

Web and Mobile GIS for Disaster Recovery and Rehabilitation: Use Case of Nepal

Suman BARAL, Nepal

Keywords: Web and Mobile Based GIS, Disaster Recovery and Rehabilitation, Monitoring and Evaluation (M&E), Project Management System (PMS)

SUMMARY

The current challenge for Nepal's recovery and rehabilitation efforts after 2015 earthquake is the innovation in data collection, management and its utilization for effective planning, monitoring, evaluation and reporting. Habitat for Humanity Nepal (HFHN) is initiating mobile and web GIS system for overcoming challenges and helping communities in building back safer homes.

Although the system is simple, it is sophisticated in terms of its effectiveness- it is location and image based mobile data collection system coupled with Web GIS based project management system for data management and presentation. Data is managed through spatial database management system and presented in the form of web maps, charts and tables. It contains powerful feature of theme based static/dynamic maps and filtering and analytical features of spreadsheets. This eliminates the hassle of playing around every time with the data to make decision products since its automatically updating system.

As the system is location and image based, HFHN volunteers go to individual houses to collect other biographical, WASH and livelihood information depending on project objectives using smart phones. It is helpful in identifying what kind of support families and communities need and determine the availability of construction workers and materials. The information can also be used for comparing data at different stages of construction, including while conducting Monitoring and Evaluation (M&E).

Since, usually houses are built on the same location, you only need to update information related to house construction to determine progress. The information can be visualized by the means of above mentioned presentation methods for decision-making. For example, if you click on a completed house on the web maps, it shows the images of latest construction stage. Firstly, it helps in identifying gaps and finding solutions. Secondly, this helps in presenting progress stories in a single map.

The summarized spatial and graphical information is helping HFHN managers and related stakeholders in planning educational and vocational trainings. It will ultimately help communities in improving livelihood and shelter related standards.

Thus, web and mobile GIS when wisely implemented, can speed up disaster recovery and rehabilitation process in an effective and efficient manner. The system then acts as a helping tool for tracking quality against standard i.e. and the progress against the target which eventually results in quality implementation of project, helping the affected communities in need in a transparent way.

Web and Mobile GIS for Disaster Recovery and Rehabilitation: Use Case of Nepal

Suman BARAL, Nepal

1. BACKGROUND

On 25 April 2015, a 7.8 magnitude earthquake struck Nepal with its epicenter in Gorkha District, approximately 81km northwest of the country capital, Kathmandu. Amid ongoing recovery efforts Nepal was struck by a second earthquake on 12 May 2015, with a magnitude of 7.4. This latter earthquake caused further damage in areas that had already been affected whilst causing new devastation in areas which had previously experienced limited damage. Intense tremors, and subsequent aftershocks, landslides, and avalanches caused widespread damage to homes, infrastructure, and livelihoods, affecting millions of people across 39 out of 75 districts. According to government of Nepal estimates, the earthquakes combined caused over 8,790 casualties and 22,300 injuries, and left over 500,000 houses fully destroyed and 250,000 houses and hundreds of historical and cultural monuments sever damaged. It is estimated that the earthquakes affected the lives of approximately eight million people, constituting almost one-third of the population of Nepal. With a responsibility as an actor of disaster recovery and rehabilitation, HHFN has been helping communities in building safe and resilient homes.

After heavy loss of human lives, casualties and infrastructure, HFHN started working for disaster response following recovery and rehabilitation. For the effectiveness in implementation, it initiated a web and mobile GIS for tracking the work progress and quality of construction to cope with the difficulties of timely decisions. The system placed on is an amalgam of mobile application, web and spreadsheet based dashboard able to visualize the implementation variables in the form of dynamically created and real time updated maps, charts and tables. The combination of these tools as a system we call it a Project Management System (PMS)s in both web and spreadsheet environment. The PMS is able to deliver the message of four pillars of HFHN's implementation strategy- social mobilization, technical assistance, tiered assistance and market development.

There have been use of web and mobile based disaster management system in the past in sporadic manner. One of the system has been built by Geospatial Lab, Kathmandu University for response and relief. There are more use cases. Although, they are dynamic in nature but have to be designed every time on adding new set of survey. With the learning from the limitations of the systems, HFHN's web PMS could work on adding projects, their map layers, tables and relevant charts with less technical knowledge.

The classical concept of GIS is changing with the emergence of cutting edge technologies- web and mobile GIS, statistical analysis of big data etc. So is the application in conjunction with diverse technologies of management and planning in disasters.

