Designing a WebGIS System to Support
Active Participation of Citizens in Land Use Planning

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Abstract: The effectiveness of a land use planning (LUP) system depends largely on its transparency. In this context, the Vietnamese LUP system is often being criticized for the insignificant participation of the local community in developing and implementing land use plans. To cope with this problem, the authors have developed a LUP WebGIS system to provide a government-to-citizen communication channel and enhance active participation of the local community in LUP. Based on an open source platform (PostgreSQL/PostGIS, MapServer, pMapper, and Apache), the LUP WebGIS system allows the citizens to browse LUP and cadastral data, make and view feedbacks and proposals to LUP plans, exchange messages with governmental staff and other citizens, etc. The system was tested in Đông Anh District, Hanoi City and achieved positive results, though some modifications are required to better suit to the needs of the citizens.

Keywords: Land use planning; WebGIS; Public participation; Open source software; Đông Anh District.

1. Introduction

Land use planning (LUP) is considered to be the most powerful tool of Land Administration (LA). The effectiveness of a LA system is largely depended on how the LUP is implemented and managed. However, LUP in Vietnam is still far from effective, being the cause of many concerns of the society.

The problems of LUP in Vietnam are well known: land use plans usually do not reflect well the real situation, and therefore have low level of feasibility and require frequent modifications and corrections. Moreover, LUP in Vietnam still suffers from the lack of transparency, causing numerous objections of the citizens, like the recent land related negative events in Tiên Lãng District (Hải Phòng City) and Văn Giang District (Hưng Yên Province). It became clear that the active participation of the community is a crucial factor for improving effectiveness of LUP in Vietnam. Because the social impacts of planning proposals cannot be accurately enough described only by using expert opinions, the opportunity to give

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feedback, if used actively by citizens, is an important factor for the correct evaluation of land use plans. In this context, we have designed a LUP information system based on WebGIS technology to provide a channel for interaction between the citizens, the land use planners, and the local government in development and implementation of land use plans. Thus, the system will encourage active participation of the community in LUP, making it more feasible and transparent.

The use of GIS, and particularly WebGIS, in LUP is actively promoted by numerous researchers in the last decade. For example, Nor Sallehi (2005) designed a conceptual model of integrated land use planning information system for Selangor State of Malaysia. The system composes of six subsystems: information supply, communication support, automated mapping, executive, administrative, and decision support. Among those, the information supply subsystem is defined as the key component [1].

Diaz et al. (2009) has identified some advantages of WebGIS application in providing participation of the community in LUP, such as "meetings are not restricted by geographical location, the public has access to the information about the issues being discussed, the information is available anywhere and at any time, the opinion of the citizens can be made anonymous and in a non-confrontational manner" [2]. The authors had developed a WebGIS system for collecting and managing public objections to municipal land use plans. The system is based on an open source platform consisting of MapServer, PostgreSQL, and PostGIS. Being deployed in Galicia - an autonomous region of Spain, the system allows the citizens to submit their objections in a specially designed form to the municipal land user plan. On their side, the municipal government uses the system to process objections and all processing stages are made transparent to the citizens [3]. In our vision, the

system has some powerful tools for collecting and processing feedbacks from the citizens, however, it does not provide them the possibility to propose their alternatives to the land use plan.

Mikkonen and Alppi (2003) denoted that interactive planning is an important trend in most developed countries. The idea is to encourage citizens to participate planning of their society and environment. In Finland, the principle of interaction is written in the legislation of land use planning and under this legislation, the Soil and Water Company has developed an ESRI's ArcIMS based feedback system used for regional planning in Tampa and Häme regions [4]. The system is used to publish the draft of regional plans and offers the citizens a chance to enter their comments attached to a location or geographic feature.

Tarig (2008) designed a coastal LUP WebGIS system based on ArcGIS Server commercial platform. The system has aim to enhance site plan review procedures by creating a collaborative LUP environment, in which all three parties: land use planner, applicant/ developer, and community stakeholders can participate [5]. In addition, the system is also helpful for educating coastal residents about conservation guidelines, water resource protection policies, and regulatory controls on land use. Therefore, it provides "a transparency to the entire LUP process that would be appreciated by the stakeholders" [5].

In China, He-Bing Zhang et al. (2010) developed a LUP management information system based on MapGIS (a Chinese GIS software package) and SQL Server platform [6]. The system consists of five modules (called "platform" by the authors), that support for land use data statistical analysis, attributive query, printing report, and browsing geographic information, user's feedbacks, etc. However, it is not very clear, how well these functions perform in real situations because the authors

does not give details on their implementation nor a showcase of the system. Based on the same MapGIS system, Hualong Zhao (2009) developed an urban planning management information system for small and medium-sized cities. The system consists of four modules: planning reference; result management; implementation tracing; and system maintenance modules [7]. The main advantage of the system is that it allows for daily updates of data by planning management department, and the data are supplied to their users in numerous statistical and graphical forms. However, the system is designed as "one way system", i.e. the data flow only from municipality's departments to citizens, but no feedback interaction between citizens and the government is provided.

