Towards using Volunteered Geographic Information to monitor post-disaster recovery in tourist destinations

Melanie Eckle
GIScience Chair,
Heidelberg University, Germany
Eckle@uni-heidelberg.de

Benjamin Herfort
GIScience Chair,
Heidelberg University, Germany
Herfort@uni-heidelberg.de

Yingwei Yan
GIScience Chair,
Heidelberg University, Germany,
Yingwei.Yan@uni-heidelberg.de

Chiao-Ling Kuo
GIScience Chair,
Heidelberg University, Germany
kuo@chiaoling.com

Alexander Zipf
GIScience Chair,
Heidelberg University, Germany
Zipf@uni-heidelberg.de

ABSTRACT

The aftereffects of disaster events are significant in tourist destinations where they do not only lead to destruction and casualties, but also long-lasting economic harms. The public perception causes tourists to refrain from visiting these areas and recovery of the tourist industry, a major economic sector, to become challenging. To improve this situation, current information about the tourist and infrastructure recovery is crucial for a "rebranding"- information that is however time and cost-intensive in acquisition using traditional information sources. An alternative data source that has shown great potential for information gathering in other disaster management phases, which was less considered for disaster recovery purposes, is Volunteered Geographic Information (VGI). Therefore, this paper introduces a VGI-based methodology to address this task. Initial analyses conducted with Flickr data indicate a potential of VGI for recovery monitoring, whereas the analysis of OpenStreetMap data shows, that this form of VGI requires further quality assurance.

Keywords

OpenStreetMap, Flickr, Disaster, Recovery, Tourism

INTRODUCTION AND BACKGROUND

Disasters pose serious threats to affected communities and environments all around the world. Such events not only cause immediate effects in the disaster-affected areas, but also lead to long-term burdens over post-event recoveries. Post-disaster recovery is especially challenging for tourist destinations, as the image and reputation of the regions is harmed. Tourists may be hesitant to visit an affected tourist destination even though the region has physically recovered as a result of the tourists' perception that the latter does not fit the image of a holiday place. Apart from this, uncertainties regarding safety and the level of reconstruction lead tourists to avoid visiting the affected tourist destination (Walters and Mair, 2012). For this reason, the image restoration of a disaster affected destination is as important as (or even more important than) fixing physical damages, which has been termed as “rebranding” in Amujo and Otubanjo (2012).

For restoring the image, information regarding the current status of recovery in terms of security, the local services, and tourist attractions is needed (Walters and Mair, 2012). While there are studies and approaches to gather recovery information using satellite imagery, on the ground surveys, and interviews, these methods demand expert knowledge, specific training, and software, and are therefore costly and time-consuming (Platt et al., 2016). An alternative data source that has shown to provide great potential for disaster management purposes is Volunteered Geographic Information (VGI)- data that is voluntarily created and maintained by international volunteers and the disaster affected people themselves (Horita et al., 2013; Liu and Palen, 2010; Meier, 2015; Poiani et al., 2015). Due to the real-time character, outreach, and cost-effectiveness of VGI, the data is increasingly utilized to support disaster management purposes. OpenStreetMap (OSM) is hereby used to gather current map data of the disaster location, including disaster related information, e.g. temporary shelters or infrastructure damage (Anhorn et al., 2016; Westrope et al., 2014). In turn, social media data is frequently used for event detection and to obtain situational awareness (Vieweg et al., 2014; Vieweg et al., 2010; Imran et al., 2014). While these potentials of VGI could be put in use in all disaster management phases, to date VGI has been almost exclusively utilized for the response and preparedness phase of disasters. In turn, its use for disaster recovery has been less explored (Horita et al., 2013; Haworth and Bruce, 2015). Accordingly, there are also no experiences in using VGI for the monitoring of recovery in specific locations, e.g. tourist destinations.

In order to close this research gap, the aim of this paper is to analyze the suitability of VGI in monitoring the disaster recovery of disaster affected tourist destinations by monitoring the level of recovery and tourist activity. The remainder of this paper is as follows. The next section provides an overview of the previous research on the use of VGI for disaster management purposes as well as previous disaster recovery studies. The approach and method section introduces our workflow and the methods that have been implemented to assess the research question. After presenting our case study and area of interest, the initial results of the analyses conducted based on the OSM and Flickr data in the area of interest are provided. The discussion, conclusion and outlook provide concluding remarks and ideas for future studies that can build on the insights gained.

RELATED WORK

Over the last couple of years, the use of VGI data for disaster management has grown in popularity. In numerous disasters, e.g. the Haiti earthquake in 2010 (Zook et al., 2010), Typhoon Haiyan in 2013 (Westrope et al., 2014; Vieweg et al., 2014), and the Nepal earthquakes in 2015 (Poiani et al., 2015), this form of data was used to obtain situational awareness, for damage assessment, and coordination purposes.

