

Can Volunteered Geographic Information be used for Cadastre? A case study in Greece for investigating the use of crowd sourcing techniques in creating Cadastral Maps

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Key words: Volunteered Geographic Information, Neogeography, Crowdsourcing, Cadastre

SUMMARY

What make citizens participate in mapping projects? What motivates them to get involved in a non-hierarchical network of individuals who collect, edit and share geospatial data? Would they be willing to participate in cadastral mapping as an alternative way to speed up the cadastral survey? The answers are still ambiguous. However it is a fact that the way geospatial data is used and the way citizens comprehend its importance have changed dramatically during the last years.

The paper briefly gives an introduction on the evolution of Neogeography and the citizens' involvement in spatial data collection, editing and uploading on the web, and of the introduction of the term Volunteered Geographic Information (VGI) and its adoption by the scientific community.

The application area chosen for the experiment is the rural part of the village "Tsoukalades", on the Greek island of Lefkada, which for several reasons has been under a cadastral survey for more than 12 years; so far the whole traditional cadastral survey procedure has been repeated four times due to a number of errors and disagreements between the land owners and the cadastral authorities. Fifteen volunteer land owners participated to a weekend experiment and collected geospatial data for the delineation of their land parcel boundaries on a cadastral map; the spatial data were collected with the aid of a handheld GPS after a brief training; the resolutions from the interviews with the land owners and the resulting citizens' cadastral map are presented.

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1. INTRODUCTION

The Volunteered Geographic Information (VGI) was coined as a term by Goodchild (2007) and was spread all over the world in a relatively short time. Its meaning is summarized by Sui (2008) and others as “the digital spatial data which is collected and edited not by data producers but by citizens who are not experts but willing to disseminate their spatial knowledge and observations” without any special invitation (Seeger, 2008). Blaut (2003) had earlier noticed the specific tension of all human beings to map by underling that all people have natural mapping abilities. In fact he predicted the evolution of mapping, the involvement of amateurs with the aid of web tools and the alteration of roles’ distribution between the mapping agencies and the users (Budhathoki, 2008).

Many different terms were invested since then, however Elwood (2008) was the first who differentiated them based on the content or the cartographic representation. In the first category terms such as *user generated content* and *collaboratively contributed geographic information* are included while in the second category terms such as *ubiquitous cartography* and *web mapping* are introduced. All these terms are parts of Neogeography (Turner, 2006) which constitute a general category including all the above. Neogeography “is about people using and creating their own maps, on their own terms and by combining elements of an existing toolset” (Turner, 2006). It is clear that although various terms are given to the phenomenon, the general meaning is the same and it is based on a “crowd sourcing” philosophy.

Many reasons contributed to VGI’s success. Affordable computer power, low cost of the equipment, widespread of broadband connection and dissemination of dynamic maps (Perkins and Dodge, 2008) are a few of them. Among the various technological and economical aspects human reasons are also included. One of them can play a critical role on the creation of accurate cadastral maps: locality.

VGI has cultivated this sense of locality. It is considered that no one knows the local area better than the residents. The whole project is based on the aid provided by the local people in many cases. The Mapchester was created within a weekend. However, the whole effort was based on the residents’ aid. Seeger (2008) notices that a volunteer offers valid information only if he is local or part of the community. The most remarkable example is the information which was provided by the residents to the whole world after the Hurricane Katrina and Haiti earthquake. Goodchild (2008) summarizes the need of local contribution to mapmaking in

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one phrase by saying that “residents of a neighborhood are inherently experts in the local area”.

However, a few concerns arise due to the volunteers’ involvement in local activities. Elwood (2008) writes that differentiations to the assigned geographic information may be noticed due to citizens’ priorities, experiences and identities. Although Flanagan (2008) notices the credibility’s importance as a combination of both trust and expertise explains that trustworthiness and expertise have both objective and subjective components. It is obvious that Volunteered Geographic Information is based on subjective reasons.

On locality’s power and the participation of citizens in the land planning as active cells of the society is based the idea of incorporating the Volunteered Geographic Information into the cadastral procedure. Generally, cadastre is an essential tool for land management and administration as it records the land parcels which constitute a part of a country’s spatial information infrastructure. As UN ECE (2005) emphasize among the various benefits of cadastre, the existence of a good land administration system guarantees the ownership, supports the fair property taxation, supports and monitors real estate markets and can act positively in reducing land disputes. A further research of the UN (Tsenkova et al, 2009) in their publication named “self-made cities” underlined the necessity of planning as an essential tool to deal with informal development which should ensure a high level of citizen participation.