Through literature review, it becomes clear that the functional support for interaction between citizens and the government is a crucial factor for a LUP information system to be useful and long-live. Without this functionality, the system will not notably differ from a set of static web pages showing LUP plans.

Regarding the technology, internet had been proved to be the best and dominated communication infrastructure for LUP information system. Due to the inherent large portion of spatial data, WebGIS technology is required for implementing a LUP information system. While WebGIS is available in both commercial and open source forms, in recent years we observed a trend of moving from the use of commercial platforms towards open source ones in the development of LUP information systems.

2. System design

The system design is carried out by using Unified Modelling Language (UML). UML is a standardized, general-purpose modeling language in the field of software engineering. UML includes a set of graphic notation techniques to create visual models of object-oriented software-intensive systems [3]. For designing the system, we used a number of UML diagrams, such as use-case, activity, class, and component diagrams.

2.1. User needs assessment

We had identified five groups of users (actors) of the system: guest, registered user, advanced user, LUP planner, and system administrator. The user needs are presented in Fig. 1 as a UML use-case diagram.

The guest user group includes unregistered users, most of them are those citizens that access the system occasionally, from time to time. The guest can register himself and browse basic data, such as land use map and LUP map. Due to the anonymous access, the guest can not make nor read feedbacks.

The registered users are considered to be those citizens, organizations, and governmental officers that have submitted relevant personal data and done an authentication procedure. They can browse basic data, send and receive messages to and from other users, and more importantly, the registered users can submit and view feedbacks to LUP plans.

At a higher level, the advanced users can do all the things that a register user do. They also can browse advanced data, such as parcel data and information on how the LUP plan affects the parcels. In term of object oriented language, the advanced user is inherited from (i.e. being a child or special type of) the registered user (Fig. 1). The advanced user can be a governmental officer, an owner of land in the area affected by LUP, or an organization responsible for implementing LUP,...

Being a special type of advanced users, the LUP planners have two main responsibilities: update LUP data and maintenance feedbacks. Every feedback made by users is reviewed by a LUP planner: he checks it for informativity,

suitability, and contact with the feedback's author if necessary. The feedback will be accepted and stored if it is useful, otherwise it will be rejected to keep the database clean.

The last type of users is the system administrator, who is responsible for maintenance and backup of data, as well as user management.

2.2. Database design

Based on the above user needs assessment, a database model was designed using UML class diagram as shown in Fig. 2. In this diagram, the arrows depict inheritance (or generation) relationship, while the strain lines depict association relationship between classes or tables. Table 1 shows a short description of main classes (tables) of the database.
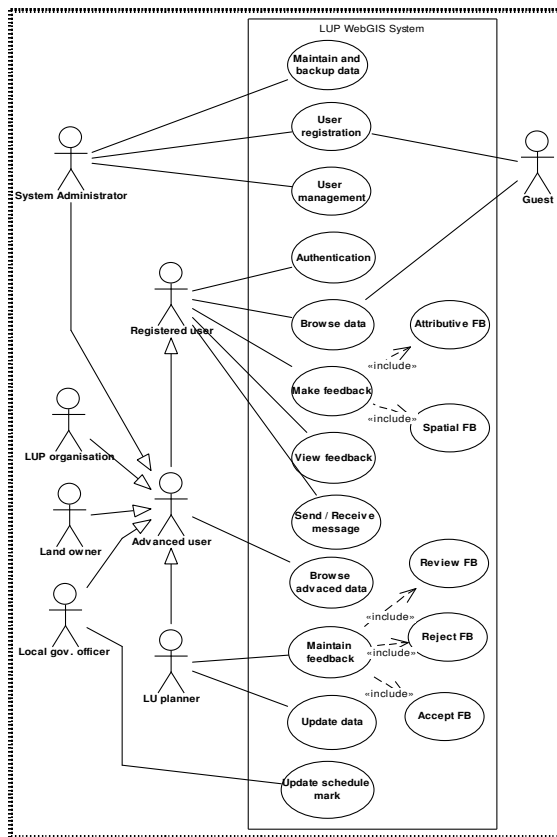

Fig. 1. Use-case diagram of the system.