One form of VGI data that was hereby increasingly utilized is OSM data[1]. The openly available map data is collected in disaster mapping activations which are launched by the Humanitarian OpenStreetMap team (HOT)[2]. HOT is hereby, on the one hand, in contact with the humanitarian aid organizations and, on the other hand, coordinating the OSM mappers to meet the humanitarian aid organizations´ and emergency responders´ needs. The data that is collected by international volunteers of the OSM community enables the localization of disaster related information and can be furthermore used to estimate the level of infrastructure damage in the disaster affected area in the direct aftermath of disasters (Meier, 2015; Westrope et al., 2014). Another OSM related project, Missing Maps[3], was launched in 2014 as a collaboration of humanitarian organizations and HOT with the objective to also make use of OSM data to enable better disaster preparedness and support of humanitarian aid efforts. While the project and the related research again showed the potential of OSM in supporting humanitarian action and disaster preparedness (Porto de Albuquerque et al., 2016; Herfort et al., 2016), to the best of our knowledge the use of OSM data for the recovery phase has been neglected in previous OSM research.

Likewise to the map data creation facilitated by HOT and the OSM community, the analyses of social media data are to a great part conducted by digital volunteers, too. The Standby Volunteer Task Force[4] (SBTF) is one of the main volunteer networks which are activated for disaster response support. By classifying, analyzing, and geo-referencing social media messages provided by the affected population in near-real time, the volunteers can help to obtain situational awareness (Meier, 2015; Vieweg et al., 2010). The use of social media was therefore also increasingly covered in research.

Several studies focused on the different kinds of information social media data could provide for disaster management, while others in turn assessed ways to support the work of the volunteers and facilitate the data

[1] http://www.openstreetmap.org 3.1.2017.
[2] https://www.hotosm.org/ 3.1.2017.
[3] http://www.missingmaps.org/ 3.1.2017.
[4] http://www.standbytaskforce.org/ 3.1.2017.

classification. Studies by Sakaki, Okazaki and Matsuo (2010) and Crooks et al. (2013) showed that analyses of social media data can help to assess the location of a disaster and the affected areas. Further studies by Olteanu, Vieweg and Castillo (2015) and Vieweg et al. (2010) moreover presented possibilities for improving the utilization of social media data for disaster management purposes by assessing the different topics that are covered in social media data in different kinds of disaster events. This approach enabled the evaluation of the sort of information that can be expected from social media in a specific type of disaster. In research conducted by the Qatar Research Institute in collaboration with the SBTF, Imran et al. (2014) introduced a machine learning approach that supports the work of the digital volunteers. Applications like the Artificial Intelligence for Disaster Response (AIDR) facilitate the classification of tweets using manual tweet classifications by volunteers as training data and a machine-learning algorithm for the further classification.

While the results of the presented studies indicate that the assessed social media data also contains recovery related information, the use of social media for information gathering in the recovery phase is still neglected in academia (Olteanu, Viweg and Castillo, 2015). To date the level of recovery and thus “returning to normal” was above all assessed using remote sensing techniques, on the ground surveys, statistics, authoritative and / or commercial data (Brown et al., 2012; Brown et al., 2008; Bolin and Stanford, 1998; Hirayama 2000; Chang and Falit-Baiamonte, 2002).

Examples of such methods have e.g. been introduced in 2008 by Brown et al.. The authors presented a method for identifying indicators of post-disaster recovery using remote sensing and field survey techniques as well as online statistics (Brown et al., 2008). Remote sensing and ground survey techniques were moreover utilized in a study concerning the initial recovery after the Wenchuan Earthquake in 2008 (Brown et al., 2012). The use of surveys has in general been popular for monitoring housing and household recovery (Bolin and Stanford 1998; Hirayama 2000) as well as business recovery (Chang and Falit-Baiamonte, 2002). Platt et al. (2016) again recommend combining different approaches, in their research approach, satellite imagery analyses, ground and household surveys, social audit, commercial and official data, statistics, and VGI. While the authors acknowledge the potential of VGI for disaster management, they doubt the usefulness of VGI for disaster recovery purposes due to an assumed lack of interest by the volunteers in recovery support. An assumption that was however not further investigated. While the introduced traditional methods proved to enable the needed information gathering for disaster recovery monitoring, they require a high level of training as well as specific technology and are time- and cost-intensive (Platt et al., 2016). Moreover, while tourist numbers for monitoring tourist activity are collected and accessible in detailed statistics for most places in our world, there are also countries in which this kind of data is not available or not kept up to date, e.g. in countries on the African continent (Christie et al., 2014; African Development Bank, 2017). In general there are differences in the scale these statistics are available in, which are varying between country and regional level. With OSM and social media having shown potential in the other disaster phases (Liu et al., 2008; Horita et al., 2013) and the use of VGI for supporting these efforts being less explored, the objective of this paper is to assess the potential of this alternative or complementary data source for recovery and tourist activity monitoring, using tourist destinations as an initial use case. In comparison to other social media platforms, e.g. Twitter and Facebook, Flickr offers a higher and easier accessibility as the Flickr API enables to acquire all possible historical Flickr data[5]. In turn, the Twitter API limits the data acquisition to a small one percent sample of the full data (Peters and Porto de Albuquerque, 2015). Facebook is even more restricted on obtaining its users’ data contributions (Solberg 2010). To ensure having a comprehensive data set to work on and which can be assessed for the crucial time of the Bohol earthquake and Typhoon Haiyan, we decided to use Flickr data in this initial study.