Having underlined the importance of land administration and the potential participation of volunteers, the role the citizens can play in the cadastral procedures should be re-defined taking into consideration FIG Commission 3 (Doytsher et al, 2010) remarks that there is a need for better investigation of the capacity of governmental agencies to monitor, evaluate and interpret the volumes of collected data through crowd sourcing methods; raising public awareness about the benefits citizens will enjoy; raising public trust, and establishing policy frameworks legally for the appropriate use of VGI.

2. CROWD SOURCING IN CADASTRE

2.1 State-of-the-art in VGI accuracy and Cadastre

Can the VGI be incorporated in Cadastre and in which extend? The evaluation can be implemented only in terms of taking into account the accuracy. As Helbich (2010), has noticed, severe concerns and limitations affect spatial accuracy; the most important are the technological bias, the various data acquisition techniques and the subjective process in data acquisition.

Many researchers have focused their attention on evaluating VGI’s accuracy over navigation. Haklay (2008), Ather (2009), Basiouka (2009), Kounadi (2009), Zielstra (2009), Ueberschlag (2010), only few of them are evaluating the accuracy of the OpenStreetMap – the first crowd sourcing map - which constitutes one of the most representative examples of spatial data

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derived by non-experts. The results were encouraging about the future of the specific data and its potential use. Moreover, Haklay (2010) did a further research proving that a sensible number of volunteers per area can eliminate the errors in mapping.

Laarakker (2011) initiated a first theoretical approach to introduce the VGI in an alternative open and flexible cadastral system by identifying the strengths and the concerns over the success of this integration. The concerns are divided into two main categories; the technical and the socio-organizational ones. The technical include the quality control of OpenStreetMap and OpenCadastralMap and the constructive technology while the socio-organizational are focused on the necessity of the project, the role that the government will play on it, the legitimacy control and the economic effects.

The major differences between the VGI and the OpenCadastralMap techniques are focused on the contributors' interests which are rather opportunistic than altruistic and the standard exchange mechanisms that are adopted in VGI environment and they are not stabilized and well defined as the official cadastral agencies prefer. The research raised operative and hierarchical differences which concern the maintenance and coordination of the volunteers and the geographic information system which should be identified in a more detailed evaluation. The author concluded his approach by underlying that "there is not much difference between the uploading of the contours of a road and those ones of cadastral boundaries predicting a positive evolution of the idea.

It is clear that the magnitude and the depth in which the VGI can be used for the creation of cadastral information are not known yet.

2.2 The Hellenic Cadastre Project- a Brief Review

The Hellenic Cadastre (HC) Project started in 1995 and cadastral surveys have been carried out in 340 regions all over the country while 95 Cadastral Offices have already begun operations in these regions. The responsible agency for the HC project is KTIMATOLOGIO SA (KT). The whole process is divided into two phases. The first one started in 1995 and ended in 2008. As of June 17th 2008, the second phase of cadastral surveys is in progress in 107 Municipalities, Communities and local districts in Attica, Thessaloniki and the capitals of prefectures which were not surveyed along the lines of previous surveys (Rokos, 2009). It is estimated that from June to December 2008, more than 2.8 million people declared to the Cadastre about 5.1 million real property rights. In the same period 17,000 legal entities declared another 700,000 ownership rights (Hellenic Cadastre, 2011). The compilation process is focused on collecting, editing and recording property and other registerable rights per property unit offering the opportunity for an accurate, authoritative and assured (AAA) cadastre (Williamson, 2011).

The main cadastral survey procedure includes the following stages:

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- Declarations are submitted to the Cadastral Survey Offices by the right holders and the registration of the declared rights is introduced in a digital database.
- The interim cadastral tables and diagrams are formed based on the data that has been collected from the submitted declarations and has been processed by lawyers and surveyors.
- The interim cadastral data is suspended at the Cadastral Survey Offices for a two-month period and dispatch of extracts is sent to the right holders for their information and acceptance.
- Objections or applications for correction of a cadastral registration are submitted and forwarded to independent administrative committees, depending on the case, by whoever has a legal right.
- The cadastral data is reformed after the examination of the objections and the correction claims and the final cadastral tables and diagrams are formed. These registrations are called Initial Registrations and they constitute the first registration in the Hellenic cadastre.
- The Cadastral Office is in operation in the particular area replacing the old Land Registry Office (Hellenic Cadastre, 2011).