2. INTRODUCTION

Web and Mobile GIS for Disaster Recovery and Rehabilitation: Use Case of Nepal (8836)
Suman Baral (Nepal)

FIG Working Week 2017

Surveying the world of tomorrow - From digitalisation to augmented reality
Helsinki, Finland, May 29–June 2, 2017

To enable families to build decent, safer homes and communities by strengthening their skills & capacity, improving their access to technical & financial assistance, building materials & skilled labor and increasing their disaster resilience, the data and information comes in the front row. The data is collected on site reaching to the individual houses. The survey basically contains location and image of the phases of houses along with the questionnaire based on pillars and project objectives. After the completion of surveys, the volunteers upload the information where there is an internet access. These data are refined and then finally presented offline as theme based static maps, spreadsheet dashboards and online as web dashboards able to filter, search and manage data.

Due to adoption of some but not all a decade old technology, the hardships come in the documentation and the proper path in finding the solutions and its application in the projects. Most of the technology goes in the hit and trials because of less use cases. Ultimately, the success matters and HFHN has an example of accomplishment in using it in a right way- use of qrcode for data consistency, data visualizations in decision making, desktop and web based dashboards and thematic maps for identifying patterns, tracking temporal and attribute changes (Abed et al., 2008). All of these aid in replacement of paper based data collection, analysis and presentation to flexible and sophisticated digital technology, and even to the next generation web based Data Driven Decision Management (DDDM).

3. METHODOLOGY

Since, the approach is about integrating different Geospatial Information Communication and Technology (Geo-ICT) tools to achieve the objectives, the workflow aka system flow in terms of process and presentation methods is represented in the figure 1 and figure 2.

The initial step is to develop infrastructure, remote mapping of survey area in OSM environment followed by baseline survey. As, the baseline surveys contains the fundamental information, there should be series of location and image based surveys during the implementation to fetch the manager with timely information for appropriate decisions. Finally, it's about final evaluation based on key indicators based on logical framework.