APPROACH AND METHOD

Disaster recovery in tourist destinations comprises infrastructure reconstruction as well as the local tourist economy getting back to normal. The focus of the analyses is therefore laid on information gathering about the level of reconstruction and the tourist activity.

Monitoring of reconstruction using OSM data

In a first step, the level of reconstruction is assessed using the OSM data that is added by the OSM community in disaster response mapping activations organized by HOT.

[5] https://www.flickr.com/services/api/ 19.3.2017.

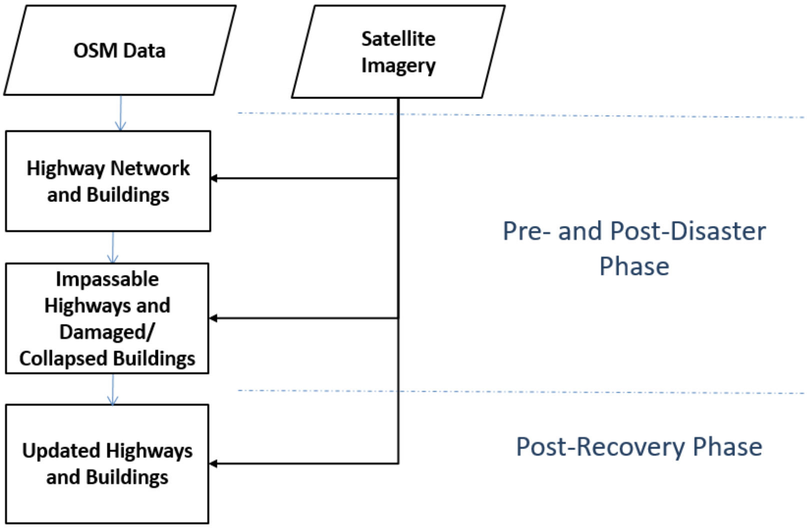

Figure 1. OSM Temporary Disaster Related Tag Workflow

In these activations, HOT organizes and coordinates the mapping activities by providing a selection of regions and features on which mappers should put their focus on. These are communicated by humanitarian organizations and first responders on the ground. In general, mappers are asked to add temporary damage related "tags" to highways and buildings using post-disaster imagery to enable damage assessment and disaster specific routing (Neis et al., 2010; Westrope et al., 2014). Tags are the attributes describing OSM features using a "key=value" structure (Ramm and Topf, 2010). In the case of a disaster mapping activation, damaged highways should be tagged with "status=impassable", obstacles on the road as "barrier=debris". Damaged buildings should be tagged as "building=damaged", totally collapsed buildings with "building=collapsed", and an area of collapsed houses as "landuse=brownfield". All of these tags are temporary additions to already existing OSM features that are added in the post-disaster phase to help emergency responders identify disaster affected areas and facilitate the disaster response coordination. As the tags are used to mark damage, they should be deleted and updated in the OSM database in the post-recovery phase when the reconstruction is finished. Consequently, the decline of these disaster-related tags can be seen as a proxy for infrastructure recovery in the aftermath of a disaster. To test this hypothesis, temporal modifications in the number of disaster-related tags are assessed. These changes can be monitored using the OSM history data in which we can access the state of the OSM database for different points in time. Using the date extension in overpass turbo[6], an OSM service which allows extracting OSM data based on defined tags via the overpass-API, queries can be run considering the specific disaster-related temporal tags and different points in time. The area of interest can hereby be utilized as a bounding box to limit the queried data and the time of computation which depends on the number of queried features. The overpass turbo service enables the export and moreover displaying the number of features that resulted from a query. Queries that are run using the same tag and bounding box for different points in time enable monitoring changes in the assessed tag count.

