Dear Author,

I was glad to review your paper, interesting for contents and final aims. I list hereafter tasks you should review for publication. I will reconsider your paper after major revisions. The argument is encouraging, but actually incomplete for methodology and output. Specific reviews of chapters appears hereafter.

- Paper is written with current and regular languages, you adopt technical jargons but not with accurate quality of single chapters. Introduction and background list a context in which the paper reveals the output. Concerning landslides, you introduce susceptibility, hazard, risk, survey types, patterns, distributions, statistics of slope failure, management strategies, risk assessment… Monitoring systems miss in the list, to complete landslide treatment from geomorphological and geophysical point of view (too much…) The general description is quite systematic but the references are not complete, because topics are vast, complex and only cited, often with a general redundancy. The database chapter explains technologies for data collection and GIS system for inventory of landslides in a territorial context. The methodology chapter should be the core, but it lists data and characteristics required for single landslide, integrating characteristic of landslide with element at risk, unclear and indefinite. Technology and Platform appears as core of the output with a copious integration of know-hows and available solutions. The study area illustrates landslides with subsequent results, but without specific enlightenment. Susceptibility map with spatial modelling and many types of data emerge again within chapter, confusing the real output.
- The paper contains an innovative issue but not well ordered. ROOMA has a complex architecture, for gathering and field survey. The activity includes android environment to deploy free and open solution for data collection. The idea is offering a crowd system, to combine user-friendly tools for geospatial activity on field. The participation could include contribution in a large area, with rapid methods for slide mapping. This challenge is innovative, but not included as priority in the paper, because not clearly linked to the landslide dataset required. The paper overbalances interest on all details of risk assessment, deleting request of landslide data and technology adopted.
- Digital field survey exists since around 10 years, within geomorphology final aims, controlled by high precision in GPS location and field GIS integration (MapIt, ArcPad, Geopaparazzi, GISTrimble, and other FOSS4G solutions). You mentioned tablet and mobiles, but the advantage of platform is android environment, customizable and free of costs. The advantage is the online-offline, independent by bandwith, offering a tool definitely fast, user-friendly and low-cost. These advantages are not enlightened. Clear problems could be bug-fixing, GPS precision. The advantage of online-offline includes clear benefits, you need to highlight them compared to traditional field survey.
- You explain the aims as android mobile application on both Offline-Online access. The aim is a fast and storing of data. The visualization and drawing tool is based on central database available to services (mobile, PCs and web browser). Data management improves in hazard event mapping as you declared, but the aim is too general, not simply split.

- Mobile-GIS has a clear gain, but limits due to dimension of mobiles, resolutions, spatial tools available, zooming, spatial extent, route, snapping and editing tools have to be revealed. If compared to desktop GIS you have to explain the difference. ROOMA has a mobile solution, introduced in data transfer. Specify the content of slides and clarify what users can do on the field. Mobile-GIS with GPS are tools to increase efficiency in data collection.
- Online-offline is an interesting approach with Geojson. How can data be saved and furthermore included in geospatial analysis? Explain a bit better the technology adopted. The architecture is not well shown.

1. Introduction

Landslides incorporate all types of mass movements on slopes (Varnes , 1984) and can be triggered by various external events such as intense rainfall, earthquakes, water-level changes, storm waves or human activities. The location, the time of event and the types of displacement can be recorded in a landslide inventory map. In this paper, we do not distinguish between "landslide map", "landslide inventory map", and "landslide inventory". Landslide maps are important factors for landslide hazard and risk assessments, particularly if there is a significant number of landslides with different types, dates, volumes and trigging factors (Coe , et al., 2004). They can be produced using diverse methods however the selection of techniques relies on the size of the area, the resolution , the scale of the map, land use, land cover, soil and geomorphology (Coe , et al., 2004; Guzzetti , et al., 2006; Hungr , et al., 2014). Formulating and documenting landslide maps is essential to define landslide susceptibility, hazard and risk and to survey types, patterns, distributions, and statistics of slope failures. However developing complete landslide inventories are difficult, due to accessibility, the dynamic nature of landslides and also the time required (van Westen, et al., 2006). Conventional techniques lead to the development of landslide inventories mainly based on the visual interpretation of satellite images, assisted by field surveys. Typical issues for creating these maps include (Guzzetti, et al., 2012; van Westen, et al., 2006; Safaei, et al., 2010):

1. All methods for developing landslide inventories have long process and intensive resource.
2. Landslides are often small with high frequency of occurrence which located in remote areas and difficult to access
3. Landslides often have different characteristics which require them to be mapped and documented individually.
4. The lack of landslide documentation and databases are the main disadvantages in the evaluation of landslide hazard risk.