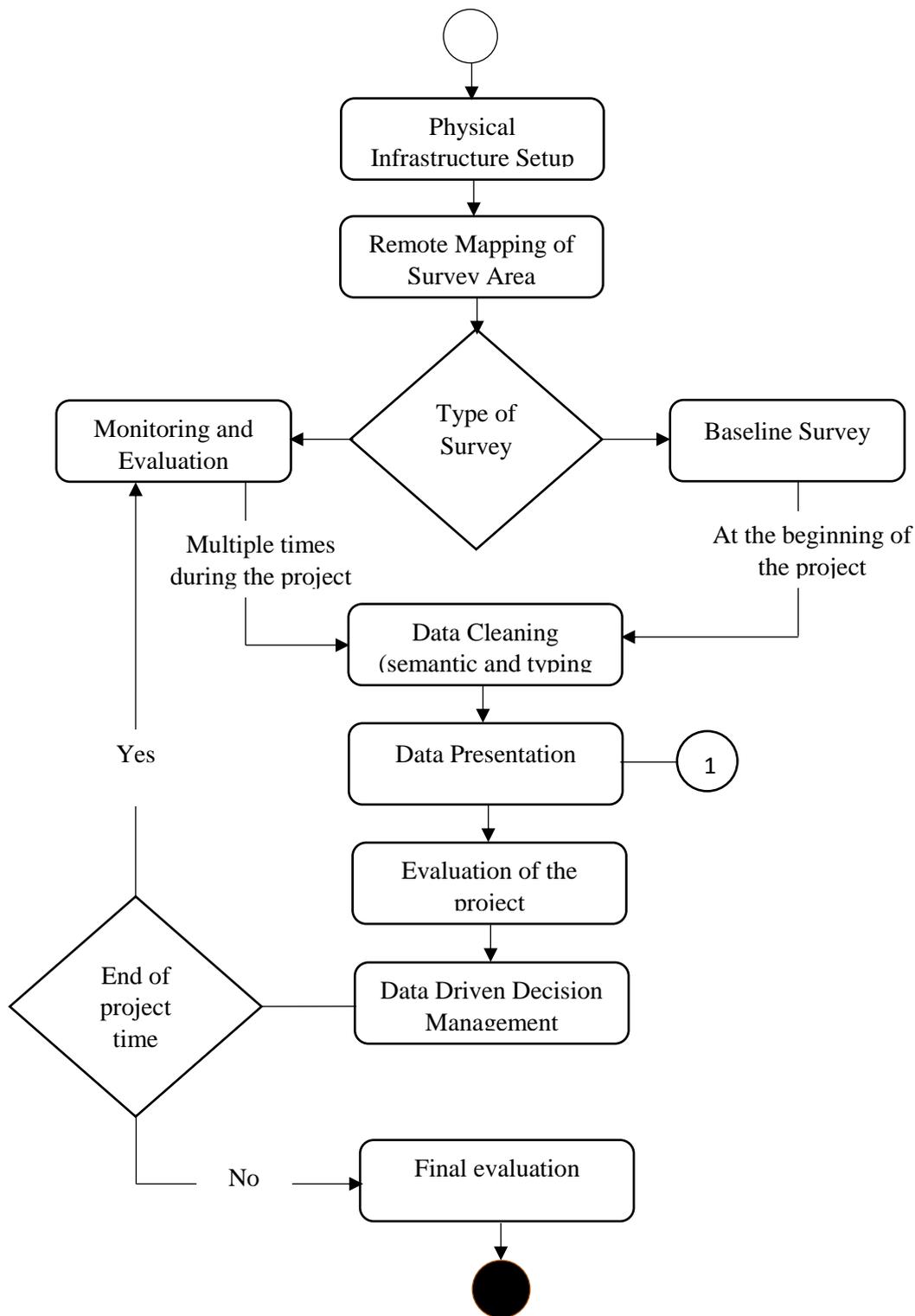


Figure 1: Workflow of the system

3.1. Physical Infrastructure Setup

This phase is the setup of hardware and software at the initiation of project. It primarily includes “web server and GIS server setup” and “mobile forms for data collection and navigation”. The mobile forms are designed in Open Data Kit (ODK) and Open Map Kit (OMK) for attribute and spatial information respectively. OMK and OSM And helps in reaching to the individual houses i.e. these are the navigation tools. The planning of methods of survey and supporting tools are designed here at the same phase.

3.2. Remote Mapping of Survey Area

With the successful completion of tools and methods defined, the next step is to digitize roads, rivers, public places of interest and houses where the baseline and M&E surveys will be conducted for smooth implantation of the project. This step is also about contribution to the Open Street Map (OSM) community. The data can be extracted and used by anyone according to the purpose.

3.3. Household Surveys

First of all, the data from OSM is extracted as MBTiles and xml files. These files are fitted into the OMK for household surveys. In the next step, the surveys are conducted. The surveys are basically the baseline and the follow ups. The baseline survey is designed according to the Logical Framework which covers the key indicators of project. Then, the process of follow up surveys are conducted using the location from the baseline and qrcode prepared with unique identification in it. Location helps in reaching to the individual houses even without human assistance and qrcode helps in maintaining data consistency and avoiding duplication as the field to fill up the identification is possible only through the scanning of qrcode.

Taking the workflow as center point, the field level monitoring is conducted by field level staffs with the help of smart phone based digital applications. The process is-

- After the questionnaire is finalized, Site Supervisors (Engineer if required) goes to individual home partner houses, scans the Qrcode provided to the home partner and update the feedbacks/queries and technical checklist. In case, the home partner location is not known, the existing location from baseline survey helps to navigate.
- The data is passed to data storage and presented in the web. Information is extracted from web dashboards.

3.4. Data Cleaning

The data is not itself clean when uploaded, there are typing and semantics errors. Moreover, during baseline, the locations are either in the point format which has to be converted to polygon and some are out of boundary. During conversion of points to polygons, the image selection for digitization should also be taken into consideration as most of the houses are often destroyed and the new location should be the house construction site. The reason of converting point to polygon is to know the tentative shape and size of previous house and easy for cartographical analysis.

3.5.Data Presentation

Finally, this is the major step in making data understandable to the managers, donors and the authority in place. Two methods are applied for the presentation of data- desktop and web based.

