidations in Serbia during the last two decades, the benefits from using these technologies were not analyzed and documented.

Objective of this paper is analysis of the impact of modern technologies on different surveying activities within the process of land consolidation and overall impact on the land consolidation as a process. Land consolidation is a complex process comprised of many phases and activities [3]. Each of the phases can be treated as a distinct unit within the whole process where application of some of the modern technologies might prove to be valuable. Therefore, possibilities of improvement of the overall process of land consolidation might be considered as a summation of improvements of distinct phases of the land consolidation.

Modern technologies that are considered in this paper for possible improvement of land consolidation process are the following: geographic information systems (GIS), global positioning system (GPS) and digital photogrammetry. Possibilities for improvement of land consolidation process will be analyzed through three criteria: cut down on expenses, cut down on execution time and increase in quality of works, all in respect to the previous way of work, i.e. without using technologies mentioned above.

2. APPLICATION OF GIS FOR LAND CONSOLIDATION

Application of information technologies (IT), specifically GIS, for certain stages of land consolidation could potentially lead to improvement of the overall process of land consolidation. Application of IT, and GIS specifically, in land consolidation phases will be considered in this paper according to the expected improvements. Evaluation of applicability of GIS technology in these phases will be given through three criteria: cut down on expenses, cut down on execution time and increase in quality of works.

Phase: Determination of the situation before land consolidation

The objective of this phase is establishment of the land consolidation database containing data on the situation before land consolidation. This database will be updated and extended throughout later phases of land consolidation. Proper design of the whole system based on the land consolidation database is of vital importance for maximum exploitation of GIS technology within overall land consolidation process. Within this phase it is required to take over all the data and documentation stored within real estate registers (land cadastre, land book). After that, all the data that are not in digital form (which is often the case) have to be digitized. This pertains to alphanumerical and graphical data as well. It is also required to establish tight connection between the data of these two types in order to increase functionality of the system and possibilities for detection of errors in data. Utilization of information systems technology at this phase of land consolidation has one other significant advantage. It provides means for easy detection of errors made during the original survey or during the maintenance of the survey data. It is often the case that errors of the survey remain hidden in survey and cadastral data for many years if the data are kept in analog form. However, in case of conversion of all the data into digital form, thorough control of the data is possible and most of these errors are detected and the data can be corrected. The most difficult part of the job in this phase is implementation of changes that, for some reasons, were not implemented in existing cadastral registers. It is required to select software that would provide efficient access to all the data from existing registers, alphanumerical and graphical ones, and also efficient storage and update of these data.

Phase: Production of maps

Design process within land consolidation requires various types of maps. Content of these maps depends on design requirements and type of works that are to be carried out within land consolidation. Production of all types of maps including cadastral, topographic, cadastral-topographic, orthophoto and others is straightforward and fast using GIS tools. Even more, these tools offer possibilities of producing maps that were not possible to produce by using traditional methods. Such an example is a combination of digital orthophoto (DOP) map and cadastral and/or topographic map data or maps containing various thematic data.

Phase: Land evaluation

Besides using GIS for the provision of digital maps for efficient field works on land evaluation, the main contribution of using GIS is also for the establishment of the book of land mass before land consolidation and the production of the records of the land before land consolidation. Technology of digital cadastral map (DCM) enables efficient polygon overlay of land evaluation layer and parcel layer and automatic calculation of values for each and every parcel and for the land consolidation territory in total. After the calculation of values for all parcels is done, automatic generation of the book of land mass before land consolidation and record of the land before land consolidation is straightforward.

Phase: Building and reconstruction of the field roads network

This phase is one of the most sensitive phases within the overall land consolidation process because here number, shape and sizes of land consolidation blocks is to be determined. Application of GIS technologies enables digital maps which can be used for the design process. The following maps can be used: spatial and urban plans, overview map of current situation, surveying cartographic data, etc. Having in mind that the analysis of lots owned by the participants of land consolidation is very important factor within the design process, it is quite clear that designer is faced with a large quantity of important data. GIS technology provides means for him to have easy and comprehensive insight into all the relevant data and therefore to come up with the optimum design solution. In order to decide on the distances between roads, i.e. on the size of land consolidation blocks, the designer needs data on lot sizes for certain types of land consolidation participants. Analytical elaboration of the design is greatly simplified and accelerated by using GIS. Calculation of coordinates for all the points of road network is straightforward. The importance of this is even greater, if one

realize that often there is a requirement to change the original design of the road network made by the designer in order to satisfy some additional requirements. Every such change calls for a painstaking recalculations to provide new analytical elaboration of the design. This was the case if one use classical method, but if GIS technology is used this is not such an issue. This was exactly the reason why designers were reluctant in the past to change their design even in cases that it was fairly justified to do so. Utilization of GIS technology enables production of several optional designs in short time. Therefore, it is possible to apply some optimization methods in order to obtain optimum and therefore high quality solution.