Commentato [S1]: Please simplify differences, is not clear for data typology and requirements.

Commentato [S2]: The access of field area is difficult (dynamic nature, what is?), because you require landslide inventory for final map.

Commentato [S3]: Long process and intensive resource. What are these parameters?

5. Limited damage data are available for landslides, which is why developing landslide vulnerability assessments is challenging.

6. The source of landslide inventories such as aerial photography, satellite imagery, InSAR (Interferometric Synthetic Aperture Radar) and LiDAR (Light Detection and Ranging) are expensive.

GIS for landslide susceptibility and hazards with respect to the type of data available, landslide type and potential extension have been described by several authors (van Westen, 1993; Guzzetti, 2000; Van Den Eeckhaut, et al., 2009; Carrara, et al., 1991; Dhakal, et al., 2000) . While the above authors have noted the importance of enhanced mapping, mobile-GIS offers technology for more effective ground-truthing and a rapid tool which can systematically fill a database, especially for unexperienced mappers. Currently, there is a high possibility to apply mobile-GIS including GPS and mapping tools to significantly increase data collection efficiencies.

In this paper, an offline-online application based on Geospatial Open-Source technologies (Called ROOMA : Rapid Offline-Online Mapping Application) is described to collect data on landslide events, hazard impacts and damaged infrastructure, which can be made readily accessible to authorities, stakeholders and the general public. This prototype provides a solution for preparing landslide hazard maps in relation with vulnerability. Besides, the advantage of an offline technology helps to map the events, especially in rural areas where internet is not available. This prototype has following objectives:

1. An android mobile application with possibility of both Offline-Online access

2. Fast and easy acquiring and storing of data and information

3. Advanced visualization and drawing tool 5

4. Central database with availability by different services (mobile, PCs (Personal Computers) and standard web browser)

5. Data management improvement in hazard event mapping and storage

The paper is structured as follows. In section 2, we first present the background, principles of the different approaches for landslide inventory, and the importance of landslide inventories maps in hazard and risk assessment. We also review some GIS tools that simplify field navigation. Then, Section 3 discusses the description of mapping method, with field survey for 10 preparation of landslide maps in relation with elements at risks. Section 4 illustrates the architecture and platform using open source geospatial technologies to map landslides by using an android application. Section 5 and 6 focus on study area and results. Finally, section 7 concludes by discussing the advantages of mobile-GIS, with the future outlook of producing landslide hazard and risk.

2. Background

Commentato [S4]: "GIS for landslide susceptibility and hazards" is redundant in the paper. These are complex and fundamental steps in risk assessment, with methodology since 10 years… Why do you consider these measurements as concept linked to landslide inventory?

Commentato [S5]: "mobile-GIS offers technology for more effective ground-truthing and a rapid tool which can systematically fill a database, especially for unexperienced mappers. Currently, there is a high possibility to apply mobile-GIS including GPS and mapping tools to significantly increase data collection efficiencies". Please explain the efficiency of the output. User obtains field data, not clear which geometries and contents. And which specific information is collected.

Commentato [S6]: A rapid offline-online technology is the output, absolutely appealing, but not well-defined as collect data on landslide events, hazard impacts and damaged infrastructure. Please specify which information and which aim users can collect during survey. This prototype provides a solution for preparing landslide hazard maps in relation with vulnerability. Too general, a Mobile-GIS offers support to landslide hazard with vulnerability (you did not introduce vulnerability before…). Be clear with details of aims.

Commentato [S7]: The chapter introduce risk management, with tasks and criteria. Landslide inventory is a part of methods available, but also the target of paper. What is the aim to illustrate all steps that you do not face? Focus on landslide inventory and the architecture provided for it.