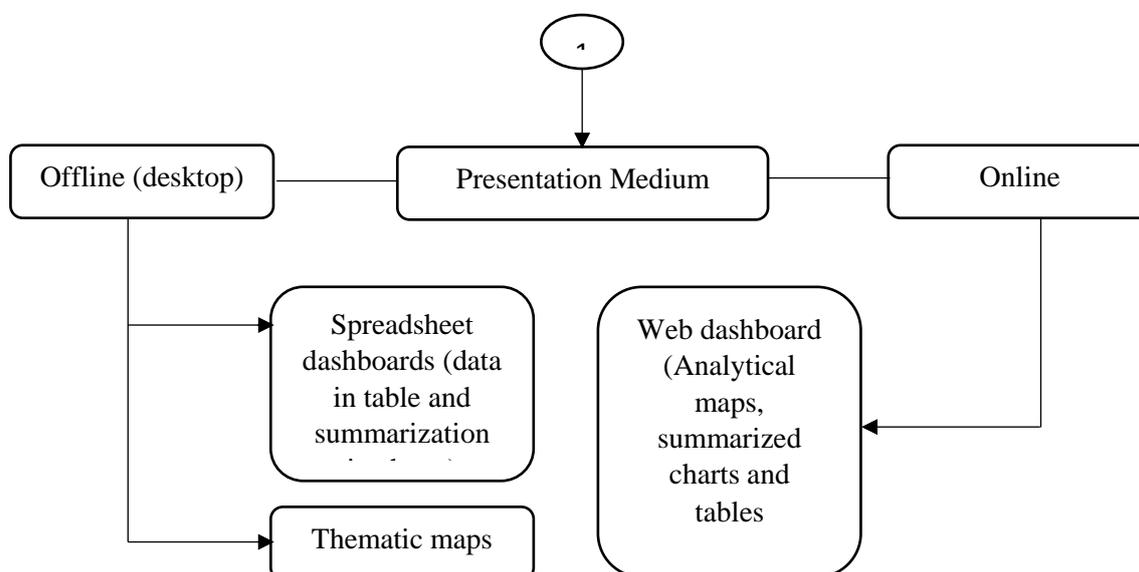


Figure 2: Data presentation mediums (continued from figure 1)

3.5.1. Desktop based presentation

The concept behind the data presentation using desktop based tools (desktop based project management system) is the management and visualization of information with sophisticated functionalities to work while there is not internet. The function includes the data mining features of excel- sorting, searching, filtering and finally presenting to the stakeholders. Moreover, the thematic maps helps in pinpointing the house/cluster of interest.

The tools used in the desktop based presentation are:

- Microsoft Excel: This tool is capable of presenting data in the form of tables, its graphical visualization along with the dashboard capable of performing temporal and simple spatial filters.
- QGIS: The QGIS is able to produce the theme based analytical maps of project indicators.

3.5.2. Web based presentation

The key concept of web based presentation (web based project management system) aka web portal is to aid the project officers and related stakeholders in planning activities by the help of required data, information and visualizations in the web environment. It is about decision making. It has mainly three advantages:

- The system is globally accessible i.e. irrespective of location and local data on hand, authorized stakeholders are able to manage project and plan further

- The system is centrally managed i.e. the system will function on only one copy of data. It has reduced the problem of same data with different version available with different users.
- The system is automated i.e. upon the addition of extra project or survey, dashboards and maps will be automatically updated

3.5.2.1. Technology

The system has incorporate the following technical specifications.

Server-side (backend)

Platform	Amazon EC2 server
Operating System	Linux, preferably Ubuntu or CentOS
Database	PostgreSQL 9.4 or higher PostGIS
Programming Language	Python 2.7 or higher
Web framework	Django Framework 1.9 or higher

Client (browser)

Web Standard	HTML5 and CSS3
CSS framework	Bootstrap 3
JavaScript Libraries	jQuery Leaflet or Open Layers (for maps). Any web chart library (for graphs)

3.5.2.2. Architecture

The architecture of the system is a three tier system. The system will reside on Amazon AWS Server.

- Data Layer: This tier of the system holds all the data collected from the baseline and inline surveys. Since the current system uses PostgreSQL in AWS EC2, current DBMS for the GIS Data visualization and mapping will also use the same source of data.
- Logical Layer: This layer is core application of the system that cotnains all the system logic. The system will be built in python (first priority) or PHP.
- Presentation Layer: Presentation layer is the application of the user interface. It includes HTML5, CSS3, JS and Responsive Framework like Bootstrap for CURD Operation of the system. This tier also includes the maps and the dashboards.

