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OpenStreetMap for cadastral purposes: an application using VGI for official processes in urban areas

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Abstract

The scope of the paper is to test if the online dynamic maps such as the OpenStreetMap (OSM) can be used for official mapping projects such as Cadastre, to investigate the advantages and the concerns of online and open to the public procedures and to identify those differentiations between experts and amateurs that play a critical role in such official projects. The specific research is focused on the use of OSM in urban areas as an alternative method to the official cadastral surveys. This paper presents the possibilities and the perspectives of OSM for spatial and attribute cadastral data collection and storage for the compilation of draft cadastral maps as an alternative methodology within the terms of the volunteered geographic information (VGI). The authors carried out a practical experiment in an extended part of the historic city centre of Athens and updated

the online dynamic map of OSM with attribute and spatial cadastral data. Surveying students explored the capacities of the dynamic map in two steps: (a) in a section where the polygons of the buildings already existed on the map, they had to improve it with attribute data, and (b) in another section where no relevant polygons existed, a spatial and attribute data enhancement was required. The research was based on the various approaches that each student adopted and the freedom that the OSM offers to the users. The results show that users can easily distinguish the differences in capacities between the OSM and the commercial software; the inexpensive, easy to use and quick methodology of the OSM in contrast to the accurate, authoritative and assured methodology of the commercial software.

Keywords: VGI , Crowdsourcing , OpenStreetMap , Cadastre , Land management and administration

THE OPENSTREETMAP FOR CADASTRAL PURPOSES: AN APPLICATION USING VGI FOR OFFICIAL PROCESSES IN URBAN AREAS

Sofia BASIOUKA, Chryssy POTSIOU and Efthimios BAKOGIANNIS, Greece

Key words: VGI, Crowdsourcing, OpenStreetMap, Cadastre, Land Management & Administration.

SUMMARY

The scope of the paper is to explore if the online dynamic maps such as the OpenStreetMap (OSM) can be used in official procedures like the Cadastre, to investigate on the strengthnesses and the concerns that arise from online and open to the public procedures like this, and identify those differentiations between experts and amateurs that play critical role in such official efforts. The aim of the specific paper is to explore the potential of using the OSM for cadastral procedures in urban areas as an alternative proposition towards the official processes. The research presents the possibilities and the perspectives over a potential use of OSM for spatial and attribute data collection and storage for draft cadastral procedures and propose an alternative methodology within the terms of the Volunteered Geographic Information (VGI).

The research team carried out a practical experiment in an extended part of the historic city centre of Athens and update the online dynamic map of OSM with attribute and spatial data. The students explored the capacities of the dynamic map in two steps; In an area where the polygons of the buildings exist on the map so they had to improve it with attribute data and in an area which required spatial and attribute enhancement as well. The research was based on the different approaches that each student adopted and the freedom that the OSM offers to its users.

The findings indicated an irresolute trend between the inexpensive, easy to use and quick methodology that the OSM offers in its use and the trustiness that the conventional software has influenced to its users.

THE OPENSTREETMAP FOR CADASTRAL PURPOSES: AN APPLICATION USING VGI FOR OFFICIAL PROCESSES IN URBAN AREAS

Sofia BASIOUKA, Chryssy POTSIOU and Efthimios BAKOGIANNIS, Greece

1. INTRODUCTION

The general fact that "accessing maps via the web has become perhaps the first step for the general public when they seek geospatial information".(Cartwright, 2003) has been enhanced during the last years due to the active participation of non-experts not only in data use but also in data manipulation. Perkins and Dodge (2008) described the main reasons of the exploitation of the geospatial information. There was not only the affordable computer power but also the mass markets of the GPS and the broadband internet that have led in that direction. Keogh and Fraser (2006) also present the free satellite imagery as one of the most important tools at the map data displays.

As a consequence, a new era raised on the web which has caused a great evolution in digital mapping. Between the static and the dynamic maps which constitute different forms of mapping the most successful are the interactive where users' actions are responded to real time by a map server as Peterson (1997) admits. Doyle (1998) supports the same perception by noticing that the advent of the computers facilitates the advance of GIS, multimedia and virtual reality. The involvement of amateurs in data manipulation which makes indistinguishable the role of users and creators has offered a new perspective at the distribution of dynamic maps. The Volunteered Geographic Information (VGI) was first given as a term in 2008 by Goodchild and easily was adopted by the research community worldwide to explain the phenomenon. Declaring the great innovation that was represented due to the great engagement of citizens in the GIS creation, Goodchild (2008) first noticed the change that comes to the relationship between the public and the spatial data. Elwood (2008) was also the first who distinguished that the term VGI is focused on the data itself, its use and its origins.

