

Prizren Cadastre Reconstruction Project and Benefits

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SUMMARY

Kosovo Cadastral Agency (KCA) is responsible for Cadastre Reconstruction and securing proper and reliable property rights in Kosovo. Maintenance and registration of immovable properties are carried out by Municipality Cadastre Offices (MCOs). MCO of Prizren was seriously damaged from a fire accident in 2007. Unfortunately the damage caused to lost of the graphical part such as the cadastral data (analog/digital maps, geodetic surveys, different registers, sketches, and archive) totally. Fortunately, the textual part of the data was not damaged since the registration in the Immoveable Property Rights Register (IPRR) is saved in the KCA servers.

Since the discrepancy between the first Cadastre graphical data realised by Former Yugoslavian Republic Cadastre Office in 1958 and re-delivered to KCA and IPRR textual data is enormous and causing problems either cadastre or IPRR procedures for MCO's Office and field works, "Prizren Cadastre Reconstruction Works" were activated by Kosovo Government in 2010.

Total Project area is 3492 ha. There were respectively 19664 IPRR records and 12328 parcels at textual and graphical databases while the difference were 7336 records. In addition to the textual and graphical data, stereo aerial photography with GSD of 10 cm taken in 2009 and some MCO provided additional graphical and textual data realized after 2007 fire were also provided and used as an important data resources.

In order to use these different data effectively following the system analysis and design phases a GIS system is established in ArcGIS platform. First; Via establishing unique ID correlation in between existing textual & graphical data bases, matching and mismatching parcels are defined. In addition to ID comparison, to make the final decision for matching parcels areal, geometric and positional comparisons are also made by using digital cadastre maps, orthophoto and digital photogrammetric vector maps produced and other MCO provided data

At the end of the project, all existing legal parcels are reconstructed and information for informal parcels (graphical and textual) is collected separately and prepared for entering into IPRR/KCLIS.

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1. INTRODUCTION

The Kosovo Cadastral Agency (KCA) is the authority for mapping and cadastre in Kosovo. KCA is responsible for the overall administration of the Immovable Property Rights Register (IPRR) and cadastre reconstruction in the country. The Municipal Cadastral Offices (MCOs) record and maintain the immovable property rights under the authority of the KCA and according to the guidelines issued by the KCA. Kosovo Cadastre Land information System (KCLIS) has been established at the decentralized MCOs in 2001 and since then updating and maintenance of graphical and textual information have been carried out by MCOs.

MCO Prizren have suffered serious damages caused by fire on 29 October 2007. Due to this fire the entire cadastral information such as cadastral plans, old Geodetic reference network data and the archive have been severely damaged. Fortunately, textual data has been saved since all registrations in IPRR are stored in KCA's servers through a direct line with MCO.

Considering the need for renovation and also that the inconsistency between graphical and textual data is extremely high, in particular in Prizren Cadastral Zone (Table-1), KCA initiated the Cadastral Information Reconstruction project for two cadastral regions of Prizren Municipality, respectively Prizren and Vlashnje cadastral regions in 2010.

Table -1 : Cadastral Zones to be reconstructed

No.	Cadastral Zone (CZ)	Zone's code	Number of parcels in textual database	Number of parcels in graphical database	Difference between two databases	The area (h)
1	Prizren	71813068	18639	11423	7216	2903
2	Vlashjne	71813006	1025	905	120	589

With this project it is mainly aimed that ;

- All legal parcels and buildings , all property rights over these objects which are included both in IPRR textual and graphical databases are defined and legalised,
- All newly formed illegal parcels and buildings, correlation of these objects with former legal parcels and property rights are defined and established both in textual and graphical data bases.

2. GENERAL APPROACH AND DATA AVAILABILITY

Different approaches can be followed for cadastral reconstruction. The most important factors influencing the methodology are existing data and techniques that can be applied. In addition, terrain conditions (hilly, undulating, plain), vegetative cover (dense, sparse), built-up areas, size of survey area, accuracy, timeliness and cost are the other factors which play important roles when selection of technology for cadastral survey.

The approaches are mainly based on (i) pure ground method using total station (TS) and Global Positioning System (GPS), (ii) air photography and ground truthing using GPS/TS (iii) Satellite Imagery and Ground Truthing with GPS and TS. It is of great importance to decide which model is the most appropriate for this purpose by evaluating the characteristic of the project area and the data availability mentioned above (NLRMP, 2008).

Due to the development of automated photogrammetric techniques and the increase in spatial resolution of imagery and accuracy, application of photogrammetric techniques have many advantageous not only for initial cadastral mapping, but also for updating of the existing cadastral system (Siriba, 2009). However, terrestrial survey is also critical elements for complementing this method, where aerial photography is not sufficient for detecting some boundary information especially in urban areas.