The roots of all classes (i.e. database tables) are *object* and *spatial_object* classes. *object* is the parent of all classes, including *spatial_object*. Direct child of *object* are classes (tables) that contain only attributive data. Those classes that contain spatial data are the child of *spatial_object*, which has *the_geom* (the geometry) attribute.

In the database, the cadastral data are presented in tables *parcel*, *land_owner*, and *registration* tables. The information model of these tables are simplified form of the standard cadastral database model developed by Vietnam Ministry of Natural Resources and Environment (MoNRE) [8].

The land use and land use planning data are presented in three tables, namely *land_use*, *land_use_planning*, and *lup_timeline*. The *land_use* table represents current land use pattern of the area, while the *land_use_plan* table represents land use planning objects, each of them has detailed information on schedule stored in *lup_timeline* table. Periodically, the progress of realizing a LUP object is checked and recorded in *lup_timeline* table by a local government officer. This progress is then compared with predefined schedule, and if a problem is identified, it will also be recorded in the table.

The opinions or feedbacks to LUP, as well as the supported communication between the users of the system, are recorded in three tables: *att_feedback* (attributive feedbacks), *sp_feedback* (spatial feedbacks), and *message*. Some feedbacks of the citizens are directly associated with an whole LUP object and they are recorded in table *att_feedback* because such kind of message usually does not need additional spatial information, except for the LUP object itself. In other cases, a feedback may not strictly be related to any LUP object, for example a citizen can draw a newly proposed LUP object

on the map. In these cases, the *sp_feedback* table is useful for recording such type of spatially explicit feedbacks.

While *att_feedback* and *sp_feedback* are the main tables for recording opinions of the citizens, the system also needs an additional channel for communication between its users. For example,

when a land use planner reviews a feedback made by a citizen, some details may be unclear and he will use the *message* table to send questions to the citizen. This will keep the main feedback system clean and simple. Each time when a user is logged in, the messages associated with her/him will float over the map window.
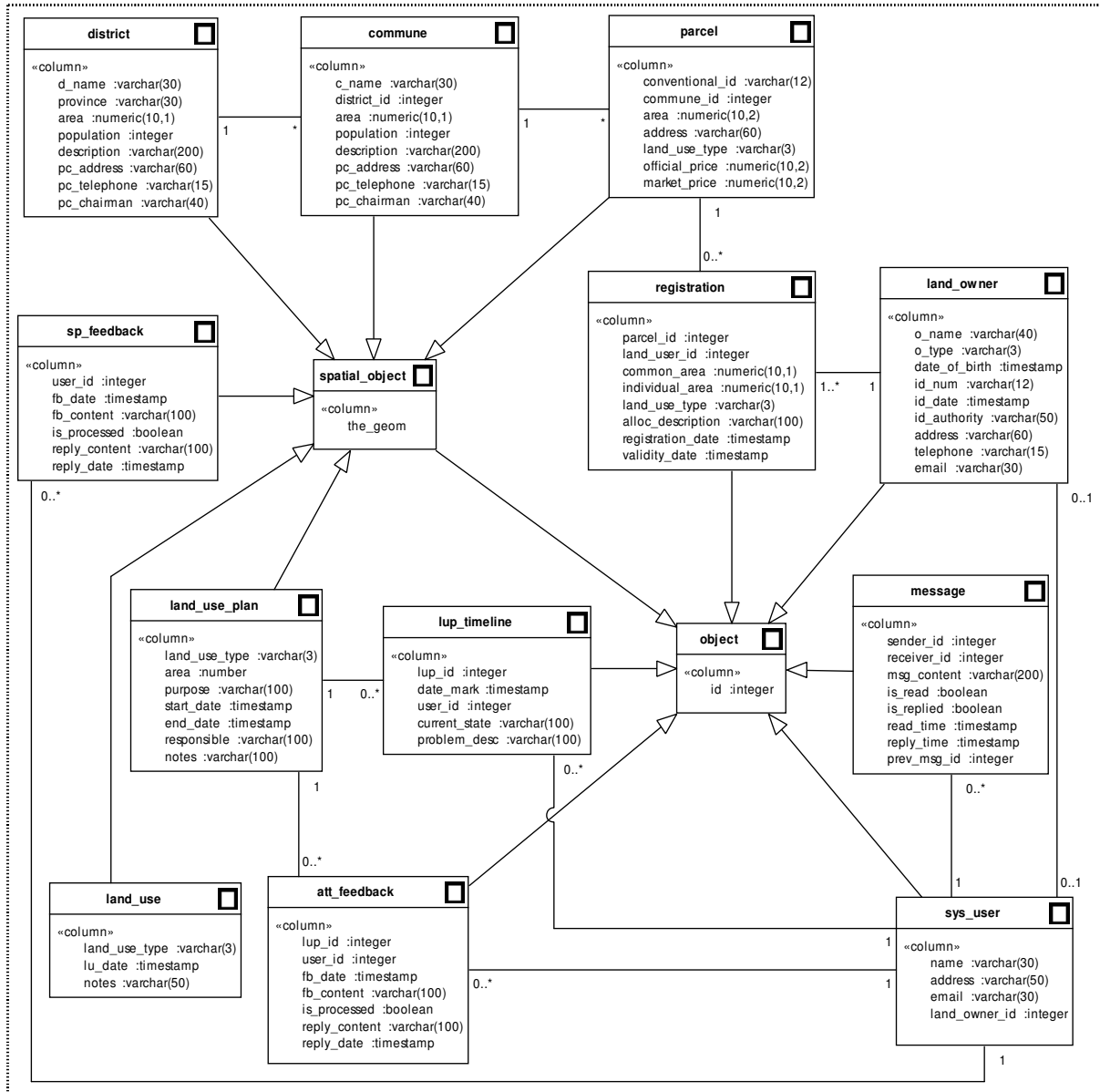