Landslide risk management estimates risk options with different levels of acceptance criteria by a number of stakeholders. It includes estimations for various levels of risk, decisions on the acceptable level, recommendations and implementation of suitable control measures to reduce risk. It requires that a number of key elements to be addressed (Figure 1): Landslide inventory, susceptibility assessment, hazard assessment, risk assessment, management strategies and decision-making (Dai, et al., 2002; Fell, et al., 2005). Landslides present visible signs for reorganization, classification, and mapping in the field, 20 completed by the interpretation of satellite imagery, aerial photography, or the topographic surface (Guzzetti, et al., 2012). There are many methodologies for landslide hazard assessment using geospatial technologies. Likewise, overviews of these methods can be seen in (van Westen, et al., 2006; van Westen, 1993; Guzzetti, 2000; Dai, et al., 2002). The classification comprises three different methodologies: 1. Qualitative 2. Semi-quantitative and 3. Quantitative. These three methods can be categorized by: 1. Landslide inventory methods 2. Heuristic methods (Ruff & Czurda, 2008; Safaei, et al., 2010; van Westen, 25 et al., 2006) 3. Statistical methods (Huabin, et al., 2005) and 4. Deterministic methods (Hammond, et al., 1992; Zhou, et al., 2003). A disadvantage of statistical models is difficulty to prepare landslide hazard (Huabin, et al., 2005). Landslide inventories are the simplest and the most straightforward initial approach form of landslide mapping and they are the origin of most susceptibility mapping techniques (Dai, et al., 2002; Wieczorek, 1983). Landslide inventory maps can be ready by gathering historic information on different landslide events or Remote Sensing (RS) data like satellite imagery and aerial photographs 30 together with field verification using GPS. They can be used as a source for hazard mapping as well because they show the locations of recorded landslides.

Commentato [S8]: Which kind of stakeholders and for which role?

2.1 Database

Commentato [S9]: The subchapter is poor of matters. You list again landslide inventory data, hazard factors, and elements at risk with a table about contents, but you declare to focus on inventory one. Why do you need to repeat? I suggest merging with next chapter.

Landslide inventory data, hazard factors, and elements at risk (Figure 2) are the main three essential layers for landslide hazard 5 and risk (van Westen, 2004). The landslide inventory is the most significant among them because it acquires the location information of landslide phenomena, types, volume, and damage (van Westen , et al., 2008). In the past years, some places have a complete historical landslide record. Some countries such as Italy (Guzzetti, 2000) , Switzerland, France, Hong Kong (Ho, 2004),Canada and Colombia have developed landslide databases and some can be accessed by internet however difficulties related to completeness in space and time is one of the drawbacks (van Westen, et al., 2006).

2.2 Techniques of landslide data collection

Landslide inventories can be characterized by scale and the type of mapping (Guzzetti , et al., 2006). The different techniques for data collection are divided to: 1. Image interpretation 2. Semi-automated classification 3. Automated classification and 4. Field navigation including total stations, GPS and recently GIS mobile. Field works mostly are carried out to classify group of landslides triggered by an event, acquire data about characteristics of landslides, check inventory maps prepared by other methods, and improve visual

interpretation of satellite images (van Westen, et al., 2006; Safaei, et al., 2010; van Westen , et al., 2008). Figure 3 illustrates all the available techniques for the landslide data collection

Commentato [S10]: Techniques for data collection are actives since years. The list of them is outside the goal of your work.

2.3 Using GIS for landslide inventory

Commentato [S11]: You reveal existing background on similar experiences, but a bit poor. Please enlarge examples, here a bit limited.