For Prizren municipality the available data sources which are considered to be used are summarized as follows:

- Ortho-Photo maps produced by 2009 aerial photographs for Prizren and Vlashjne CZs with resolution of 10 cm and 20 cm respectively.
- Stereo digital aerial photographs with ground sampling distance (GSD) of 10 cm taken at 2009 associated with related information (GPS/IMU data, GCPs established and signalized for aerial photography).
- Cadastral sheets produced in the years between 1957-1983 with scale of 1/500, 1/1000 and 1/2.500, UTM registered TIFF format.
- Immoveable Property Rights Register (IPRR) files for Prizren and Vlashnje Cadastral Zones.
- Vectorized data of the cadastral sheets (KCLIS).
- MCO's existing data (surveys /co-ordinates, sketches, other relevant documents for parcels' register, not included in IPRR/KCLIS data).
- First and second order ground control points with point sketches.
- 1 / 25.000 topographic maps, UTM registered TIFF format.

All these data listed above are in official geodetic datum used in Republic of Kosova territory and known as “KOSOVAREF01” (Kohli et al., 2001; Kohli, 2002; Meha, 2005). The datum is based on ETRS89 (European Terrestrial Referent System) and GRS80 ellipsoid is used. The projection system is conform cylindrical Gauss-Kruger (zone 7th) with an origin of 21st meridian and scale of 0.9999 in central meridian.

As the result of above depicted explanations and evaluations it is decided to use photogrammetry as a powerful tool to set all details already existing in the field , to define change detections as well as to provide a basic infrastructure for all kind activities to be carried in the project area via comparing existing graphic cadastre sheets, textual IPRR and other possible information captured in the area.

Therefore, it is planned to produce digital line maps for the rural and residential (urban) areas both to set up a powerful infrastructure and to define possible differences between former and existing positions, dimensions and geometric specifications of parcels and buildings via overlaying it on existing cadastre sheets.

For rebuilding of cadastral information in Prizren CZs, while aerial photography survey is considered as main component, field site measurements by total stations and GPS are used to complementary to photography in order to reach maximum accuracy and down the cost and time to finalize the project on time.

3. CADASTRE RECONSTRUCTION PROCESS

Cadastral Reconstruction (CR) process are planned to be implemented in five phases namely (1) preparatory works, (2) CR execution, (3) public display, (4) field verification and identification, (5) final data QC and data delivery.

3.1 Preparatory Works

Preparatory works comprise of below given sub-phases which could be executed as parallel process;

3.1.1 Quality check of the delivered data

For the delivered data an initial QC procedure are applied and all efforts are made to complete missing information as much as possible by requesting from related authorities. After the quality check, it is recognized that cadastral sheets are properly transformed and no problem is detected for the edge matching and transformation and that the other graphical and raster data are also fully in conformity with the KOSOVAREF01 datum.

In addition to the data given above, there are also aerial photographs taken by analog camera in 2004 and derived orthophoto maps with a resolution of 40 cm. Due to that the side overlap is not satisfactory which are in between 5%-25% and also orthophoto maps are not sufficient

for 1/5.000 scale map accuracy, it is decided not to use 2004 aerial photographs and orthophoto maps for both rural and residential part of cadastre applications.

Due to the lack and insufficient distribution of the Ground Control Points (GCP) delivered for 2009 aerial photography which are not so good to maintain photogrammetric block stability, 9 additional GCP are surveyed with GPS and used in aerial Triangulation.

3.1.2 Public Awareness Campaign

This includes formation of reconstruction committee, announcement via public communication means and meetings. A committee responsible for the implementation of rebuilding cadastral information is formed by KCA. The Committee is responsible for public awareness campaign, public display and resolution of appeals and complaints of the citizens involved in CIR.

During the CR process the Committee visited both CZ's and attended meetings with the citizens and informed in details the citizens for the benefits and the need to actively participate and co-operate in the process of CR and also realized public awareness campaigns (information) by leaflets , billboards, national and local TV and radio broadcasts, etc.

3.1.3 Photogrammetric Compilation

This process includes image processing for digital images, determination of projection center coordinate and camera attitude parameters by using GPS/IMU data, aerial triangulation measurement and bundle block adjustment and photogrammetric feature extraction for digital vector map (VM) production.

The aerial triangulation surveys and adjustment are performed using total 30 GCPs with Inpho–Match AT SW and resulted in about 1.8 cm standard deviation of point coordinates. Following the aerial triangulation, photogrammetric compilation process is carried out using stereo photogrammetric models with respect to large scale maps feature extraction expectations, but special importance are given to parcels and buildings.