Fig. 2. Database model of the LUP WebGIS system.

Table 1. Description of main tables of the LUP database

Data table	Data content	Important attributes
parcel	Data on physical parcels	*conventional_id*: parcel's ID under conventional parcel naming system; *commune_id*: ID of commune or ward where the parcel is located; *land_use_type*: current primary land use type; *official_price*, *market_price*: official (defined by the government) and market price of the parcel.
land_owner	Data on land users (land owners)	*o_name, o_type*: full name and type of the land owner; *id_num*: ID card number (or registration number of organization); *address, telephone, email*: contact information.
registration	Data on land ownership	*parcel_id*, *land_user_id*: ID of parcel and land user; *common_area*, *individual_area*: area for common and individual uses; *land_use_type*: registered land use type.
land_use	The most recent land use pattern	*land_use_type*: land use type code, e.g. LUC, ONT,...; *lu_date*: date when land use object was checked and updated.
land_use_ plan	The current land use plan	*land_use_type, area, purpose*: land use type, area, and purpose of LUP object; *start_date, end_date*: date period when LUP object is supposedly being realized; *responsible*: information on organization responsible for realizing LUP object.
lup_timeline	Schedule control of LUP object	*lup_id*: ID of LUP object; *date_mark*: date when the schedule mark was made; *user_id*: ID of user making the mark; *description*: description (realized, unrealized, etc.); *problem_desc*: description of problems and proposed date and solution.
att_feedback	Attributive feedback	*lup_id*: ID of LUP object; *user_id*: ID of user who made the feedback; *fb_date*, *content*: date and content of the feedback; *is_processed*: true if the feedback was processed by LU planners; *reply_content, reply_date*: content and date of the last reply.
sp_feedback	Spatial feedback	Similar to *att_feedback*, without *lup_id* attribute.
message	Communication between users	*sender_id*, *receiver_id*: IDs of users who send or receive the message; *content*: content of message; *is_read*, *read_time*: status and time if the message was read; *is_replied*, *reply_time*: message replica; *prev_msg_id*: ID of message to which this message is replied.

2.3. Software platform selection and system development

As by design, the LUP WebGIS system uses internet infrastructure for transfer spatial and attributive data in the client-server architecture between the government and the citizens, it requires the following minimum set of software for functioning:

- A database management system (DBMS) for managing spatial and attributive data;

- A map server for producing map images and map queries against data supplied by DBMS;

- A web server for handling user's requests and producing web pages in response;

- Web browsers for displaying data and provide basic user interface at client computers.

All of the above software types are available in both commercial and open source forms. About ten years ago, most of WebGIS systems were built on commercial software platforms due to limited functionalities of open source ones. However, in recent years, open source software had grown up tremendously and at this moment, they have enough functionalities to build complicated systems, such as land information systems [9]. Thus, the choice of software platform is not obvious as it

was before.

In this research, we choose open source software platform to develop the LUP WebGIS system due to three reasons: low cost development; better community support; and compliance with the strategy of Vietnamese Government on using open source software in governmental organizations. Upon this solution, the following software packages were chosen as they are the most proven open source software solutions: PostgreSQL and PostGIS for attributive and spatial database management; UMN MapServer for producing map images and map queries; Apache for handling requests and producing web pages. For leveraging faster and easier system development, the pMapper PHP/MapScript framework developed by Armin Burger (*http://www.pmapper.net*) was selected.

With the above choice, the architecture of the system is presented in Fig. 3. The system development consists of the following steps:

- Standardizing and loading LUP and cadastral data into PostGIS/PostgreSQL database;

- Defining security model and user management at database level;

- Customizing MapServer's map file for producing map from database queries;

- Modifying source code or adding plugin to pMapper to achieve required functionalities.