Web and Mobile GIS for Disaster Recovery and Rehabilitation: Use Case of Nepal (8836)
Suman Baral (Nepal)

FIG Working Week 2017

Surveying the world of tomorrow - From digitalisation to augmented reality

Helsinki, Finland, May 29–June 2, 2017

3.5.2.3. Module – User Management

There is three of level of users. These are mainly:

- **Administrator:** user to add, edit or delete users
- **General administrator:** privilege to officers and managers for respective project wise data and information create, edit and update.
- **General users:** just for visualization without any authority.

3.5.2.4. Module – Project Management

The project management module includes features of real-time or frequently updated table, dashboards and maps

- Able to filter, search and visualize geographically and attribute wise information
- Images associated with different phase of construction of a house along with unique spatial QR code attached to be able to open in web browsers
- Charts, tables and graphs updated automatically with filtering and search functionality
- Summarization of project activities
- Project/phase wise search and visualization functionality
- Able to track the progress on timely basis- daily, weekly, fortnight and monthly and generate reports

3.6. Evaluation of project

The positive change of Knowledge, Attitude and Practice (KAP) is the success of any project. To measure, the clear indicator for output, outcome and goals is necessary. Based on literature, the evaluation process we adopted is result/need based evaluation. So, the phases are as below which are supported by the information from the survey.

- **Monthly evaluation:** Conducted every month measuring the affect in the indicator
- **Quarterly evaluation:** Summary evaluation based on monthly evaluation

3.7. Data-driven decision management (DDDM)

The DDDM is about decisions that can be backed up with verifiable data. The data in the database are linked to highly accessible web based dashboards which are preferred means of checking progress versus work plan and quality against standard of construction information at the village/individual level.

3.8. Final Evaluation

The final evaluation is conducted based on quarterly evaluation. The data feed from the field into the presentation and management systems helps in assessing the KAP for defining success and failure based on key indicators of Logical Framework to assess reconstruction outcomes.

4. DISCUSSION

The fundamental concept when it comes to disaster recovery and rehabilitation, the safe shelter is in the front row. GIS is the new age tool for safe shelter based DDDM and it has served in effective project implementation. As the project is supported by four pillars namely social mobilization, technical assistance, tiered assistance and market development and these pillars has a support of web and mobile GIS. With the help of the system, the baseline has information related to project objectives. Moreover, the follow up questions also helps in situational management and change plan accordingly. It assists in strengthening pillars with the help of data and information by:

4.1.Social Mobilization

- Baseline database creation and maintenance for housing recovery and reconstruction mapping of vulnerable community and beneficiary records based on CBS data.
- Assist through data/information- in enrollment process by providing information about beneficiary, to tracks progress against targets during important phase of rehabilitation activity and assess social and reconstruction outcomes.
- Preparation of analytical maps based on surveyed data

4.2.Technical Assistance

- Creation and maintenance of assistance database linking it with baseline data required for technical assistance.
- In case of limited assistance, data is filtered and analyzed as per requirement. The list of trainees, if required, are selected from database.
- Assisting HFHN engineer and field managers for set-up and checking housing support services as per Government of Nepal installment schedule and reconstruction guidelines based on the input information.

4.3.Tiered Assistance

- Making information available based on indicators of poverty and vulnerability criteria in keeping with the CBS developed database, taking into account family savings, remittance, and income for assistance.
- Update and maintenance of information management database.
- Provide information of beneficiaries – non-financial assistance and financial assistance based on poverty, vulnerability and accessibility.
- In a gist, it's a base in implementation of tier assistance

4.4.Market Development

- Vulnerable group identification based on certain criteria for livelihood generation tiered assistance
- Provide updated information of market, its change to assist the stakeholders.

To this date, the system has been serving as a medium of data presentation for DDDM. So, is the success in earthquake recovery and rehabilitation with transparency in the process.

5. CONCLUSION AND RECOMMENDATION

Web and Mobile GIS for Disaster Recovery and Rehabilitation: Use Case of Nepal (8836)
Suman Baral (Nepal)

FIG Working Week 2017

Surveying the world of tomorrow - From digitalisation to augmented reality
Helsinki, Finland, May 29–June 2, 2017

Disaster is an inevitable phenomena which may occur anywhere, anytime. The aftermath management is the challenge, hence necessary steps need to be taken to manage it effectively. The existing system used by HFHN is one of the effective GIS technology to meet the needs of disaster recovery and rehabilitation for implementation with an effect thereby giving homes and hopes to the disaster affected community. Mobile and web GIS technology has its major pros on the fact that helps in spatial DDDM. The system in place is also capable of providing on time information for identifying and segregating the houses based on socio-economic status thus providing the equitable support. In addition, the project penetration has been increased by maintaining the interpersonal and interposition communication between the stakeholders with the help of system and therefore helping to be on the same page. Due to these advantages, cutting edge technologies have been made to adopt to support extended scope of GIS in recovery and rehabilitation.