Data obtained from field survey, laboratory, and image analysis can successfully been manipulated in the Open Source GIS and allow for graphics production, visualization, image processing, data management and spatial modelling. Many improvements in digital mapping and mobile GIS using Open-Source Geospatial technologies have been revealed in the field of data acquisition for landslide hazard and risk~~,~~. The BGS digital field mapping system (BGS-SIGMA mobile 2012) includes customises ArcMap 10 and Ms Access 2007. It is designed to capture the data in the field on rugged tablet PCs with integrated GPS units and requires Arc Editor Licence to run (BGS, 2013). Geodata implemented a mobile application that can add hazards as point markers with an attached image (GeoData, 2015). Another prototype for landslide geomorphological mapping using Geospatial Open Source software such as MapServer and Postgis was implemented in the Olvera area, Spain (Mantovani, et al., 2010). WbLSIS (Acharya, et al., 2015) is Conceptual Framework for Web-GIS Based Landslide Susceptibility. Another web-GIS tool was (Latini & Köbben, 2005) developed for landslide inventory with paper field works for landslide data collection. Temblor is a mobile application for visualizing hazard maps online anywhere (Temblor, 2016). And finally, Global disk platform by UNEP is a web-GIS platform by using open source can visualize hazard maps and some other data from so many countries (UNEP, 2014). Data available in that platform is limited. However there are few works with an option of using mobile technology for landslide field survey, there are some other works related using satellite images and mobile GIS. ~~For example,~~ there is a GIS mobile application for data collection of cadastre mapping using Esri and Google SDK (Bronder & Persson, 2013). Besides, Geoville has a highly-automated land cover and land use mapping solution that transforms satellite images into intelligent geo-information (Geoville, 2016). Besides, USHAHIDI can build tools to solve countless data acquisition, data management, mapping, and visualization challenges using multiple sources such as mobile application, email, and twitter (USHAHIDI, 2015).

Commentato [S12]: What is the aim of this sentence. It is out of context.

Commentato [S13]: Please explain what is

Commentato [S14]: If your mark Open Source GIS as guideline, these techniques does not look compatible…

Commentato [S15]: Output running on rugged tablet, able in few copies, only for technicians. Not clear why it is not in Technology of ROOMA.

Commentato [S16]: Mobile app in android collects info on field, I supposed by different users. This is the advantage. Dot point or polygons can be marked on field since a lot of years. MapIT e.g. or ArcPad, if you maintain ESRI environment. If you pass on Open Source GIS the environment is another. With other solutions.

Commentato [S17]: You mentioned GeoServer, here you list only MapServer. Why this choice?

Commentato [S18]: Cadaster ?

Commentato [S19]: Two professional outputs, one is a company and one is a crowd emergency webgis. What is your choice?

3. Methodology

Natural hazards present some of the greatest impediments to development in mountain areas. Landslides are impacted by huge number of components, for example geology, land cover, land use practices and earthquakes. Discovering number of landslides and spatial distribution is one method of creating hazard maps. Table 1 illustrates different types of information which can be collected during a field trip of mapping landslides. Landslide inventory is a primary and significant factor of the hazard assessment for qualitative and statistical analysis (van Westen, et al., 2006). The application was developed to complement conventional remote sensing for landslide inventory creation. It is based on a prototype web and mobile GIS application including an online database to overcome some of the aforementioned problems related to landslide database development. This

Commentato [S20]: Why do you collect point, line and polygon as shape of landslides. Do you plan different methodologies?

methodology compensates the lack of landslide inventory and precise topographic process diminishing the resources and time for storage and update. In addition, the combination of the ROOMA data collection method in the field with GPS and satellite image as source maps can significantly improve the accuracy of input field data.

3.1 Recording not only landslide characteristics but also elements at risk

Elements at risk are the obligatory data for landslide risk assessment. Elements at risk state buildings (houses, schools and etc.), inhabitants, road networks, utilities, infrastructure and many other factors which can be at risk in an affected area. Importance is placed on data related to houses and people. Generally, data for elements at risk are collected by satellite images and result in the production of versatile databases. However for this prototype, elements at risk (Figure 4) can be recorded directly in the field along with gathering other attributes of landslide event data (Table 1). Elements at risk have different characteristics including spatial (the feature in relation to the landslide) and non-spatial like temporal (e.g. inhabitants) and thematic characteristics (e.g. material type of the buildings). Figure 4 describes different types of spatial and non-spatial data that are recorded in our database. However, the only mandatory data to be recorded is the feature and name of event, the rest of data can remain null and be filled later if necessary.

4. Technology and Platform: Mobile GIS

Free and Open Source Geospatial Software (FOSS4G) have significantly improved the efficient mapping and management of post disaster and impacted areas around the world (UNEP, 2014; Geoville, 2016; USHAHIDI, 2015). GIS can integrate different layers of spatial data on landslide occurrence to define the effects of various parameters.