- Writing PHP scripts for querying data against the database and producing html pages to display in web browsers. PHP is a server-side scripting language designed primarily for web development. PHP is highly popular and according to Wikipedia (*https:// en.wikipedia.org/wiki/PHP*), it is now installed on more than 244 millions websites and 2.1 millions web servers. Apache and pMapper natively support PHP, while MapServer supports it via PHP/MapScript library.

- Writing JavaScript code for instant interaction between the users and the system, and for partial data update at client computer using AJAX (Asynchronous JavaScript) technique. Unlike PHP, JavaScript code runs on client computers within a Web browser and offers richer user interface (such as dialog with complex elements) at higher speed.

3. Testing, results and discussion

For the testing purpose, the developed LUP WebGIS system was experimentally deployed for the case of Đông Anh District, Hanoi City, Vietnam. The district has location in the North-East of Hanoi City and is separated from the city's downtown by the Red River (Fig. 4).

Đông Anh District has an area of 182.139 km^2, population of about 337,000 inhabitants in 2009 year [10]. Being a peri-urban area, the district has a very dynamic economics, leading to an intensive urbanization process. Under this process, the land value goes up tremendously, causing a lot of land conflicts and land related objections of the local community. It is therefore very important to develop a relevant LUP plan that leverages rational use of land resource and satisfies different interests of various types of land users.

Upon the request of People Committee of Đông Anh District, a group of LUP specialists from Vietnam Institute of Geodesy and Cartography took the responsibility to develop the LUP plan of the district for the period of 2011-2020 years. The process was started back in 2010 year and recently, in April 2013, the LUP plan was passed final review. The pre-final version of the LUP plan is used in this research. In addition, we also use the LUP plan of Hanoi City for the period of 2011-2020 [11] that was obtained by courtesy of Vietnam

General Department of Land Administration (GDLA). Table 2 presents the list of data collected for testing in Đông Anh District.

The data were checked for consistency and then transformed into VN-2000 spatial reference system, 3-degree UTM zone with central longitude of 105°00'00".

For the test, we deployed the system on a small home server using free dynamic DSN service provided by Vitalwerks LLC (*www.noip.com*). Due to low speed of internet connection in some cases, we used a local server (server and client on the same laptop computer) for field works.

The test involved 11 participants: five citizens from Kim No Commune, three citizens from Đông Anh Townlet, two LA students from VNU University of Science, and one LA officer of Dong Anh District. The LA officer also plays the role of a LUP planner because she had actively participated in the development of district's LUP plan. Before doing the test, the participants learned for about 10-15 minutes on the purpose of the system and how to use it. Then they are free to explore data and give feedback, if any. Because many citizens are unfamiliar with computers, they got an assistance from their children or a technician from the research group.

After connecting to the server and doing an authentication procedure, the users can do the following:

- View thematic and base map data;

- Manage data display modes (turn on/off a layer, zoom in/out);

- Search for specific objects by their attributive value or by location;

- Query information of an object of any layer in manual or automatic mode. Fig. 5 shows an example of automatic querying a LUP object: when the user hovers the mouse on an object (the planned urban residential area North Red River 3 in Fig. 5), a floating window will show up and display its description and realization schedule.

- Make/edit spatial or attributive feedbacks to a LUP object. Fig. 5 shows an example of making a spatial feedback to a part of the planned urban residential area North Red River 3.

- View all feedbacks related to a specific LUP object by clicking on it. Fig. 6 lists all feedbacks made to the planned urban residential area North Red River 3.

- Communicate with other users via message subsystem.

By ending the test, the participants were interviewed on usefulness and usability of the system. Summary of participants' opinions are presented in Table 3.

After doing the test, most of participants said that the system make interest to them. Only two said that they do not have interest because they do not care about LUP or do not believe that the system is useful for them.