Phase: Grouping of parcels and estates

This phase is at the heart of the land consolidation process because it is here where the decision is made about the location, size and shape for the lot allocated to the owner. Using adopted solution for the field roads network, it is possible to calculate elements for new land consolidation blocks. Therefore, by using proper software tools it is straightforward to calculate the value of the land mass after land consolidation , as well as a value for each land consolidation block. As it was the case with the establishment of the book of land mass before land consolidation, at this phase it is possible to use automatic procedures to establish the book of land mass after land consolidation, to calculate the reduction coefficient and to apply it through the record of the land before land consolidation. In addition to these functions, GIS technology at this phase can provide tools for the production of the proposal for the land mass redistribution. Expert working on allocation of lots has tools that can greatly help in finding suitable solutions. The possibility of making different maps for general insight into the structure of allocated lots significantly aids the process. Besides these maps, it is also possible to create maps for certain land consolidation participants in order to solve some critical cases. Without utilization of GIS technology this would be practically impossible because it would be too expensive. After the location for the new parcel is determined, it is possible to get the elements for the parcel boundary stake-out practically instantaneously. This is accompanied by the graphical presentation of the parcel and its surroundings. Having all of these reports, expert working on allocation have insight into the shape and location of new parcel within the new land consolidation block, so he can make some corrections, if required. Additionally to advantages offered in terms of graphical presentation and data processing, information technologies also provide database of land consolidation for storing all the data relevant for land redistribution. Well-designed data model provides possibilities for easy inventory and data browsing and queries. For example, it is possible to see the extent (percentage) of already allocated parcels for any land consolidation block at any point in time. Also, it is possible to check if there are too many parcels for any land consolidation block, to see the percentage of parcel allocations for owners, to see statistics on land areas, owners and land consolidation mass that has been allocated so far, etc. Information technologies provide possibilities for the application of optimization models of operational research. The basic precondition for applying these methods is formulation of correct mathematical model that would meet the requirements for optimization of redistribution of land mass. Implementation of optimization model is possible only by using information technologies, since this problem involves solving systems with a lot of unknowns.

Phase: Production of digital cadastral maps and real estate cadastre

Having in mind that new cadastral maps have been produced within previous phases (Building and reconstruction of the field roads network and Grouping of parcels and estates), it might be only required to transform them into the form prescribed by the relevant legislation of the state survey (By-law on Digital Cadastral Map). All the data needed for the production of the real estate cadastre database can be obtained from land consolidation database (database produced within the phase Grouping of parcels and estates). These data only have to be transformed into the format (data model) prescribed by the relevant legislation.
Only those phases of land consolidation that significantly benefits from using new technologies were considered within this section. It does not imply that these technologies are not used or to be used within other land consolidation phases. On the contrary, utilization of these technologies in other phases is also important and it is mainly based on provision of various maps and other data for more successful and more efficient workflow. Review of all land consolidation phases and possibilities of application of GIS technology within these phases is given through the fulfillment of the three criteria (Table 1).

Table 1 : Land consolidation phases and possibilities of application of GIS technology

Land consolidation phase	Cut down on expenses	Cut down on execution time	Increase in quality
Preliminary works	●		●
Determination of borders of land consolidation area			
Determination of the situation before land consolidation		●	●
Establishment of geodetic network			
Detailed survey			
Production of maps	●	●	●
Land evaluation	●	●	●
Definition of principles of land consolidation			
Building and reconstruction of the field roads network	●	●	●
Grouping of parcels and estates	●	●	●
Adjustments of border lines	●	●	
Technical consolidation of agricultural land			●
Building of drainage system	●	●	●
Building of irrigation system	●	●	●
Wind protection of agricultural land			●
Water erosion protection of agricultural land			●
Environmental protection	●	●	●
Development and restoration or rural settlements	●	●	●
Stake-out of constructions, land cons. blocks and parcels	●	●	
Production of cadastral maps and parcel list	●	●	●
Cadastral land classification and land evaluation	●	●	
Production of real estate cadastre database	●	●	●
Production of documentation on executed works	●	●	●