One of the most representative examples of dynamic maps which have flourished with the aid of amateurs and stay updated with their daily contribution in the OpenStreetMap (OSM). The OSM as a project started in 2003 and was founded by Steve Coast in an effort to create the first free of restrictions map. As the welcome message reveals in the home page (OSM, 2014), the OSM is a voluntary, free of charge project which provides the users with online maps. The key of its success is that it has been created from non-experts. Its main purpose is the creation of a free digital map of the whole world which will have been created from non experts. Different terms have been used for the characterisation of the OSM project. Many researchers have categorised it as "Volunteered Geographic Information" while others as "User Generated Content" (Sieber, 2007) and some others as a global phenomenon which has derived from civil society. Kingsley (2007) first introduced the term of "civil society"

for a non hierarchical network of self – organized individuals who contribute to mapping by using global mechanisms. It is clear that although different terms are given to a phenomenon, the general meaning is the same and it is based on a "crowdsourcing" philosophy.

The main factors of its success are mainly four; time, cost, public participation and free distribution of data.The speed in which the project is covered can be characterized as heady. Large areas have been mapped in relatively quick time by volunteers. The fact is that the national mapping agencies would need more time and money for mapmaking these areas. The cost is another important factor which turns OSM to be so successful. Not only is the equipment more affordable but also the staff offers its services voluntarily. As Mayo (2007) admits there are many voluntary organizations which complain about being unable to afford official mapping data and Perkins and Dodge (2008) state that the cost for the national mapping agencies is extremely high. Moreover, the OpenStreetMap is a nonprofit social network which means that the users are not bombarded with advertisements or other commercial offers. OSM follows Brown's (2001) philosophy which says that the web would be better off if community were left to non profit entities. The users of the OSM are not exploited in other manners for the services which are offered to them.

Although the benefits from the OSM are unexceptionable, there are two basic concerns that have arisen from its use. First of all, OSM is manipulated from people that are non experts in cartography, in mapmaking and in surveying. Goodchild (2008) notices the reasons that have lead to this trend. Not only do the free tools not require great expertise but also the GPS equipment has facilitated the data collection. Secondly, what Tulloch (2008) names digital vandalism, yelling and deliberate misdirection is under consideration since OSM was launched. The impacts in OSM may be various and they lower the offered quality. The whole philosophy is based on the altruism of the editors. Although, it is taken into account only the good motivation there are many concerns which arise.

2. LAND MANAGEMENT AND CROWDSOURCING TECHNIQUES

Within the new era that has raised in web, the great possibilities that are offered to the users via the dynamic maps and the new technologies which have invaded into the manipulation of data, another field presents great interest due to its socioeconomical perspectives; Land Administration. It's importance has been underlined by Williamson (2012) who has given three main characteristics of a proper land administration system. It should be accurate, assured and authoritative. Enemark (2014) gives another direction to the Land Administration Systems (LAS) by introducing the fit-for-purpose Land administration which should be flexible, inclusive, participatory, affordable, reliable, attainable and upgradeable.

The necessity of a proper Land Administrative System as a tool of land management is not new. The local communities recognize how strictly correlated are the decision making policies to the LAS during the last decades.Theoretically, land administration is defined as the process of determining, recording and disseminating information about the tenure, value and use of land when implementing land management policies (UN – ECE, 1996).

Practically, it is generally approved that the main targets of development in each country are defined among others by local history, ethical issues, and governmental policies which require the proper implementation of Land Administration Systems. Both approaches, theoretical and practical converge to the same outcome; LAS is not only a sign of local development and organization. It reveals a civilized community.

Apart from all theoretical approaches, only the 25% of the land parcels have been formally registered in LAS (McLaren, 2011). Due to these two main controversial aspects, the universe trend leads to a Public Participation Geographic Information System which "is a field of research that, among other things, focuses on the use of GIS by non-experts and occasional users" (Haklay, 2003) and empowers GIS users to use the technology purposefully to capture their local knowledge and advance their goals (Talen, 2000).