Seven participants (2 students, the LA officer, and four citizens) believe that the system will help (at various levels) to make LUP process more transparent. Two citizens said "No" because they doubted in the quality of provided data. This reflects the real situation in Vietnam, where LUP plans usually are not published timely, and the data themselves experience frequent updates without proper notification to citizens. Therefore, the developed WebGIS system serves a good technical tool, but is still insufficient for involving the citizens into LUP processes. Besides technical solution, it is very important that the government has a clear policy on publishing LUP data.
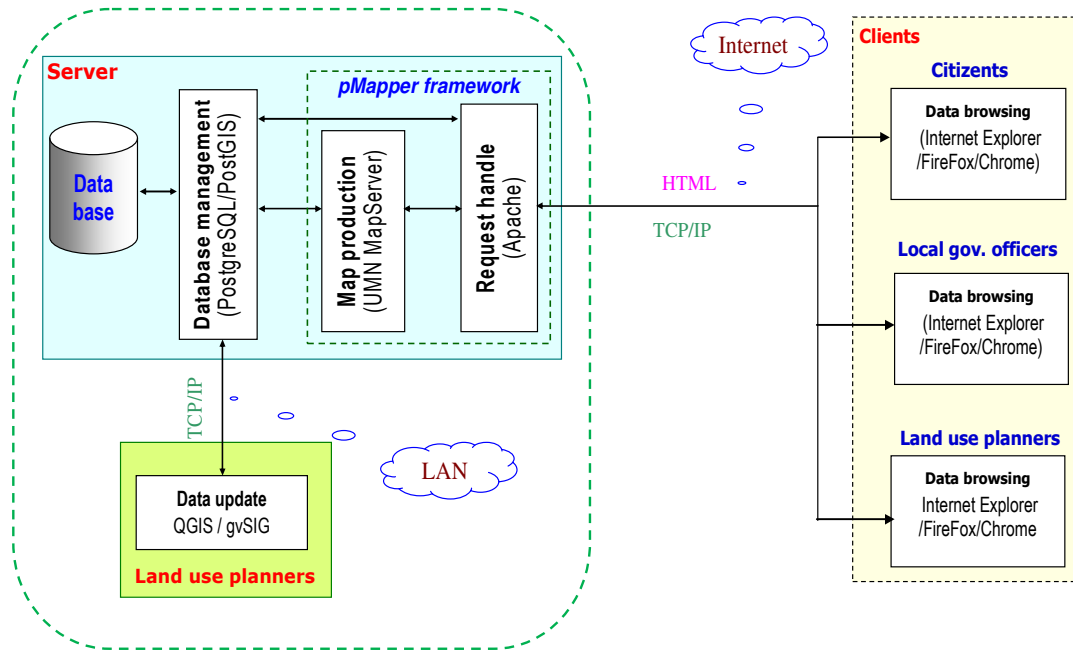
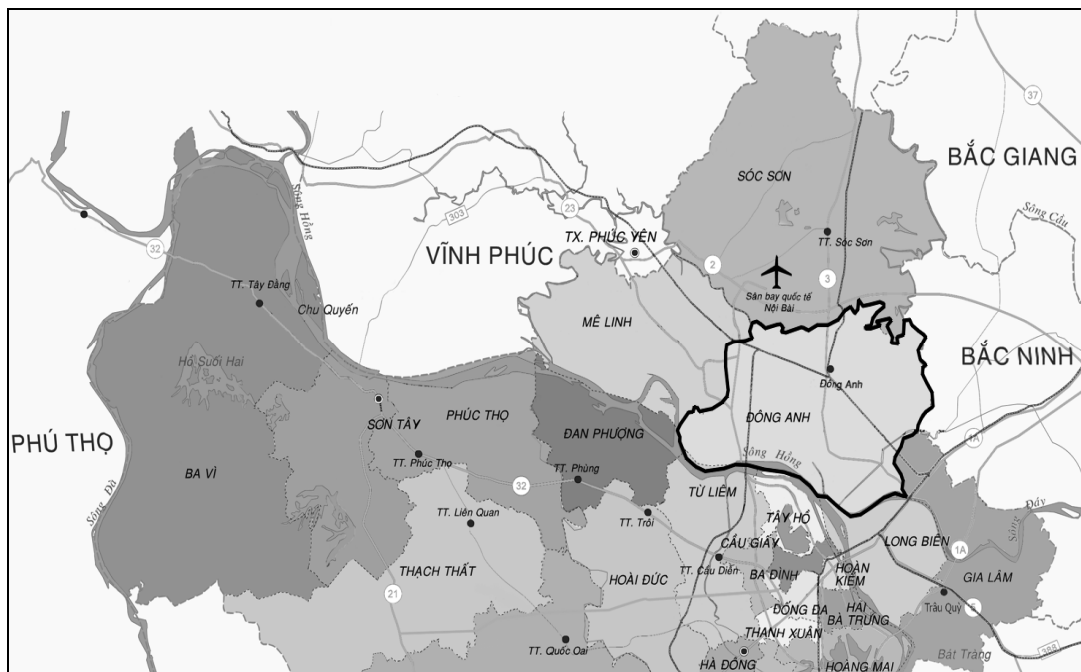Fig. 3. Architecture of the LUP WebGIS system.