3. CASE STUDY

The area of interest Lefkada is an island of the Ionian Sea and belongs to the Ionian islands complex. It lies between the islands of Corfu and Kefalonia. It is very close to the shores of the western mainland of Greece covering an area of 302.5 square kilometers and is the fourth in size in the Ionian islands complex, with a population of 23.000 people.

The community of Tsoukalades is one among seven communities which apart the municipality of Lefkada. Tsoukalades village is located in 220 meters elevation in the north-west part of the island and it has 431 habitants according to the last census. However this record varies depending on the season of the year.

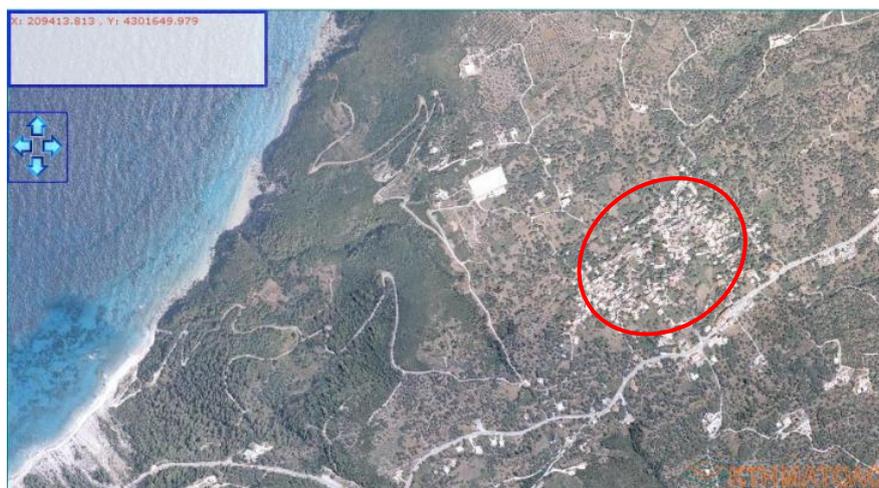


Figure 1: The community of Tsoukalades and the area of interest (marked in red)

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The compilation of the cadastral survey began at the community of Tsoukalades (Figure 1) during the first phase of cadastral surveys and it is still uncompleted due to errors and discrepancies between the existing properties and the cadastral maps produced by the contractor responsible for the cadastral survey, despite his efforts to re-survey the area. The main errors, according to the cadastral agency, are noticed at the *location, shape and boundaries* of the land parcels. Errors are also noticed at the *records of the cadastral tables* where properties are recorded to belong to “*unknown owners*”. In an effort to unblock the market KT tried to identify the size of the problem; for that the boundaries of the parcels in two cadastral units numbered 340370913 & 340370914 were resurveyed by the qualified staff of KT during the summer of 2009 (Papadopoulou, 2010). The process has been implemented in cooperation of KT and the municipality of Lefkada and the new cadastral maps and records are related to those provided by the contractor.



Figure 2: Cadastral survey produced by the contractor (in red); cadastral survey produced by KT (in green)

The owners were asked to indicate the boundaries of their parcels during the re-survey and draft sketches were designed by the KT experts during the field measurements. The authorities recorded the owners' and/or witness's name. New digital cadastral diagrams were compiled on large scale orthophotos (LSO) produced in 2007 by KT as cartographic base maps. A new correction process was adopted. All records were checked and compared to the new spatial data. The obvious errors were corrected administratively, with a decision by the head of the cadastral office and all individual cases were checked no matter whether the parcels were declared by the owners or were located after the correction. Figure 2 shows a

part of the cadastral map created by the contractor (in red) and the new survey by KT (in green); large discrepancies in location, shape and size of parcels can be identified which means that gross errors have been made during the first cadastral survey.