Photogrammetric digitalization are realized according to exterior roof borders or roof prints of buildings. It is assumed that the foot prints of the buildings and the separation lines between adjacent buildings which can not be differentiated in densely inhabited areas are completed with a comprehensive field completion work.

The outputs of this process for the project were parcel corner coordinates, roof print coordinates and foot print coordinates as far as measured for buildings with roof, and roof print and foot print coordinates for the buildings without roof.

Total area of 2670 ha is digitized and edited to provide a full topology then all data is converted to Arc GIS shape format. The collected information which reflects the current

situation is very valuable for establishing the legal and informal parcels and new buildings other than the vector and raster data provided.

3.1.4 Orthophoto Map Digitization

Some 822 ha of 3492 ha of total project area, which mostly covering rural areas does not have stereo aerial photography coverage. For this area cause it is not possible to extract necessary information via photogrammetric tools, existing 20 cm and 10 cm resolution orthophoto maps are used as source material at Vlashjne and Prizren CZs respectively. This orthophotos are digitized for parcel boundaries, buildings, roads and other relevant object extractions.

3.1.5 Digitization of available cadastre sheets

The cadastral sheets are formerly vectorized by KCA. The procedure implemented to control the digitization accuracy and also compatibility with new produced VM derived using aerial photograpy taken in the years 2009 resulted in that there is no datum or scale problem. But we detected some missing information in the provided cadastral vector data (KCLIS), which are available in rasterized cadastral sheets.

The reason is that some improvements have been made on cadastral sheets but not included in the vector data since initial vectorization. Therefore, missing parcel and building information are captured by overlying existing vector data onto cadastral sheets using the method of heads up digitization.

3.1.6 Integration of MCO provided vector data with spatial data

MCO has some partial vector data produced as the result of some local application such as unification, division etc. and not integrated into KCLIS/IPRR. These data including some local information were integrated with the spatial data after checking with the existing situation and textual data.

3.2 CIR execution

3.2.1 Objectives

Cadastral Reconstruction in the project area is aimed (KCA, 2010);

- To reconstruct existing legal parcels by formation, presentation and registration in graphical part of all parcels that are registered in IPRR.
- To formalize (legalize) informal parcels by formation, presentation and registration of cadastral parcels in graphical part and in IPRR/KCLIS. These are the parcels which citizens/owners have formed based on some document or direct agreement not registered to IPRR nor in graphical part. For informal parcels, information is prepared separately for entering into IPRR/KCLIS.

- To survey of objects which include measurement, formation of buildings and parts of buildings and their registration in IPRR/KCLIS.
- To update of all cadastral and property data for IPRR/KCLIS and in the graphical part of cadastre based on legal documents in force.
- To solve or report the problem, in the cases where there is inconsistency between lawful owner (the one who is registered in IPRR) and actual possessor (title holder) of the property, and between legal area of the parcels registered in IPRR and technical area in graphical part.
- To define state-owned, socially-owned or publicly-owned properties as well as illegally occupied properties during reconstruction process.

3.2.2 Data Integration

This process involves the correlation of title deed records with spatial data using existing information to define matching and mismatching, to classify existing textual and graphical data and to determine complementary field data capture process. Title deed information for each parcel are grouped as unchanged parcels for which the shape, location, owner/possessor information has not changed since initial cadastre, changed parcels (divided, unified, shared), and private and state owned parcels

For these purposes, the basic input data available are the IPRR, KCLIS vector data improved with the inclusion of additional digitized parcels and buildings from cadastral sheets and of MCO partial vector data, orthophoto maps (OP), newly produced vector maps (VM) and the rasterized cadastral maps in case needed for checking.

To formulate some similar reconstruction problems seven different cases are defined (Table2) and relevant solutions are created. In the Table compatibility between IPRR, KCLIS and VM/OP in terms of ID number, area, shape and location are classified. The degree of area conformity is taken as 3% of the parcel area, required by law. Some examples for these cases are depicted in figure 1.

Table -2 : Possible cases for cadastre reconstruction

Case	IPRR	Cadastre KCLIS	VM/OP	EXPLANATION
1	+	+	+	Everything is OK, nothing to do.
2	+	+	-	New parcel (Unification, division etc.)
3	+	-	-	Requires owner application with legal documents
4	+	-	+	Cadastre needs to be updated
5	-	-	+	Informal parcel
6	-	+	-	Requires owner application with legal documents
7	-	+	+	Title deed registry needs to be checked

Integration of spatial database with textual data involves the following process:

- Each parcel is represented as a closed polygon and identified by a unique ID number.
- In the textual data (IPRR) including information on ownership, land type, etc., each parcel is also referenced by this unique ID number. This provides a basis for integration of digital map data with the textual data.
- After integration of the textual and spatial data, it is defined which parcels do not have a corresponding textual detail or parcel number, or where the textual and spatial data do not match each other.
- After establishing matching between existing textual & graphical data based on Unique ID correlation process areal matching and mismatching parcels are defined.