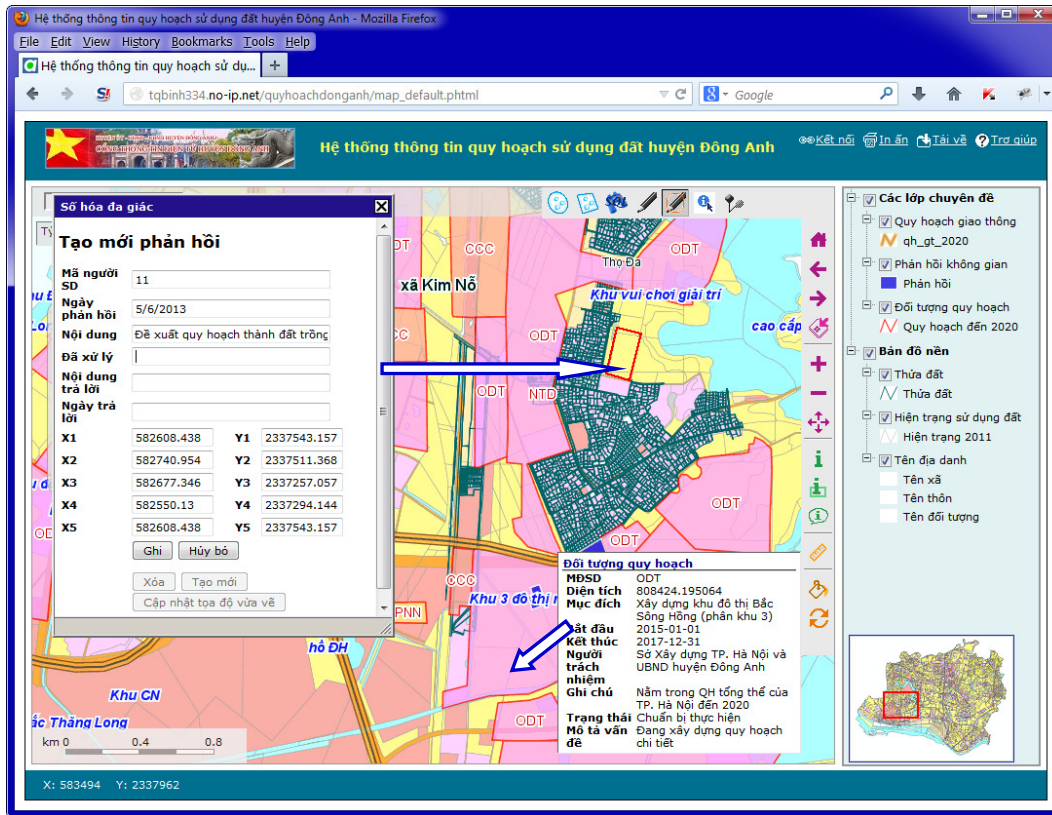Fig. 4. Location of Đông Anh District in the Northern part of Hanoi City.

Fig. 5. User interface of the system: querying information on LUP object (bottom right)
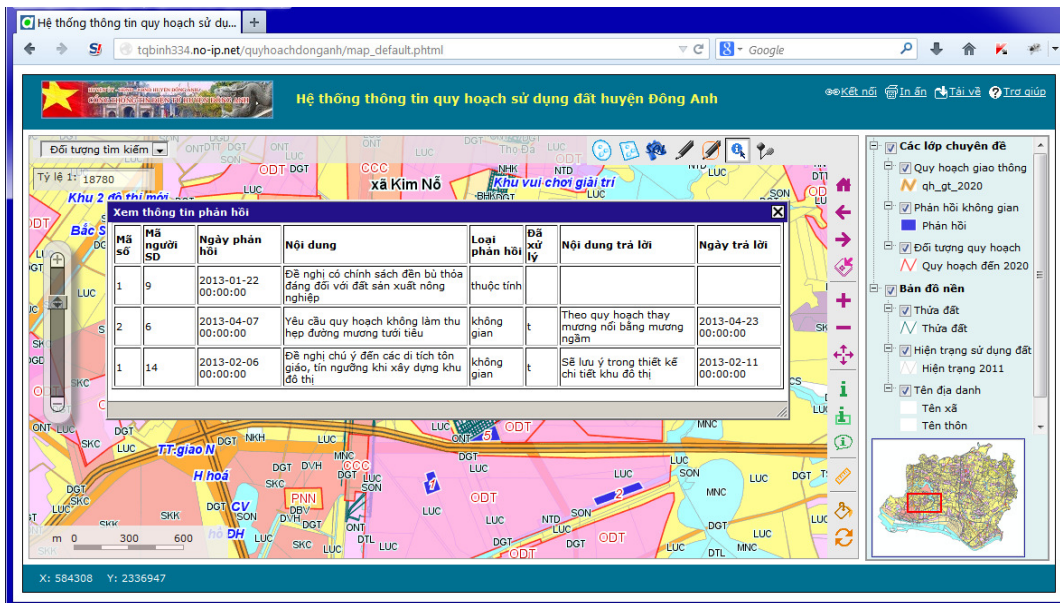and creating spatial feedback (top left).