3. APPLICATION OF GPS FOR LAND CONSOLIDATION

As it was the case for the following section, potential benefits provided by utilization of GPS technology will be considered as summation of improvements within distinct phases of the land consolidation. Accordingly, application of GIS will be considered within phases of land consolidation. Applicability of GPS technology in these phases will be given in the same manner as it was done for GIS, i.e. through three criteria: cut down on expenses, cut down on execution time and increase in quality of works. Active geodetic reference network (AGROS) has been established in Serbia. It is operational and available for use for all commercial applications and therefore for land consolidation as well. AGROS network greatly simplify the use of GPS technology. Application of GPS technology supported by AGROS network is considered within this section.

Phase: Determination of borders of land consolidation area
By using GPS technology it is much easier and more efficient to do survey and to do stake-out of border points. Limitations imposed on using classical surveying methods no longer apply here. The best results are obtained by using real time kinematic GPS method (RTK) using AGROS. Procedures require engagement off fewer human resources than it was the case of using classical surveying methods.

Phase: Establishment of geodetic network
Geodetic network is developed within land consolidation territory to serve for the maintenance of the survey. Network is designed following the principle of developing polygons of network points with the requirement that from each point at least two other points are visible. This requirement is obsolete (unnecessary) in case of using GPS, but it is fulfilled so that other surveying methods can be used during the maintenance of the survey. These methods, especially polar method using total station, are still heavily in use for these purposes, so this requirement is justified. Measurements on new network points could be done using relative kinematic

positioning supported by AGROS. This procedure provides significant savings in time and human resources in comparison to traditional geodetic methods. In case that aerial photogrammetry is planned this method can be used for determination of control points required for aerial triangulation. In addition to benefits already stated, it is possible to plan activities on network development independently of other land consolidation phases. Therefore, these activities could be planned for the time when it is mostly suited, so additional savings could be made.

Phase: Detailed survey
Geodetic survey of certain real estate objects by using GPS method could be done in order to update existing cadastral real estate registers or to get the data on those real estate objects that would retain their shape and position after land consolidation is finished. The best results are obtained by using real time kinematic GPS method (RTK) using AGROS. This eliminates the requirement for the geodetic network on land consolidation territory. Objects that are subject to this survey are usually scattered throughout land consolidation territory, so collecting large quantity of data that is not to be expected. GPS method is therefore the best solution for this survey.

Phase: Stake-out of constructions, land consolidation blocks and parcels
Geodetic stake-out of constructions, land consolidation blocks and parcels could be done efficiently by using GPS technology. As for other phases, this could be done using relative kinematic positioning supported by AGROS. Stake-out and controls are easier and more efficient using GPS than traditional surveying methods. Limitations such as visibility of points, obstacles on the field and others no longer apply. Additionally, less human resources is required.

Table 2 : Land consolidation phases and possibilities of application of GPS technology

Land consolidation phase	Cut down on expenses	Cut down on execution time	Increase in quality
Preliminary works			
Determination of borders of land consolidation area	●	●	
Determination of the situation before land consolidation			
Establishment of geodetic network	●	●	●
Detailed survey	●	●	
Production of maps			
Land evaluation	●	●	●
Definition of principles of land consolidation			
Building and reconstruction of the field roads network			
Grouping of parcels and estates			
Adjustments of border lines			
Technical consolidation of agricultural land			
Building of drainage system			
Building of irrigation system			
Wind protection of agricultural land			
Water erosion protection of agricultural land			
Environmental protection			
Development and restoration or rural settlements			
Stake-out of constructions, land cons. blocks and parcels	●	●	
Production of cadastral maps and parcel list			
Cadastral land classification and land evaluation			
Production of real estate cadastre database			
Production of documentation on executed works			

Review of all land consolidation phases and possibilities of application of GPS technology within these phases is given through the fulfillment of the three criteria (Table 1).

4. APPLICATION OF DIGITAL PHOTOGRAMMETRY FOR LAND CONSOLIDATION

Photogrammetry was already used, to a certain extent, within the land consolidation projects in Serbia. Having in mind expansion of applications of this technology of surveying in Serbia in the last fifteen years, and also stagnation in land consolidation projects, it is reasonable to investigate possibilities of application of digital photogrammetry for land consolidation. The same approach will be used as for the analysis of GIS and GPS technologies (application within land consolidation phases and evaluation via three criteria).