The Volunteered Geographic Information has invaded in many applications worldwide due to the needs and the challenges that nations and populations face. However, there are still many concerns for its implementation in governmental projects for land administrative purposes. For example Sui (2009) has declared that it is unlike VGI to obsolete many of the conventional GIS practices by government or industry. A more recent research carried out by Haklay (2014) explored the potential of incorporating crowdsourcing applications in governmental projects and investigates on real experiments worldwide by volunteers. The interest of this research is focused on the part of Land Administration and especially Cadastre which can flourish with the aid of VGI. (figure 1)

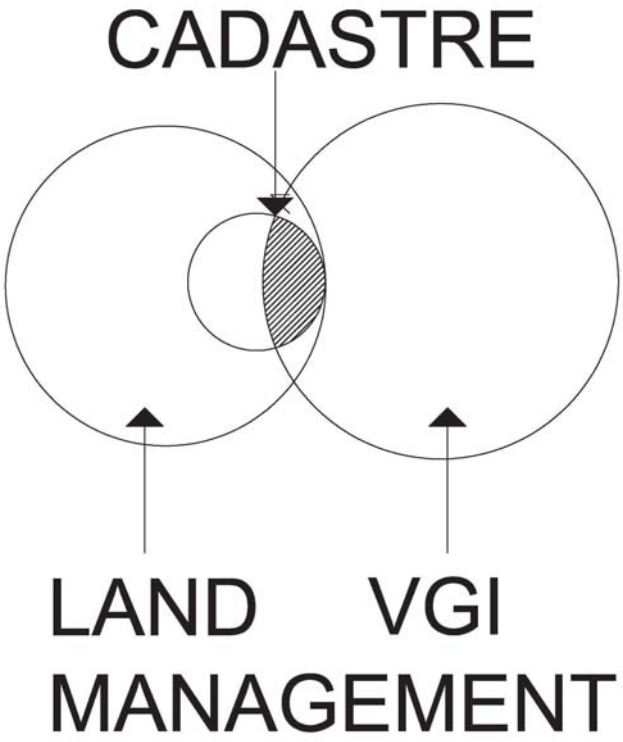

Figure 1: The research field

The research worldwide has indicated a new trend in the investigation of crowdsourcing in Cadastre. Laarakker and de Vries (2011) gave the term Opencadastre by exploring potential perspectives and weaknesses of such an approach. Basiouka and Potsiou (2012a) carried out the first practical applications worldwide with the aid of handheld GPS and innovative techniques in rural and urban areas. Since then, the research has attracted the interest of Navratil and Frank (2013) and De Vries et al (2014) who investigated on the term Neo-cadastres in an effort to explore the involvement of VGI within the traditional methods of Cadastre.

Although the skepticism around the potential combination between Land Management and VGI remains in theoretical levels by the opponents, successful practical applications take place in large extend worldwide. The main reasons of their flourishment are mainly focused on the special needs of every society, the limited time and the lack of resources that are prohibited for conventional practices. The perception that only developing countries adopt crowdsourcing techniques is mistaken. According to other myths, the developed countries are not interested in crowdsourcing techniques, the societies are reluctant into voluntary participation and experts are hostile. Below, are given three successful examples of practical applications that use crowdsourcing in Land Administration.

- Crowdsourcing satellite imagery in Somalia is a project that was launched in an effort to map all shelters that are located in the Afgooye corridor with the aid of satellite imagery.

- Shelter Associates, slum mapping in India is an NGO project which is focused on housing projects, sanitation, health and education initiatives in India. It is a hybrid model with expert and local volunteer contributors and has used GIS since late 1990s for informal settlement mapping. (Shelter Associates, 2014)

- MapKibera is the third successful project which is focused on the creation of topographic and purpose-build maps for the management of supplies in health, education, security and water sanitation in one of the biggest informal settlements of the world. (MapKibera, 2014)

3. THE PROPOSED CROWDSOURCING CADASTRAL MODEL

The proposed crowdsourcing cadastral model is based on the participation of citizens in a semi-hybrid approach where citizens participate as volunteers and experts work as leaders supervising the whole process. The semi-hybrid model can be applied and used either in local or national level; it can have a wider application in many countries and communities that face land issues.

The model includes both amateurs and experts for its implementation. For its success, it requires the participation of locals, experts and NGOs while the coordination will be carried out by the official mapping agency. Thus, a wider participation and application for land tenure and registration can be gained. The citizens will participate not only in spatial but also

at the attribute data collection. The practical experiments until now have indicated that both procedures can work efficiently with their aid (Basiouka and Potsiou, 2012a, 2012b) and contribution although different methodologies have been adopted in each one. For its implementation basic training and workshops will take place at the beginning of each application. Also, supervision and quality controls will be carried out by the experts (figure 2).