The final cadastral diagrams and tables have not been formed yet. The next steps of the re-survey process followed by KT include:

- Cadastral tables and diagrams will be suspended at the cadastral office and the Municipality office of Lefkada at a scale of 1:1500 on the LSO orthophoto.
- Extracts from the cadastral registrations will be sent by post mail to those who have declared a right. Through the suspension procedure the right holders will be able to check the content of registrations and either accept the new boundary survey with attestation of the originality of the signature or submit objections to any errors or oversights.
- Detailed information is attached to each letter which will be sent to the interested parties explaining the process that they should follow and the actions that have been completed until now.
- The whole process will be open to anyone with an interest so that he/she will be able to submit an objection. The coordinates of each parcel will be made public so that the accuracy of the cadastral extracts to be tested.
- Announcements will be posted at the communal office of Tsoukalades so that all interested parties will be informed under the responsibility of the Municipality of Lefkada.

According to KT after the re-survey of the cadastral units 340370913 & 340370914 six error categories are identified on the cadastral survey and the cadastral diagrams delivered by the contractor. The various final cadastral extracts (after the re-survey by KT) send to the land owners by KT for verification and objection submission included:

- Land parcels which have been redefined into the same cadastral unit after the boundaries or location correction.
- Land parcels which although they were declared by the owners within the declaration period they were not recorded by the contractor in the interim cadastral plans. The aftermath research proved that they should be registered into the cadastral records.
- Land parcels which were registered into the interim cadastral plans by the contractor as belonging to wrong cadastral units but after the re-survey it was found that they should be relocated within the cadastral units 340370913 & 340370914.
- Land parcels which had to be removed from the cadastral units 340370913 & 340370914 as after the re-survey it was discovered that they belong to other units.
- Land parcels that were not registered into the cadastral records at all. They were indicated during the re-survey by KT and defined to be within the cadastral units 340370913 & 340370914. However, the specific parcels cannot be legally recorded to their owners now within this process due to legislation restrictions.
- Land parcels which are located in adjacent cadastral units and are affected geometrically due to the correction of the boundaries of the unit which is under re-survey.

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3.1 The Use of crowd sourcing in improving the draft cadastral survey

The northwestern part of the area of interest having the unique cadastral code 340370914 was mapped during a weekend; nineteen parcels were traced with the aid of a handheld GPS, fifteen volunteers and three experts from the research team of NTUA participated to the project. The idea was adopted from the weekend mapping parties which are organized in the United Kingdom for cartographic purposes (Basiouka, 2009). The parcels were chosen randomly so that the sample will be representative. Not all the parcels of the area were mapped because not all the interested parties were present at the island of Lefkada or were available to participate when the experiment took place. The volunteers that participated were encouraged to show the boundaries of their ownership and collect the tracks by themselves using a handheld GPS provided by the School of Rural and Survey Engineers (SRSE). The research team has contacted the local authorities; the local authorities informed the land owners and asked for volunteers; a meeting was arranged between the research team and the volunteers to explain them the objectives of this research and the use of handheld GPS; data have been collected by the volunteers; interviews and discussion was arranged after the data collection; final data editing was made by the research team in the office.

The adopted methodology was the absolute kinematic positioning which is primarily used for navigation. This method is appropriate for determining the position of boundaries by walking around their perimeter (Pacione, 1999). Its first advantage is that the data are collected in a relatively quick time. There is no risk for gross errors (such as location of a parcel in a neighbouring cadastral unit) as the land owners know the place well. Moreover only a single low cost GPS device is needed. Its main disadvantage is that the accuracy of handheld GPS devices is influenced by several factors and varies with the location and the terrain relief where it is being used. The accuracy of GPS is also dependant on the signal strength. Many different environmental factors can also affect the accuracy of GPS receiver. Atmospheric conditions can also degrade the accuracy of the GPS unit.

A good estimate usually varies between 5 meter and 10 meter. Moreover, the kinematic positioning is vulnerable to multipath and obstructions to satellite signal and especially in the area of interest which was an olive grove.

What made the volunteers participate to this experiment? The question is quite simplistic but the answer is clear. As Kingsley (2007) has noticed the civil society shares the same goals and has created a non hierarchical network of self – organized individuals. The interview with the volunteers showed that the specific network of volunteers was willing to participate so that the time and cost of cadastral surveys to be minimized and the errors to be eliminated; as they have experienced the disadvantages of the formal cadastral procedure at first hand, they themselves have pointed out that the procedures should be simplified, costs should be reduced and finally the real estate market start operating again.