Technology is trash until it serves the purpose of serving humanity. Instead of high end sophisticated technology with atheistically beautiful design, the pragmatic solutions are necessary (Baral et al., 2015). Sometimes, the adopted technology is viewed from same angle. This needs to be changed. Since, it's a fairly new technology, its adoption by majority of the organizations is a challenge. Still some organizations take it as unwanted burden and budget costing. But with the adoption and example from HFHN, the demand of GIS based project management system is increasing witnessing its usefulness.

The advancement has no limit. The system could be developed further with automated features-automatic report generation, the report with summary of implementation indicators, advance graphical and spatial representation, scheduled email notifications, alerts on tasks etc. With amalgamation of these features, most of the time, the complaint is about cost and time but when developed dynamically, it could serve many projects with a single development cost. It could be developed on Service as a Software (SaaS) model. So, our aim is using technology for disaster recovery and rehabilitation focusing on centrally managed and globally accessible system. It continues.

REFERENCES

- GIS in the Web Era. Available at:
http://esripress.esri.com/storage/esripress/images/188/115391_webgis_chapter01.pdf
(Accessed: 14 February, 2017).
- Mansourian, A., Rajabifard, A., Zoj, M. V., & Williamson, I. (2006). Using SDI and web-based system to facilitate disaster management. *Computers & Geosciences*, 32(3), 303-315.
- Lwin, Ko Ko, and Yuji Murayama. "Web-based GIS system for real-time field data collection using personal mobile phone." *Journal of Geographic Information System 3.04* (2011): 382.
- Brinkhoff, T. (2008, July). Supporting mobile GIS applications by geospatial web services. In 21st Congress of the International Society for Photogrammetry and Remote Sensing, Beijing. Disponible en http://www.isprs.org/proceedings/XXXVII/congress/4_pdf/154.pdf.
- Emrich, C. T., Cutter, S. L., & Weschler, P. J. (2011). GIS and emergency management. *The SAGE Handbook of GIS and Society*. London, Sage, 321-43.
- Abed, F. H., Hongxi, Z., & Hongyan, Z. (2008, September). Open source web-based GIS and database tools for emergency response. In *Automation and Logistics, 2008. ICAL 2008. IEEE International Conference on* (pp. 2972-2976). IEEE.
- Baral, Suman (2015, November). Using social media post for post disaster information management. In *FIG – ISPRS workshop, 2015: International Workshop on Role of Land Professionals and SDI in Disaster Risk Reduction: In the Context of Post 2015 Nepal Earthquake*.

BIOGRAPHICAL NOTES

Suman Baral is a GIS-Database Expert at Habitat for Humanity Nepal who want to make GIS as a tool for serving and saving lives. He is also a part time Assistant Lecturer of Digital Cartography and Digital Web Mapping at Himalayan College of Geomatic Engineering and Land Resources Management. With progressive experience in geospatial field from assistant to Expert level, he has collected ample of knowledge of diverse sectors- educational, consulting firms, government and non-government organizations.

He has presented papers on national and international platforms, some are- FIG-ISPRS Workshop 2015, Nepal, FIG Working Week, New Zealand, and UN Nepal Workshop on application of GNSS etc.

CONTACTS

Suman Baral
Habitat for Humanity Nepal
Sanepa, Lalitpur
NEPAL
Tel. +9775521182
Fax +1-5520778
Email: sbaral@habitatnepal.org
Web site: <http://www.habitatnepal.org>