Phase: Determination of borders of land consolidation area and detailed survey
Digital photogrammetric mapping on digital photogrammetric workstations (DPW) is efficient method for determination of coordinates of all points on borders of land consolidation area and for the detailed survey as well. The precondition is that these points were covered with proper photo targets (marks). Photogrammetric mapping is significantly more efficient and it also requires less human resources. Therefore, this method is the best solution for mapping borders of land consolidation area and real estate objects that would retain their shape and position after land consolidation is finished. Another application of photogrammetry could be use of digital orthophoto (DOP) to check consistency of borders of neighboring cadastral municipalities and land consolidation territory border. It is possible to map these borders from existing cadastral registers and to overlay them with DOP. This would provide means to check consistency of cadastral data and the real situation on the field. Some field works might be required in order to correct detected inconsistencies. Potential problems arising from determined inconsistencies and further activities on correcting these inconsistencies could be foreseen and planned easily.

Phase: Determination of the situation before land consolidation
The role of digital photogrammetry at this phase is on analysis of existing real estate and survey data. This is closely related to the use of DOP. By overlaying existing cadastral maps (scanned maps) and DOP it is possible to determine two things: level of update for cadastral maps and quality of data contained on maps. The level of update is determined by comparison of borders of cadastral parcels mapped on cadastral maps and their appearance on DOP. Quality of data contained on cadastral maps could be evaluated by checking positional accuracy of the data overlaid with DOP. Of course, accuracy of DOP has to be considered as well, since it limits the evaluation. Usually, cadastral maps are very old and in a very bad condition, and therefore accuracy of data is questionable. Comparison with DOP can give general insight into the data quality. This knowledge is essential for further phases of land consolidation.

Phase: Production of maps
Digital photogrammetry is dominant method for acquisition of large quantity of spatial data and therefore its application within this phase of land consolidation process could be very important and valuable. Digital photogrammetry can provide up-to-date data for many of maps that are commonly produced within land consolidation, but it can also provide other maps required by the designer. Certainly, the most significant product of digital photogrammetry is DOP and it could potentially be one of the main maps to be used in land consolidation. It provides insight into up-to-date situation on the field. This is often required for planning and executing various activities within many phases of the land consolidation process. Preliminary technical solution could be devised using DOP as a background. Combination of DOP and other maps (cadastral, topographic, thematic) and use of GIS technology enables production of completely new hybrid maps that could be of large importance for all phases of the design process within land consolidation. Additionally, digital photogrammetric mapping can be used for other purposes if designers decide so. Depending on the requirements of specific project, mapping of certain territory of interest could be required. The level of detail and content depends on specific requirements of the designer. So, on-demand mapping by using digital photogrammetry could provide specified maps of required quality with minimal costs in time and resources because it significantly reduces field surveys. Therefore, designers have at their disposal cheap and efficient method for making maps and the method is not influenced by some limiting factors such as: weather conditions, available human resources, equipment for field survey, accessibility to the field, etc. Digital photogrammetry also provides another type of spatial data that is important for the design process within land consolidation– digital terrain model (DMT). Mapping on digital photogrammetric workstations provides DTM whose accuracy and level of detail is considerably better than DTM obtained from standard maps. Existing maps (state base map, for example) usually do not contain terrain data of adequate quality and field surveys for direct acquisition of new terrain data are usually too expensive to be used.

Phase: Building and reconstruction of the field roads network
Application of digital photogrammetry within this phase of land consolidation is mainly related to the provision of maps that should help designers to realize activities of this phase more efficiently and with better quality.

Many factors have to be considered in order to design proper network of field roads. Digital orthophoto enables general insight into the situation on the field for the whole land consolidation territory and also insight into many other elements that could have influence on the road network such as: current condition and structure of existing field roads, shape, extent and distribution of parcels with long-term land use, land use, locations of farm centers within land consolidation territory, etc. DTM is one of the products of digital photogrammetry that could be used for activities within this phase of land consolidation. Terrain surface usually has prevailing influence on the shape of the roads network.
Only those phases of land consolidation that significantly benefits from using digital photogrammetry were considered within this section. It does not imply that this technology is not used or to be used within other land consolidation phases. On the contrary, utilization of this technology in other phases could be important and it is mainly based on provision of various maps and other data for more successful and more efficient workflow.
Review of all land consolidation phases and possibilities of application of digital photogrammetry within these phases is given through the fulfillment of the three criteria (Table 3).