(a) Case 1



(b) Case 2



Figure 1: Some examples from different cases

Matching parcels means that textual and spatial data are compatible with each other in terms of area, position, geometry, owner/possessor etc. This decision should be produced regarding existing legal information and/or other different source materials such as new produced VM and OP maps, field surveys and queries and other relevant materials provided by owners/possessors/MCO. This clears up the legal parcels and buildings which have stayed unchanged in the mean time by unification and division.

The parcels where the textual and spatial data do not match each other in terms of ID and also area are checked one by one through all vector and raster data sets. This is very intensive and hard work which requires good experience to detect the problem and to create solution. Therefore, sufficient experienced man power is reserved for this task.

If all graphic information having consistency among them does not match with textual data, then there could be some missed or unregistered information exist in IPRR. This could be new registers, some unification or division process not legally defined or registered.

By overlying existing cadastre parcels in KCLIS and cadastre parcels surveyed photogrammetrically or digitized by orthophoto or surveyed in the field, if any mismatching issues or difference exist it can easily be detected. Mismatching could be from the point of geometry, position and area. Some reasons may be that any process carried out by the MCO is not registered to IPRR/KCLIS. The reason of mismatching could be divisions, amalgamations, sales and informal usages of private and/or public areas or unregistered or new constructed buildings etc.

For mismatching parcels where cadastre parcels surveyed by photogrammetry are compatible with the IPRR, which means that graphical data not updated parallel to the IPRR, graphical part are improved using photogrammetrically derived parcel information so as to match IPRR. Otherwise, i.e. if they are not matched by office works, field measurements are planned for verification, up-date and identification.

One of the other important output of this process is to define informal parcels which have been formed by citizens/owners based on some agreement, but not registered in IPRR nor in graphical part. For informal parcels, graphical and textual information are prepared separately and get ready for integration into IPRR/KCLIS.

3.2.3 Change Detection

The purpose of this stage is to prepare data and information to be verified, identified or re-captured in the field. This is also done by overlaying KCLIS data and newly produced VM on

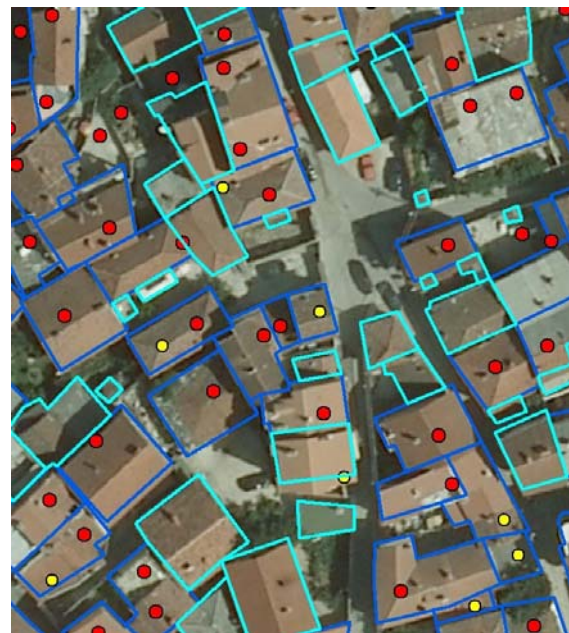
the cadastral sheets & OP maps one by one and taking into account the IPRR, matching and mismatching parcels and building.

New parcels and new buildings came out after 2009 aerial photography were defined by using change detection algorithms in between orthophotos and ortho-rectified Quick Bird Satellite Imagery of dated July 2010. About 450 new parcels and buildings are detected and surveyed by GPS and TS methods in the field.

Additionally, former and new building information are extracted of by comparing buildings and shelters exist in former cadastral maps and up-to date orthophoto/VM data. To do that, all building and shelters are marked and coordinated in the cadastral sheets with different symbols. After they are put on VM overlaid orthophotos, information on new buildings or buildings matching former cadastre sheets or buildings do not exist anymore are derived (Figure-2).



(a) Cadastre sheet



(b) Orthophoto map

Figure 2: Comparison of new and former information for building extraction, (a) Red and yellow circles stands for existing building and shelters in cadastral sheet. (b) Light blue rectangles represent the parcel in which new buildings have been constructed.