ANNEX

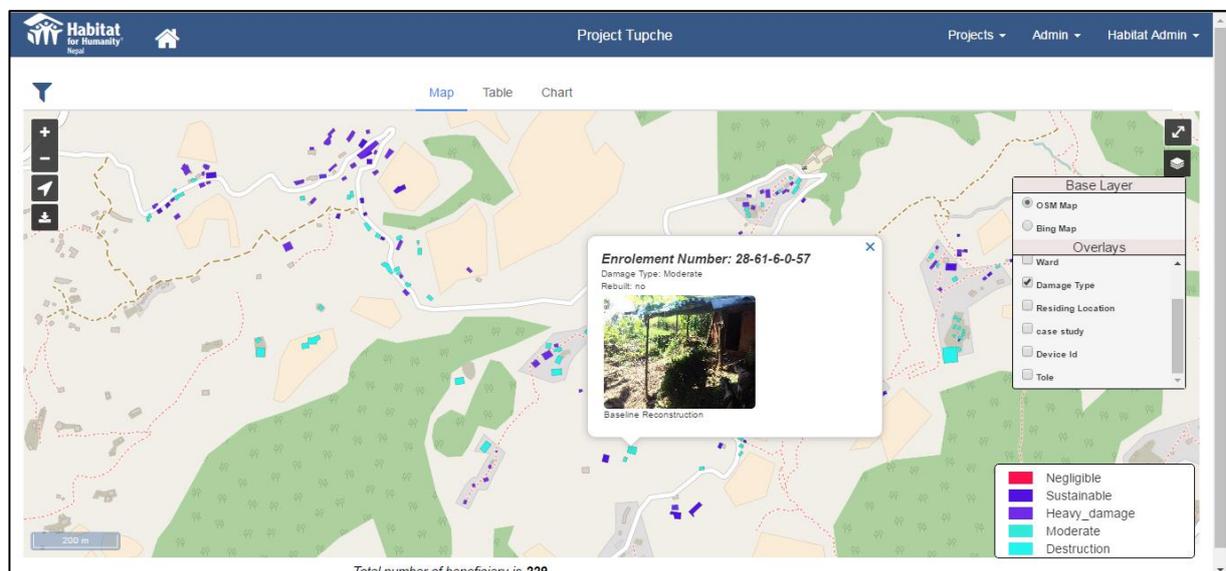


Figure 3: Map page of web based project management system

Web and Mobile GIS for Disaster Recovery and Rehabilitation: Use Case of Nepal (8836)
Suman Baral (Nepal)

FIG Working Week 2017
Surveying the world of tomorrow - From digitalisation to augmented reality
Helsinki, Finland, May 29–June 2, 2017