Table 3 : Land consolidation phases and possibilities of application of digital photogrammetry

Land consolidation phase	Cut down on expenses	Cut down on execution time	Increase in quality
Preliminary works			●
Determination of borders of land consolidation area	●	●	
Determination of the situation before land consolidation			●
Establishment of geodetic network			
Detailed survey	●	●	●
Production of maps	●	●	●
Land evaluation	●	●	●
Definition of principles of land consolidation			
Building and reconstruction of the field roads network	●	●	●
Grouping of parcels and estates			●
Adjustments of border lines			
Technical consolidation of agricultural land	●	●	
Building of drainage system	●	●	●
Building of irrigation system	●	●	●
Wind protection of agricultural land	●	●	
Water erosion protection of agricultural land	●	●	
Environmental protection	●	●	●
Development and restoration or rural settlements	●	●	●
Stake-out of constructions, land cons. blocks and parcels			
Production of cadastral maps and parcel list			
Cadastral land classification and land evaluation			
Production of real estate cadastre database			
Production of documentation on executed works			

5. EXPERIMENT

To demonstrate and evaluate improvements and benefits achieved by using modern technologies a real case of land consolidation from the practice is analyzed. Land consolidation project has been finished recently. Therefore, all the possibilities and benefits of using modern technologies in practice, with all the problems and limitations, could be demonstrated.
Land consolidation of the territory of cadastral municipality of Nova Gajdobra is taken for the analysis. Cadastral municipality Nova Gajdobra is located on the territory of political municipality of Backa Palanka in the Serbian province of Vojvodina. It has the area of 1775 ha and build-up area of 108 ha. Total number of land

consolidation participants (owners) is 909 and number of parcels is 2203 (data taken from the register of determination of the situation before land consolidation).
Project of land consolidation has been realized using surveying/GIS software MapSoft 2007 and all of its modules including module Komasss (designed and developed specifically for the support to land consolidation) and module PhotoSoft (module for digital photogrammetric 3D mapping). Of course, some other software tools have been used as well such as: software for digital photogrammetry (aerial triangulation, DTM extraction, orthorectification, etc.), software for GPS data processing, RDBMS software, standard office software, etc.
Draft of the document called Surveying normatives (text in Serbian, Geodetski normativi) is used for the analysis. This document is published by Republic Geodetic Authority (RGA) of Serbia in 2002 and it contains figures pertaining to required resources (human resources and equipment) to finish certain phases of land consolidation ([2]). These figures are mostly obtained from experiences in the past, so it can be assumed that they pertain to the use of classical technologies for land consolidation. These figures are given in Table 4.

Table 4 : Normatives for works within consolidation phases if classical technologies are used

Land consolidation phase	ha/man-day	Total man-day
Acquisition of data from the cadastre and land book, public display of the situation before land consolidation, production of the register of determination of the situation before land consolidation and registering of changes, production of the overview map of current situation	5	334
Aerial photogrammetric survey, field preparation, making of the flight plan, photography	35	48
Determination of borders of land consolidation area, survey of long-term land use areas	-	12
Production of the book of land mass before land consolidation	10	167
Production of the records of the land before land consolidation and corresponding summary	20	83
Design of the field roads network, design of the irrigation and drainage network, design of the geodetic network	2.16	100
Analytical elaboration of the design project of land consolidation	2.5	670
Land mass redistribution, approximation of new parcels, parcellation, calculation of areas	4.97	336
Establishment of geodetic network, polygon network	5.45	306
Stake-out of the designed field roads network, stake-out of the designed irrigation and drainage network, stake-out of new parcels	2.5	668
Production of the records of the land after land consolidation and corresponding summary, production of the book of land mass after land consolidation, production of summary reports	15	111
Production of resolutions on redistribution of land mass	6	278
Cartographic processing of maps	4	417
Production of new field survey sketches	7	238
Cadastral land classification and agricultural valuation	65	26
Determination of area for cadastral municipality		3
TOTAL		**3797**

From experienced gained during the land consolidation of cadastral municipality of Nova Gajdobra new figures on required resources (human resources and equipment) to finish certain phases of land consolidation are obtained. The figures pertain to the new methodology to land consolidation using modern technologies (Table 5).