Figure 2: The proposed crowdsourcing cadastral Model

The process will be based on open and commercial software as well because the experience has indicated that their combination offers the required freedom that the openness that these projects require.

The spatial collection of parcel boundaries may be done with three different methodologies. The first approach is focused on the plain declaration of the ownership by giving the point of its centroid. The benefits are obvious; a quick and inexpensive method which can be implemented only with the participation of citizens. The volunteers can take a single measurement and can declare their ownership online. However the boundaries are not obvious and the centroid may vary in perplexed shapes. The specific proposition fits in areas where the official cadastral declaration is in preliminary stage.

The second approach is focused on collecting the parcel boundaries with the aid of handheld GPS, tablet or smartphone. Although the approach is quite vulnerable in terms of quality, it can be used for the creation of the draft cadastral maps. The volunteers can collect spatial data with experts' support after having been trained. The society is put in the centre of decision making policies which is vital for the success of projects that affect the life of citizens.

The third approach follows the online approach. The citizens can declare their ownership by using online dynamic maps and online orthophotos which are provided via the website of the official mapping agency. The experience has indicated that the specific methodology is extremely successful in urban areas where the construction system is continuous with blocks of buildings and the spatial data collection with smartphones or GPS fails to access either the vertex of the boundaries or the required accuracy due to the signal discrepancies.

The correlation between the OSM and the Cadastre as an easy and quick idea for the creation draft cadastral maps came due to the lack of other accurate way for mapping in

urban areas. The restrictions that the official mapping agencies have posed in measuring turn the use of handheld GPS prohibited. Although in urban areas there are high resolution satellite images, the majority of the agencies ask for field measurements which is not only expensive but also time consuming.

The attribute data collection can be implemented with the aid of online databases which can store and maintain the saved information. Until now, the declaration of the property in Greece follows the hard copy methodology. The owners have to fill an application and submit it in the cadastral office. The specific process can be replaced by an online application via web or by using applications in smartphones. It is clear, that the VGI methodology is open and can offer various approaches depending on the different needs of every land administrative project.

4. THE APPLICATION

The practical application took place as an experiment with the aid of 20 undergraduate students of the School of Rural and Surveying Engineering, NTUA who undertook the module "Cadastral Systems Development and Management" of the 9th semester. The experiment was carried out at the historic city centre of Athens and the area was divided into two parts; the first part was enhanced with attribute data and the second part with spatial and attribute data as well. The first area is located at the eastern part of the Acropolis and northern of the Acropolis Museum. The second area is southern of the Acropolis and directly adjacent to the Acropolis Museum. It is remarkable that within the parcels that were edited by the students was the parcel of the Acropolis Museum which lacked before the experiment attribute and spatial information.

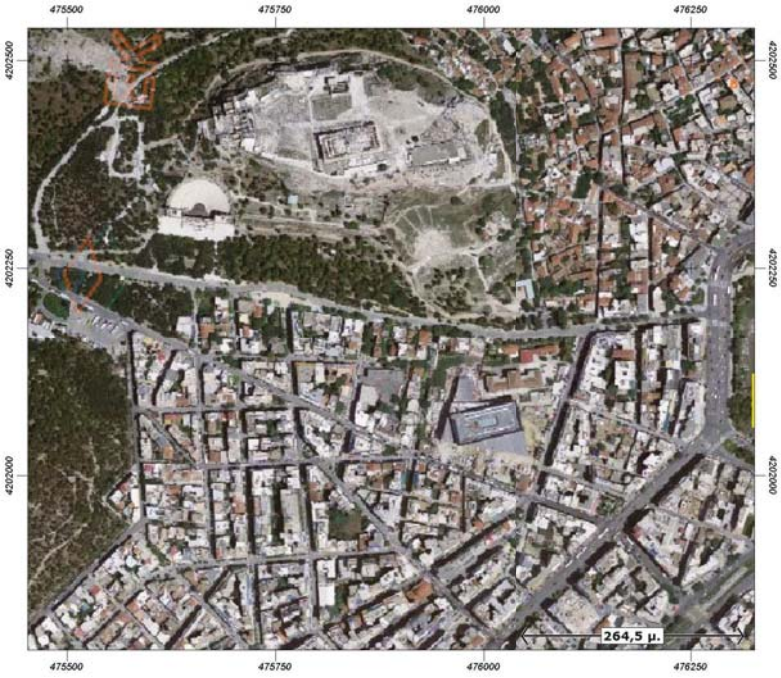

Figure 3: The area of interest (Source: Ktimatologio S.A.)