Fig. 6. User interface of the system: displaying all feedbacks related to a LUP object.

Table 2. Data collected in Đông Anh District

Data	Description	Source
Cadastral map	42 map sheets at scale 1:500 covering residential areas of Kim No Commune. The maps are relatively old.	Đông Anh People Committee
Land use map	District's land use map in 2011 year at scale 1:10,000.	Đông Anh People Committee
LUP map (district level)	District's LUP map for the period of 2011-2020 at scale 1:10,000, pre-final version.	Đông Anh People Committee
LUP map (city level)	Hanoi City's LUP map for the period of 2011-2020 at scale 1:50,000.	Vietnam GDLA
Data collected in the field	Data on some LUP objects, opinions and proposals of the local community to the LUP plans.	VNU University of Science

On the amount of data provided by the system, almost all participants think that they are sufficient. Some people wished to add data on land ownership and detailed information on each land parcel, but these data are not of primary concern and may make the system too complicated.

After exploring LUP data, some active participants wanted to propose feedbacks to LUP authority. One proposed to change a rice field into area of fruit trees (see Fig. 5). The other asked the government to take measures to preserve religious objects inside a planned urban residential area, etc. Active discussion of participants shows that the citizens want a government-to-citizen communication channel to express their opinions on everything affecting their life. The channel, if available, will significantly improve the effectiveness of land administration system in general, and land use planning in particular.

As for expectation of participants, six of them said that the system more or less meets their expectation on functionality and user interface. Two participants did not have answer because they had no idea on such system before. Three participants said that they expected a much more simple system than the testing one. In our vision, a solution to this problem is to make a dual user interface system: one interface is kept as the current, and the other is maximally simplified for people that do not have a good knowledge and need only basic data.

Concerning the easiness of use, many citizens do not have a computer knowledge and therefore cannot operate properly. However, nowadays a lot of young people in rural areas have a good computer skill, and unskilled users can ask their young relatives to help them to find interested information. Another solution is to do basic training and then ask the citizens to work in group with one-two leaders knowing how to operate the system properly.

Despite difficulties in operating the system, most of participants find it helpful for them, and they wish to use the system in the future as long as the government supports it.

From the obtained test results, some remarks can be made as follows:

- The system is fully functional if it is deployed on a good internet infrastructure.

- Many citizens find the system interesting because it provides them useful information and serves a good channel to communicate with the government.

- To provide sufficient data and functionality, the system becomes complicated to many regular users, especially in rural areas. To cope with the problem, it is wise to make a dual interface system: one is full-featured for advanced users, the other is maximally simplified for regular users.

- To ensure the usefulness of the system, it is very important for LUP authorities to post reliable and timely data, and to update data frequently.

Table 3. Summary of opinions of 11 participants of the test

Question	Number of answers			
	"Yes"	Rather "Yes"	"No"	Cannot decide
Does the system make interest to you?	5	4	2	0
Will the system make LUP more transparent?	5	2	2	2
Are the provided data sufficient for you?	5	5	0	1
Do you propose some feedbacks to the current LUP plan?	2	3	6	0
Does the system meet your expectation?	2	4	3	2
Is the use of the system easy to you?	4	1	6	0
Do you need a help of other people to use the system?	5	2	4	0
Will you use the system in the future?	4	4	2	1

- Once getting acquainted with LUP data, the citizens actively make feedback to existing LUP objects or propose new ones. However, due to different viewpoints and limited knowledge, in many cases the feedbacks and proposals are unclear, poor spatially defined, or irrelevant. To make the opinions of the citizens useful, a close communication between them and LUP authorities must be maintained.

4. Conclusions

Active participation of the local community in development and implementation of LUP is crucial for its success. In this context, WebGIS technology is an ideal tool for making a good government-to-citizen (G2C) communication channel to exchange data, knowledge, and opinions.

At its current development level, open source WebGIS is ready for creating full-featured, rich interface LUP information system.

WebGIS and geospatial technologies are still unfamiliar with most of citizens, especially in rural areas. Therefore, to foster the use of LUP WebGIS system by the local community, it requires proper training, working in group, and active support from the local government staff.

The LUP WebGIS system is only a technical tool for G2C communication. In order to make it functional and gain effectiveness, a policy on transparency of LUP must be developed and implemented.

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