The identified strong points of the experiment are:

- The participation to the project was noticeable in accordance to the magnitude of the village especially if it is taken into account that the experiment was actualized during the summer period under hot weather conditions.
- The volunteers were extremely willing to participate to the project due to the inconvenience they had received by the formal cadastral survey; they answered sensitive personal information concerning their property (e.g., the objections preparation and submission in order to correct the numerous errors of the cadastral survey prepared by the contractor is very expensive; property market was blocked for 12 years, etc).

No boundary disputes among the owners were noticed. Although a few owners were not present at the area of interest when the experiment took place many relatives of them or simply their neighbors offered to show the boundaries of those properties which were the actual ones according to the last cadastral extract provided by the KT agency.

The identified weaknesses of the experiment are:

- Accessibility was limited in some points due to spikes or cultivated crofts. Due to the olive trees the GPS signal was obstructed in a few cases.
- Some elder volunteers provided with a handheld GPS were not familiar with new technologies preferring keeping a supervising role indicating the boundaries of their parcels to the younger.

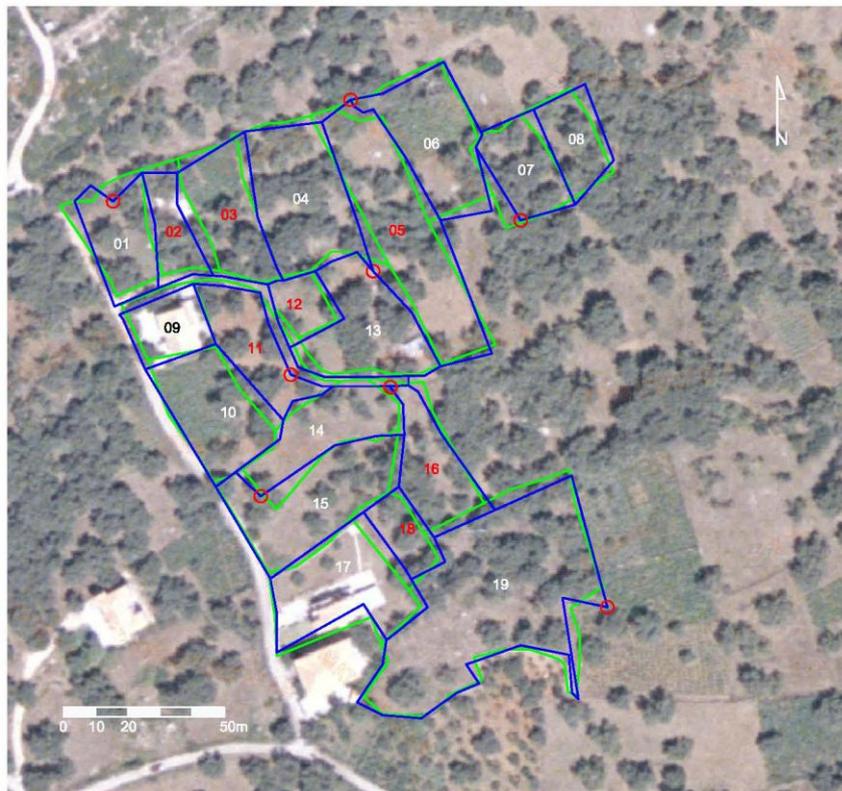


Figure 3: Cadastral re-survey provided by KT (in green) is compared to the land owners cadastral survey (in blue)

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Editing of tracks and creation of cadastral extracts was done by the researchers' aftermath at the laboratory.

The comparison (Figure 3) of the cadastral survey produced from measurements taken by the volunteers to the cadastral re-survey provided by KT (Figure 2 in green), which is considered to be the accurate cadastral map, shows as expected some discrepancies at the boundary nodes and the boundary lines of the parcels. More specifically eight of the hundred measured nodes (in total) have coordinate deviations greater than 5m (these nodes are marked in a red cycle in Figure 3); the area size of seven out of the nineteen land parcels (37%) differs from the correct size (the one of the KT's re-survey) more than the acceptable tolerance of the technical specifications of the Hellenic Cadastre (these parcels are marked with a red cadastral code number in Figure 3). However, the location and shape of all land parcels are correctly defined and the majority of the land parcels' area size is sufficiently defined (within the requirements). On the contrary in the cadastral survey delivered by the contractor, although high accuracy surveying instruments were used and the formal procedures specified in the technical specifications of KT had been followed, almost the total of land parcels were wrongly shaped and the area size of only 10.5% of them was within the technical specification requirements. It must be mentioned here that this is not an exceptional situation in the Hellenic cadastral process in the rural areas on the islands; e.g., so far similar problems have been identified in the whole islands of Lefkada, Mitilini, Chios, Alonisos and KT currently investigates the most appropriate procedure to correct these cadastral surveys delivered by the contractors.