The two areas were divided into blocks and each student edited two or three blocks of buildings depending on their size and left free to fill the required information.

4.1. The area of interest

The area of Plaka is a historical neighbourhood of Athens, in the heart of the city centre with predominant cultural and historical significance. The urban planning of the area is constituted by small, narrow paths and blind alleys, small houses that do not exceed the two floors and private yards. Its land use is restricted to general residence with small shops that cover the local needs of the inhabitants and small touristic shops and cafes or restaurants for the needs of the visitors. According to the Ministry of Finance, the land value per square meter fluctuates between 1550 to 3000 euro.

The neighborhood of Plaka is protected by the greek legislation and the UNESCO as well with a series of laws which target to protect and maintain its unique physiognomy. A series of laws protect its architecture, the monuments that are located within it, the permitted land use in the wider area and its archaeological importance. The greek state has enacted degrees for all the manifestations that rule the area of interest. It is remarkable that there are more than 30 single legislations concerning the specific area, underlying its significance and the necessity for holistic protection. 24 single laws protect the area archaeologically, 4 laws pose the rules for urban planning and 1 law investigates on the land use.

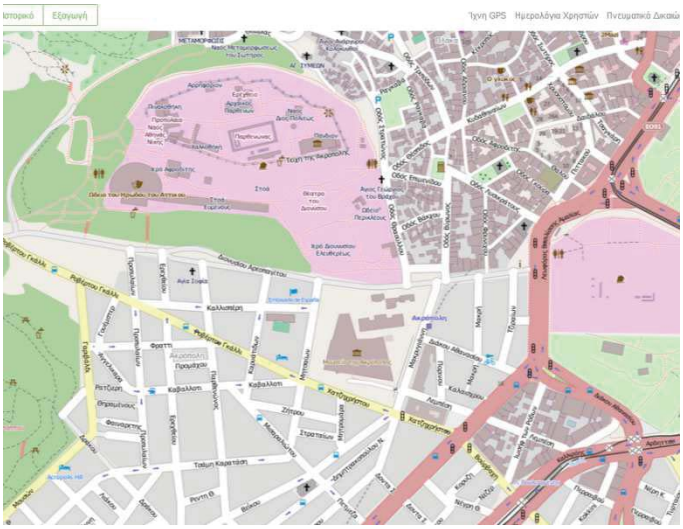

Figure 4: The area of interest before the experiment (Source: OSM)

4.2. The OSM approach

The practical application divided into five main steps; training, quest of legislation and planning restrictions, data collection and manipulation, evaluation of the process. After a brief training the students were left free to adopt the desired methodology and face the case study according to the requirements that the research team posed. The students were asked to come in contact or visit the responsible public services and collect information about the urban planning, the building and the archaeological restrictions of the area as a second step of the process. The third step was focused on the autopsy that the students did at the area. The students visited the area and collected attribute and spatial data with the aid of paper maps, a few of them collected GPS tracks by using handheld GPS or smartphones and they enhanced their field research with photographs. The students created an account at the OSM and edited the attribute and spatial data. The attribute data was edited according to the categories that already exist and the spatial data was enhanced based on the three different methodologies that the OSM offers to its users. At the end of the experiment, the students evaluated the process and identified the perspectives and the concerns. (figure 5)

The team estimated that the time required for the whole process was less than a week including the time needed familiarization with the OSM editing process and the required contact with the corresponding public services. The cost remained low except for the GPS or smartphone equipment which was optional for those who already had it.