There are new developments in Open-source geospatial technology for visualization and analysis landslide maps, including (Leaflet, 2015; BoundlessSpatial, 2016; Cordova, 2015): 1.Digital acquisition and editing tools, 2. Advanced geo-visualization, 3. Enhanced integration with satellite imagery using TileMill (Mapbox, 2016), 4. ~~Well organized~~ combination with database management systems and 5. Amplification of the accuracy by using mobile GPS (Cordova, 2015).

In an inventory map, the different geometrical features (points, lines, and polygons) by different descriptive attributes e.g. type, date, activity, triggering factor and hazard degree are given in GIS format. The landslide data can be displayed using a combination of points (markers), lines and polygons. The best practice is to gather them as polygon features to have the option to calculate the area. With the help of Cordova (Cordova, 2015) and PhoneGap (PhoneGap, 2015) for android, the offline component of ROOMA was developed to simplify data collection in the field in remote areas where internet access is poor. The data can be exported to GeoJSON-TXT (GeoJSON is a format for encoding a variety of geographic data structures (GeoJSON, 2015)~~)~~

Commentato [S21]: Not clear

Commentato [S22]: ROOMA should improve quality and quantity of inventory. GPS is basically important, depend also by resolution and signal. Field survey usually requires control on GPS signal and calibration, otherwise field survey is not precis. Did you treat it? Which kind of satellite images do you use? Field data is corrected by images. But is it on field control or post-processing? Please specify this integration, it is fundamental.

Commentato [S23]: Title not acceptable. Integrate with previous chapter.

Commentato [S24]: Confusing. The previous methodology treats landslides with characteristics (materials, type, damage). Here element at risk. Merge all data type in same chapter.

Commentato [S25]: Do you mean landcover mapping? Otherwise you cite a company…

Commentato [S26]: Too vague, specify simply your aim.

Commentato [S27]: Which is the difference between Open Source Geospatial Software and Open-source geospatial technology. Clarify.

Commentato [S28]: Which DBS? Who is the owner.

Commentato [S29]: Why do you repeat so many times?

Commentato [S30]: This is innovative. You have to dedicate more time then past experiences on classic landslide database… Your app treats with PhoneGap, linked to existing web development. By website I read "hybrid applications built with HTML, CSS and JavaScript". You should specify which link on web storages, simply to include in your methodology.

files and transferred through the internet to the online component where the main database is located. This enables the collection of data from multiple data collectors ~~to be entered~~ into the same database. The geodatabase was designed to incorporate geospatial data acquired in the field, delivered as an input to the system (e.g., type, shape, volume, date, triggering factor, hazard degree) with elements at risk data connected to a specific event (e.g., building information, road network, damage information). The FOSS4G technologies selected to provide this module were PostgreSQL 9.4 (PostgreSQL, 2015) and Postgis 2.1 (PostGIS, 2015) for spatial database management. The GeoServer 2.6 (Geoserver, 2015) module, in connection with Geodatabase (Postgis), is delivered for spatial analysis and visualization. This component brings a complete and up-to-date description of the different layers including a landslide event layer, elements at risk layer and detailed information of landslides in the study area including event descriptions and photo clusters. Finally, the outcomes are captured and shown through GeoServer and OGC services such as Web Map Service (WMS) and Web Feature Service (WFS) as well as being exported as shapefile format and visualized in other GIS software ~~like ArcGIS or QGIS~~. MySQL database (MySQL, 2015) and UserCake library (UserCake, 2015) improve the user management and authentication. Two type of users are available in the system: Public and Administrator. Based on their privilege, they can access to different components of the online version. For example, only the administrator can define a new study area and assign it to different users. Figure 5 displays the technologies and the frameworks of this prototype.

The offline component of ROOMA (Figure 6) contains the following modules: 1. Geolocation, 2. Map with combination of multi-source base layer 3. Map drawer (Line, Polygon, Rectangle and Marker) 4. Satellite image as the base layer and 5. Saving options as Geojson-txt file in the offline mode. The mapping process is quick and easy; different features such as polygons, points or lines can be drawn on a map drawer after geolocation. Following, different satellite images as base layers assist for finding different objects on the map. However, the online component presents more modules besides map and geolocation modules: 1. Map with combination of multi-source base layer, 2. Saving online events directly to database, 3. Photo mapping, 4.Photo and event clustering, 5. User privileges 6. Data storage and analysis, 7. Import from/Export to Shape files.