Table 5 : Normatives for works within consolidation phases if modern technologies are used

Land consolidation phase	ha/man -day	Total man-day
Determination of transformation parameters (WGS-GK), geodetic leveling, data processing	-	12
Aerial photogrammetric survey, field preparation, making of the flight plan, determination of coordinates for control points, photography, aerial triangulation, digital orthophoto production	-	20
Analysis of existing cadastral registers, processing of existing cadastral maps, digitization of cadastral maps data, calculation of areas, conversion of cadastral database	170	10
Determination of borders of land consolidation area	550	3
Production of the register of determination of the situation before land consolidation public display of the situation before land consolidation, invitation of owners, registering of changes and documents, printing of the register of determination of the situation before land consolidation,	7.5	225
Survey of long-term land use areas, constructions and changes on the field		3
Land evaluation, polygon overlay of parcels' layer and land evaluation layer, calculation of parcels' values, production of the book of land mass before land consolidation, production of the records of the land before land consolidation and corresponding summary, printing	1700	1
Production of maps, photogrammetric mapping, cartographic processing, printing	110	15
Design of the field roads network, design of the irrigation and drainage network, design of the geodetic network		80
Analytical elaboration of the design project of land consolidation		10
Land mass redistribution, parceling, calculation of new areas, Production of the records of the land after land consolidation and corresponding summary, production of the book of land mass after land consolidation, production of summary reports		200
Establishment of the geodetic network		82
Stake-out of border points for all designed objects (land consolidation blocks, parcels, field roads network, irrigation and drainage network)		120
Production of resolutions on redistribution of land mass		10
Production of digital cadastral map database and the list of areas	170	10
Production of new field survey sketches	420	4
Cadastral land classification and agricultural valuation	65	26
Production of cadastral database		1
TOTAL		832

Finally, a comparison table could be given for the engagement of resources for land consolidation works using classical and new methodology using modern technologies (Table 6).

Table 6 : Comparison of engagement of resources using classical and new methodology for land consolidation

Land consolidation groups of phases	Classical methodology man-day	New methodology man-day
Preliminary works	644	289
Land consolidation project design and project execution	2469	502
Closing works	684	41
TOTAL	**3797**	**832**

From the Table 6 it can be seen that savings in time and costs are significant. Even though figures given above pertain to the land consolidation of specific territory of Nova Gajdobra, based on the analysis of activities within certain phases of land consolidation process it can be stated that these figures are a good indication of improvements and benefits in general if new methodology is used. According to its area, number of parcels, condition of real estate register, type of terrain, ownership structure and other relevant parameters, cadastral municipality of Nova Gajdobra is an average cadastral municipality among those that are to be subjected to land consolidation. However, the analysis is based on figures given within the document made by Republic geodetic Authority ([2]). Figures given there are based on experiences gained within a large number of land consolidation projects executed in Serbia in the past. This document is the only relevant document of this type, but these figures have to be taken with a certain reserve. Organizational and other aspects of surveying companies has been changed a lot during the last few decades, so it is reasonable to assume that the overall efficiency of surveying activities is increased. Therefore, lower figures for man-days for classical methodology than those given in the previous tables should be more realistic.

6. CONCLUSION

Based on the considerations given in the paper, as well as the results from the experiment, an obvious conclusion could be made: application of modern technologies significantly improves the process of land consolidation. Savings in costs and execution time and increase in quality of works are tremendous. However, it can be stated that contribution of GIS, GPS and digital photogrammetry is not equal. Quantification of savings criteria clearly indicate that it is GIS technology that provides the greatest savings in time and resources. GIS and information technologies in general, if applied properly, can eliminate unnecessary waste of time and human resources required for the production of a whole range of paper documents during land consolidation process (register of determination of the situation before land consolidation, books of land mass for situation before and after land consolidation, records of the land before and after land consolidation and corresponding summaries, resolutions on redistribution of land mass, analog maps). Automatization of the process opens possibilities of concentrating human resources on more important issues that require human intelligence and cognition. On the other hand, standardized jobs are assigned to the machines.

Demonstrated possibilities and benefits of application of modern technologies within land consolidation will also lead to the new approach of planning land consolidations in Serbia. Until recently, execution of land consolidation required considerable time. This made the process unpopular in the ayes of land owners and decision makers (municipality authorities, ministry for agriculture) as well. It is reasonable to expect that the decrease in time for the execution of land consolidation, provided by the application of modern technologies, will result in more projects of land consolidation in the future.

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