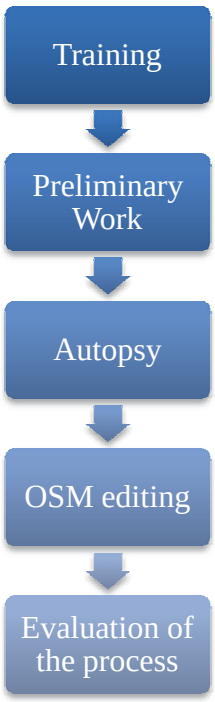

Figure 5: The process

4.3. The attribute data collection

The attribute data collection is based on two main categories; general data for the area of interest and particular for each building and floor. The students were asked to edit the name of roads and fill the missing information, to add the most predominant POIs such as monuments and add the condition, the use and the number of floors for each building. All the information was stored within the OSM at the given categories. (figure 6). The OSM offers the flexibility to its users to edit the data by using three different editors; iD, Potlach2, Josm or Merkaartor. The first two editors are incorporated within the programme. The last two are external, require plug-in and although they are considered as more perplexed in use, they offer greater flexibility and advanced tasks in use. For the specific task, all students used the iD editing as it filled the requirements and the needs of the research and was evaluated as easy and quick.

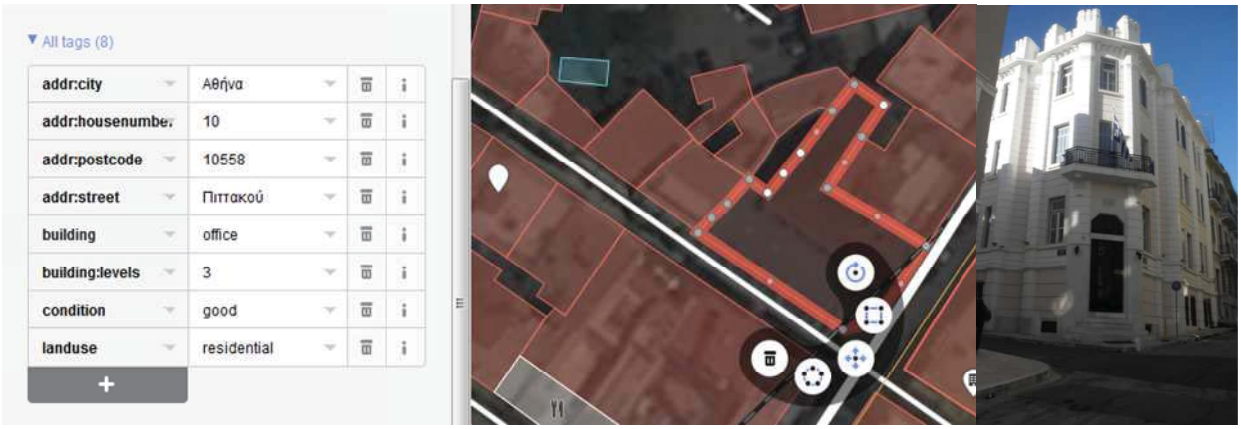

Figure 6: Attribute data editing within the environment of OSM (Source: OSM)

Although, the system is characterized as an open and flexible tool for its use, a set of rules were posed so that the representation to be unique and all students to follow the same

guideline. First, the annotation of the roads had to follow particular rules for a unique presentation. Thus students were advised not to use greek or caps lock. Secondly, the condition of the buildings was divided into four main categories; intolerable, deficient, fair and good. The research team posed the rules so that all students to use the given terminology with the same way. The term “intolerable” was given to ruins or uncovered buildings. The term “deficient” was given to buildings that require extended work to be good and the term “fair” was given to those that require little work. Thirdly, another issue that the research team faced had to do with the land use that differentiated in each floor. A generalization was posed; the predominant use of the building was recorded and the POIs were put as pins creating a temporal thematic map (figure 7). The practical application indicated that the existing land use matches to the permissible land use.

Figure 7: The OSM before the attribute data enhancement (left) and after it (right) (Source: OSM)

4.4. The spatial data collection

The OSM offers the flexibility to its users either to collect spatial data with their equipment and upload it or digitize the buildings on the satellite layer of the map using the provided tools and the desired editor. The students of the experiment asked to follow the methodology that they prefer and document their choice. The producing result was satisfactory for the research team. The majority of the students selected the easy way to digitize the satellite image of the bing by using one of the two editors and underlined the loss of accuracy due to the leaning of the image (figure 8). A small percentage of the students collected GPS tracks with their GPS or smartphone but they mentioned as major disadvantage the signal

Figure 8: Digitization of the parcels on the OSM(Source: OSM)

discrepancies that also affect the accuracy. A great number of students however investigated on their knowledge on commercial GIS packages and created a semi-hybrid model between ArcGIS and OSM. They used orthophotos that are provided by the national mapping agency, they digitized the buildings and they created a new layer. The new layer was imported in OSM by using the Potlach2 editor (figure 9).