The user can save or upload these features as one event and define additional characteristics such as ~~land use, damage, trigger, possibility of hazard etc~~. Figure 7 and 8 illustrates how an admin can view different landslide events in the online version with the possibility of editing events.

Commentato [S31]: Which one?

Commentato [S32]: Correct but redundant sentence

Commentato [S33]: Describe which info by photo

Commentato [S34]: User profiles

Commentato [S35]: Not all components of architecture are explained. Consider them and introduce.

Commentato [S36]: Why do you use prototype definition? The app will be updated, is not completed working or you need a piloting?

Commentato [S37]: Explain which kind of combination.

Commentato [S38]: Not clear which analysis you intend

Commentato [S39]: Editing events of landslides based on satellite image is not innovative. Field survey exists since a lot. You should mark the online-offline technology as real advantage on field. You did not describe the relations to update database in online-offline condition. You should describe how can be data collected be synchronized. Do users choose online-offline mode or is automatic upgrade based on bandwith? Figure 8 is not innovative, simply you edit a polygon on a raster image, what is new?

5. Study area

Many landslide studies have been conducted in the Everest regions (Gupta & Saha, 2009; Bajracharya & Bajracharya, 2010; ICIMOD, 2016; Sato & Une, 2016). The 7.6 magnitude earthquake in Nepal on 25th April 2015 and a series of aftershocks significantly increased the risks of landslides (Collins & Jibson , 2015). Nepal has a high natural geological fragility which was further increased by the 2015 earthquake, which triggered several thousand landslides (ICIMOD, 2016; Collins & Jibson, 2015). The ROOMA application was tested in

the Phewa Lake Watershed (123km2) in Western Nepal, Kaski District (Figure 9) where our team has been monitoring landslides since 2013. An intense rainfall event (315 mm in 4 hours) killed 9 people on 29 July 2015 in Bhadaure-5 near Pokhara and another 25 people were killed nearby Lumle in Parbat District (BBC, 2015). It was very hard to differentiate those landslides and their properties through image interpretation so the urge for field mapping was very high and the landslides have to be identified on the field whether close to the event or far. The ROOMA application ~~was~~ run for a rapid assessment of landslides triggered by this event or reactivated along with their land-use characteristics and damages such as houses, schools, roads, rivers, agriculture fields and forest area. (Figure 10).

Commentato [S40]: Clarify distance, features, polygon revealed. Actually it is only a picture.

6. Results

~~To test the prototype~~, two days of field work were conducted in the Phewa Lake watershed, and based on medium resolution satellite image (GeoEye 2015, 5 meter resolution) added to ROOMA application, 59 landslides were mapped. The mapping of landslides (using polygons) was accompanied by data collection on land use features for each event (e.g. adjacent roads, rivers, forest, and critical infrastructure) to give better indications of surrounding features. The extreme advantage of mobile-GIS is gained in relation to the existence of landslides and determination of the frequency distribution of landslide areas. The satellite image added to the application significantly eased the exploration of this area and assisted the visual interpretation process. The data were collected on-site either close to road or from a distance which enabled easy interpretation for landslides which would have been difficult to access otherwise (Figure 11 and 12). Figure 11 represents a new landslide documented near the road that was not visible in satellite image and ~~figure~~ Figure 12 shows a larger landslide which was located within a distance and it is clearly visible in image interpretation. Most of large landslides were mapped by distance. Figure 13 shows the distribution of landslides in that area where most landslides occurred in the centre.

Commentato [S41]: Parameters not present in previous list within methodology. Did you add new text? Why?

Commentato [S42]: Clarify the link between mobile-GIS and frequency distribution

Commentato [S43]: It is a reason why you integrate satellite image. It has to be mentioned within definition of methodology

Commentato [S44]: It is a bit ambiguous. You update landslides with you field actions, but some of events are not accessible, but visible only with distance like in Figure 12. I would consider as integration.

Commentato [S45]: Large landslides are visible on satellite. Did you edit on desktop GIS or check shape of landslide on field. IT could be a tool to upgrade what is existing as polygon.