3.2.4 First Data Quality Control

During the execution of all phases of the CR process, Quality Assurance and Quality Control procedures are implemented. So internal QC procedures of data produced are satisfied before preparing them for public display and for handing over to KCA for approval.

Topology building is the most important issue for digital cadastral map, which describes how lines and polygons connect and relate to each other. Topology building is done by treating each intersecting point as a node. The data, topologically validated before further processing as clean data is an essential prerequisite for accurate results. During the validation process, topological inconsistencies caused by inaccurate digitizing are detected, and corrected to ensure clean data.

3.3 Public Display

Following completion of CR works or also finalization of above defined two phases public display took place in order to present reconstruction works. With respect to the relevant laws/rules/regulations 60 days public announcement are given to the citizens or residents via public communication means such as radios, TVs and news papers, and also posters and brochures are prepared, to notify the works already finished.

All citizens could see the prepared documents which were announced and/or hanged at public places such as municipality offices, cadastre offices, schools or shortly governmental buildings or offices etc.

During public display owners/residents could apply in case any complain or objection for irregularities, forgotten objects, wrong or missed identifications or registries or any other issues thought as wrong and/or deficient.

3.4 Field Verification & Identification

In the frame of this activities parcels and buildings, not detected from orthophotos and air photographs were measured by field teams equipped with Real Time Kinematic GPS System and ESRI ArcEngine mobile data capture tools. These are mostly new buildings and new parcels came out after 2009 defined by change detection using satellite images for 2010 and orthophoto maps produced from 2009 aerial photography. Whenever and where GPS system doesn't regularly works then conventional methods such as total station surveys are implemented to measure position and dimensions of the parcels & building.

Additionally, for the buildings with roof and without roof which were pre-determined photogrammetrically, horizontal distances from roof to foot prints were surveyed with simple laser meters.

Field measurements were also carried out for the parcels divided in IPRR, which did not have a corresponding division in graphical parts of cadastre or digital photogrammetric vector

maps, and if graphical data could not be updated because of that parcel boundaries were not detected from VM/OPs and the other existing materials.

Identification studies were executed parallel to field works. All records for the ownership captured during this works were integrated to database via mobile GIS tools and hardcopy versions were prepared.

3.5 Final Data Quality Control

KCA carried out final and detailed QC of the data following completion of Public Display and before the data entering into the system according to the Manual for Quality Control and Quality Enhancement of Data from Cadastre Reconstruction of KCA (Schmidt and Schmieder, 2010). Only after this final QC, where the findings are that the work was done accurately and without errors, KCA started the process of data entering into IPRR/KCLIS System.

4. RESULTS AND SOME SUGGESTIONS FOR THE CADASTRE RECONSTRUCTION PROJECTS

In recent years cadastre renovation or cadastre reconstruction studies are one of important issues occupying the agenda of most of the countries and surveying world as well. As appreciated Prizren & Vlashjne CZs projects comprising of approximately 43.000 IPRR records, 20.000 independent parcels and 36.000 buildings are finalized in 4.5 months.

It is evaluated that the most important factor in completion the project on time are;

- Assignment of many required personnel, hardware and software for office as well as field works,
- Power of digital Photogrammetry providing personnel and time savings and speeds in the data capture process for parcels, buildings, roads and all other necessary details,
- GIS system providing speed and elasticity for the decision making processes and querying capabilities,
- Orthophoto maps providing a visual infrastructure for evaluation and interpretation of received results.

In the lights of above given information, digital photogrammetry is considered as a vital tool to realize efficient cadastre renovation projects. For this purpose it is recommended to use stereo aerial photography of

- GSD = 8-10 cm. and digital photogrammetry for urban areas,
- GSD = 20-30 cm and digital orthophotos for rural areas,

Following the delivery to keep the data up-dated, each IPRR process requiring graphical operations such as division or unification must be executed in KCLIS on a timely basis,

similarly any graphic operation should be realized on IPRR as soon as possible or as a parallel process.

Any process or permission for planning, construction, degradation and similar process related to graphic or textual base must be executed in alignment with MCO. For this purpose the date of delivery must be accepted as the turning point for this up-dating operation.

Informal parcels & buildings number of which are extremely high (around 4000 & 23000 for Vlashnje and Prizren CZs respectively) are needed to be formalised, This process can be managed more comfortably for publicly owned properties because it needs a governmental decision and stability. But for private properties, a consensus is necessary for the owners and possessors where the duration and procedures can be time consuming and difficult and may need court decision or other legal procedures. But it is believed to create a solution on a timely manner before the process get more complex and inextricable.

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BIOGRAPHICAL NOTES

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