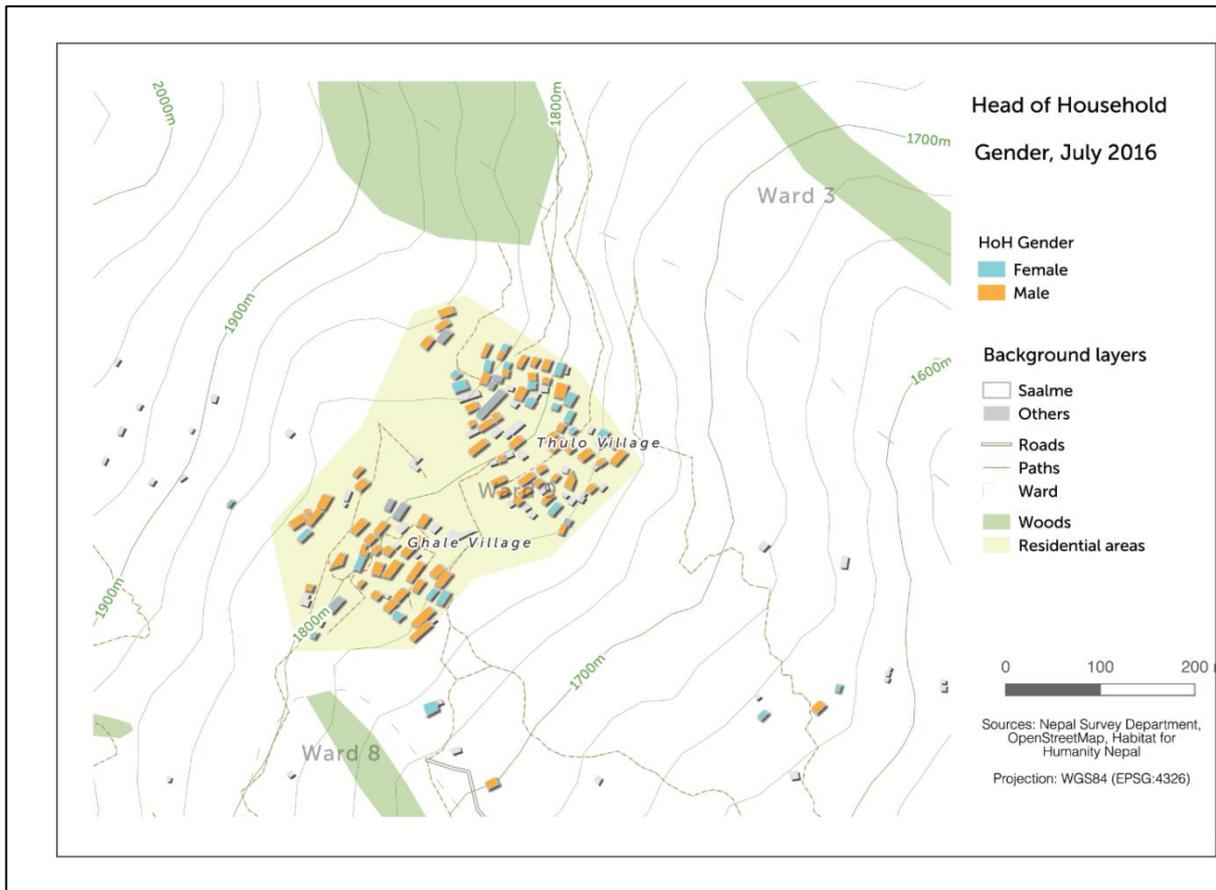
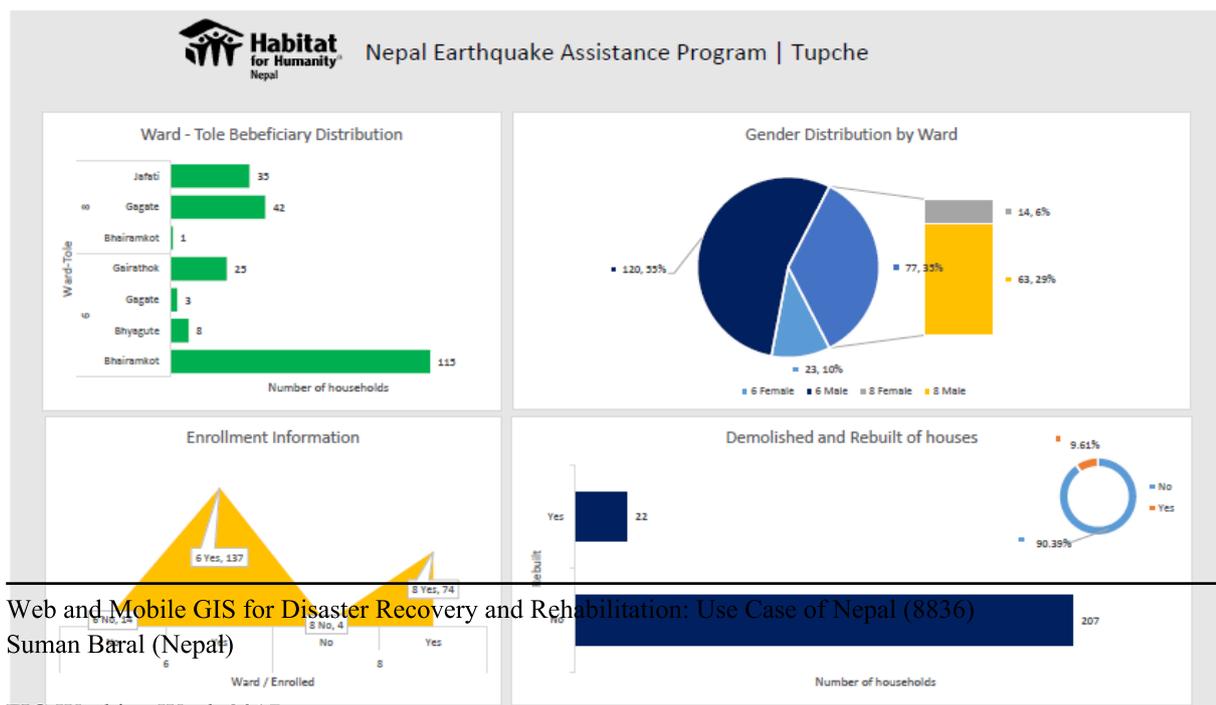


Figure 4: Sample thematic map of project site



Web and Mobile GIS for Disaster Recovery and Rehabilitation: Use Case of Nepal (8836)
Suman Baral (Nepal)

FIG Working Week 2017

Surveying the world of tomorrow - From digitalisation to augmented reality
Helsinki, Finland, May 29–June 2, 2017

Figure 5: A snap of excel dashboard