All data were uploaded to the online version and then exported to a shape file. It was possible to perform the rest of the analysis in QGIS however it is planned to add extra modules in online version for querying, summarizing results and finally having landslide susceptibility map. Data obtained from the field survey were successfully analysed in the Open Source GIS with more detailed analysis possible such as distribution of landslide type, material, elevation, damages, surface areas and volume, graphics production, spatial modelling, and visualization of many types of data. For example, all the information about land use characteristics and their damages for different landslide were gathered separately in our database and can be useful for more detailed analysis.

Commentato [S46]: These are scientific and practical results. Not clear and too general. Delete.

Commentato [S47]: New version of output

Moreover, further analysis of land use/cover changes has been carried out based on visual interpolation on a multispectral satellite image (SPOT 2016, 2 meter resolution) acquired in 2016 after this field checking. Basically our ground truthing brought the confidence for further mapping (177 Landslides mapped afterward)

of the additional smaller landslides that were not mapped during the field survey. Figure 15 shows these landslides on the map.

The advantage of a mobile version in field over mapping using only GIS and high resolution satellite images (in office), is that some features characteristics of landslides are not visible only on images. Coupling satellite image interpretation with field observation allow to identify better the type of landslide, even using a medium resolution satellite image (~5 m). The Figure 16 shows such example: the detail mapping on standard GIS permits to identify active landslides in the gullies, i.e. debris-flow and shallow landslides, while the lower resolution image coupled with field survey permits to identify a larger landslide. The landslides linked with the gullies is simply the limits of the larger one, where the activity is obvious.

Commentato [S48]: This conclusion is positive. You declare landslides in gullies visible with high resolution images, while adding filed survey you can define and edit better the polygons.

7. Discussion ~~and Conclusion~~

Landslide inventories define vulnerability, hazard, landslide susceptibility and risk by investigating the information on type, pattern, distribution and slope failures (Guzzetti, et al., 2012). Earlier works on landslide hazard evaluation shows that considerable developments have been accomplished in the last decade, GIS tools are now crucial for landslide hazard and risk assessments, however, the generation of landslide maps including elements at risk and an online database in a larger scale appears a stage too far especially in data poor countries having such an offline application can provide a significant technological leap and save valuable resources. The value of landslide inventories relies on the accuracy and certainty of the information which is problematic to define (discussed in introduction) however, different mapping approaches on Open Source Geospatial technologies, can significantly simplify the production of these maps. ~~Moreover, the ability to use the Open Source software indicates that analyses can be carried out without incurring the high costs associated with software acquisition, a particular advantage for developing country, researchers and government officials.~~

Commentato [S49]: Reply all these aims within discussion. While you focus simply on data collection and database…

Commentato [S50]: Quite old sentence…

Commentato [S51]: You repeat several times elements at risk, but I do not see some examples about field trip or database about them.

This application incorporates rapid, economic and participatory methods for mapping landslides. It uses satellite images as multi-source map and enables multiple data collection to finally be collated in a centralized database. Data can be acquired in offline version using android device or an online mode using all browsers in Pcs, tablets and mobiles. The study was applied for mapping landslides in post-earthquake Nepal, but, it can be practical for other hazard events such as floods, avalanches, etc. Nevertheless, this offline version can be improved by adding more components for distance calculation, continuous lines sketch, recording foot paths and merging the GPS located camera with the azimuth of data to help generating 3D models of the area.

Commentato [S52]: You do not mention before. Who participates and which organizations or teams.

Considering all the difficulties stated in this work, a landslide mapping are typically carried out based on the experience of the expert however, by getting support of mobile GIS, this application is easy to be run by non-expert and general public as well. A combination of satellite data and web-GIS technologies brings the ideal solution for landslide hazard and risk data acquisition especially more high resolution satellite images can be available recently and sometimes freely. The paper concludes that the ROOMA tool will increase the quality

Commentato [S53]: Concept of data synchronized and gain of time with ROOMA are not mentioned.

of landslide maps as well as ~~susceptibility, hazard, risk assessments~~, and landscape modelling and will also assist the speed for preparation of above products.

The paper accomplishes several of new improvements and future works, for example adding the topographic data DEM, spatial-temporal modelling by using landslide inventory maps. More works are needed to incorporate vulnerability components, where more attentions are needed in defining vulnerability values in order to generate risk maps. Finally, it is essential to integrate a spatial decision support systems to use such data for landslide hazard and risk assessments for both stakeholders and local authorities.