Figure 9: Editing with the aid of ArcGIS & OSM

The results of the last approach were impressive as they combined two different methodologies, offered a really accurate result in terms of quality and supported the desired model of experts and volunteers simultaneously. Moreover, the OSM offered the capacity to put the borders of the land parcels by using photo-interpretation methods and digitizing the satellite images which was found useful and easy especially in urban areas like this where the continuous construction blocks the field measurements (figure 10).

In general, the experiment indicated that the knowledge of the students over the objective was crucial for its success. Errors of roads which crossed buildings or other common topological issues were either avoided or corrected in due time.

4.5. Results

After the application completed, the students were asked to evaluate the process and the software that they used and the research team evaluated the results as well. In most cases, their evaluation was identical.

Strengthnesses of the experiment

- Quick and inexpensive methodology.
- Easy to use/edit/store data.
- Open to the Public and the society to participate and get informed.
- Flexible in terms of editing and manipulation by non - experts.
- Temporal accurate maps.
- Online and on-time monitoring of the work.
- Application in a variety of projects.

Concerns over the experiment

- Manipulation of third parties which may lead to changes or destroys.

- Limitations or generalizations within the attribute data storage.
- Quality concerns which can bypassed.

It is clear that the crowdsourcing techniques can be extremely useful when the borders and the rules are well defined from the beginning. The experience has indicated that well structured projects which put the citizens in the centre of the decisions and adopt crowdsourcing techniques can flourish with the support of the experts and the governmental bodies . The specific practical experiment indicated the great potential that OSM can offer in cadastral procedures as a significant part of the LAS and can be applied with minor differentiations or improvements in various land issues.

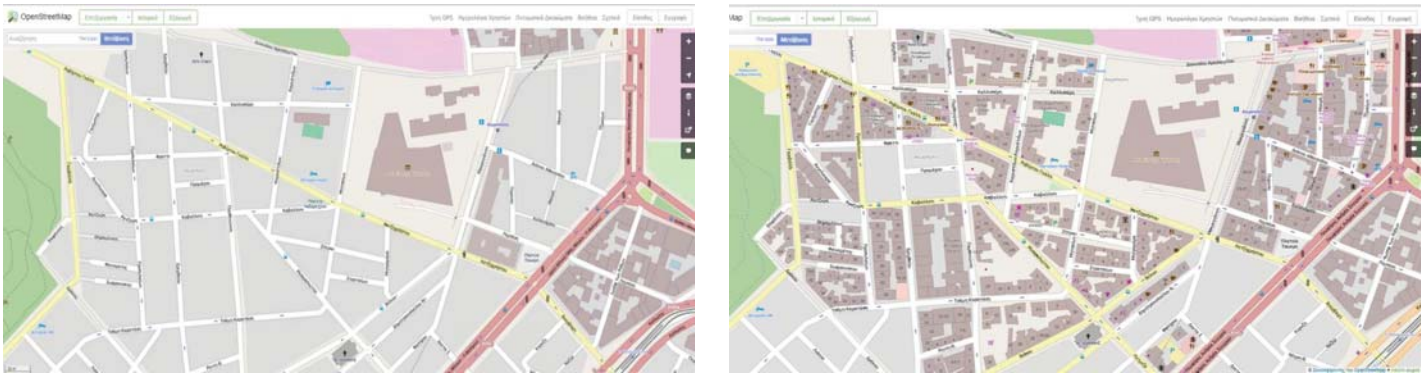

Figure 10: The OSM before the spatial data enhancement (left) and after it (right) (Source: OSM)

5. CONCLUSIONS

The experiment constitutes the first application worldwide which explored the potential to introduce VGI in Cadastral processes by using the first crowdsourced map, OSM. Its' innovation is also focused on the involvement of undergraduate students for the accomplishment of the specific purpose. It is a general fact that VGI and Land Management are two different academic fields that attract the interest of the academic team due to their socioeconomical impact. Their combination is a challenge that has many aspects still to reveal.

The scope of the research team is to continue exploring various aspects of the VGI philosophy and how affects Land administrative issues. The legal framework, the european framework and the worldwide requirements are among the next steps of the study. One the greatest challenges that the research community will have to face within the next decades will be on land issues. The use of crowdsourcing techniques will be inevitable so the only way to work efficiently is the requirements to be posed by the experts from the beginning.

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