3.2 The Problems in Property Registration and Property Market in the Area

During the second day of the experiment, all volunteers participated to a meeting and were interviewed for the process of the formal cadastral survey in their community. Based on the volunteers' interviews the greater area was re-surveyed more than four times.

The first cadastral map version was done at the cadastral office of the island where the land owners were asked to define the boundaries of their land parcels on orthophotos for the compilation of the cadastral maps. The result was not successful as the rural area is covered by trees so the exact boundaries and location of the parcels was ambiguous and the visual recognition was difficult. A re-survey was then attempted in the field by the contractor with the aid of a handheld GPS, but without the involvement of the land owners. The result led to a general misplacement of several parcels within the same Cadastral Unit or even in different Cadastral Units, even in different Communities. The contractor tried to improve the situation without any significant results and the cadastral study was delivered to KT.

Due to the increased number of remaining objections, once again surveyors went to the field as members of joint committees of the Hellenic Mapping and Cadastre Organization (HEMCO)-the supervising agency- and KT-the agency responsible for the cadastral survey-

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to investigate the amount of errors claimed by the owners and to estimate the size of the problem.

KT then commissioned a complementary cadastral survey study and so the area was surveyed with the aid of total stations and GPS, according to the technical specifications, by a new private contractor who however undertook to correct the errors in only some scattered areas within the greater area.

As a great number of errors still exist the cadastral survey cannot be finalized yet and, due to that, the real estate market is blocked in the greater area for more than 12 years. To overcome the problem the new management of KT decided to fully re-survey the two cadastral units (those under study in this paper) in order to investigate the most appropriate procedure (within the existing legal framework and the technical specifications of the project), times and costs for a total re-survey of the area; the cadastral maps of these two cadastral units are still at the suspension process open for objections submission.

The volunteers were also interviewed about the major problems they had faced during the whole process of the formal cadastral survey.

Among all, the most important ones, according to the land-owners view, are:

- The cost of the whole cadastral survey process is extremely high. The owners are led to pay to private lawyers and surveyors more than 2000€ to prepare the request for correction of their declared ownership any time they submit an objection. The specific amount is given for each parcel separately, on top of the fixed cadastral survey fee that has to be paid by each right holder when an area is declared to be under cadastral survey.
- The long duration time of the whole process has led to great discomfort for the owners.
- For more than 12 years the owners are unable to transfer their properties as the region is still under cadastral survey and the boundaries or the location of their parcels are not fixed although they are obliged to pay all property taxes for it.

4. CONCLUSIONS AND PROPOSALS

The first approach to use crowd sourcing techniques in the compilation of cadastre maps in rural areas shows that owners are willing to participate. The formal procedure which requires that owners will identify their parcels on orthophotos at the cadastral office seems to be difficult and confusing to most of them. The results of this procedure can be so confusing that the whole cadastral survey can be delayed for decades, costs can be increased and the impact on the market can be huge. On the contrary it is easy and cheaper for the owners to collect raw measurements on the field by themselves. No gross errors in the location of parcels have been detected during this experiment. It needs to be further examined how the measurement accuracies can be further improved and how far the land owners involvement in the cadastral survey process can be extended. Currently, it can be said that Volunteered Geographic

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Information can be integrated in a practical form to the cadastral surveys although there are still concerns that the procedure is not regulated yet. The first practical approach was positive although a more detailed research is still required.

The involvement of volunteers in the cadastral surveys should be extended in the data collecting and editing process for the compilation of the draft cadastral maps in the rural areas where there are no addresses and the visual recognition of land parcels on orthophotos is difficult for the land owners. Further research will be done by the research team to investigate the potential involvement of land owners in the editing of the collected data as the real meaning of voluntarism supports, and to identify a new role of the local authorities that may facilitate the cadastral survey by providing the volunteers with open software and the equipment but also by facilitating some brief training of the team leader. Registration fees should be reduced as the land owners will actively participate to the cadastral survey, gross errors and objections will be eliminated and the duration of the survey will be reduced dramatically. Land owners will be willing to participate.

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