Monitoring of tourist activity

Economic recovery in tourist destinations is to a great part related to the tourist sector recovery. An increase in tourist numbers in the former disaster affected region can therefore be seen as a sign for economic recovery. To assess the number of tourists within the Flickr users which can facilitate the estimation of the overall tourist activity, a pre-processing of the OSM and Flickr data is conducted followed by the analyses of the VGI data.

[6] http://overpass-turbo.eu/ 3.1.2017.

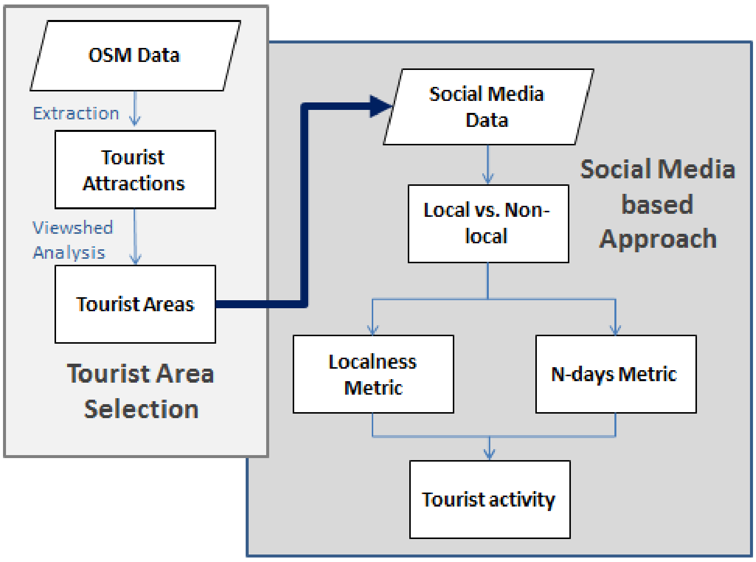

Figure 2. Tourist Activity Monitoring Workflow

In a first step, all relevant tourism related OSM features are selected. These features are assessed by searching for all OSM tagging combinations that are used to describe touristic places in OSM in the OSM Map Features[7]. All features containing a "tourism"-key or "historic"-key and all features that are tagged as "amenity=place of worship" within the area of interest are selected using a bounding box of the area of interest and querying the current state of the OSM database. In the next step, these features are exported using the overpass turbo service to identify all places that could be of relevance for tourists visiting an area. Additionally, to ensure that only relevant social media data is included in the analyses, in the further step, a viewshed analysis is conducted, using the viewshed tool of ArcGIS, on the basis of a digital elevation model (ASTER GDEM 2) and the selected OSM features (Tachikawa et al., 2011). The viewshed analysis provides all places from which at least one tourist sight might be visible considering the given conditions and the terrain. Thus, all tourism data that might have been incorrectly georeferenced can be excluded. Moreover, all social media data with location accuracy less than street-level is removed. In the further analyses, only the social media data within the viewshed is used to ensure a high level of thematic relevancy.

After the pre-processing of the data, initial analyses of the social media data are conducted. Herein the users are classified as tourists or local social media users according to their contributions. Therefore, two different methods are tested and combined. The first approach is the so-called *location field* or *localness metric* (Jurgens et al., 2015). Hereby the home or residential address of the social media users, which can be added in the user profile, is used to assess if a user is a local or non-local. In our case, non-locals are seen as equivalent to tourists and will also be referred to as such in the following. As this method can also imply a certain level of inaccuracy and should be applied in combination with other related methods (Hecht et al., 2011), we additionally apply the *n-days localness metric* to verify the results (Hecht and Stephens, 2014).

In the second method, the time range of the social media posting in a specific area is taken into consideration. Social media contributors that are posting messages for durations less than the defined number of days are herein classified as a non-local, contributors that are providing data for longer than this defined time duration are assumed to be local. Durations of ten days have shown to provide useful results (Hecht and Stephens, 2014; Li, Goodchild and Xu, 2013). For this reason this period of time is also used for our approach. The results of the two methods are compared and the consent data is used for the visualizations and interpretation (Johnson et al., 2016).

CASE STUDY

The Philippines have been selected as the case study for this initial research as the group of islands is one of the major tourist destinations. Tourists are mainly visiting the islands in the dry season from November to April/ May every year[8]. Apart from this, the Philippines are also known to be prone to earthquakes and typhoons[9]. In

[7] http://wiki.openstreetmap.org/wiki/Map_Features 3.1.2017.
[8] http://www.lonelyplanet.com/philippines/weather 3.1.2107.

2013 two of these events affected the islands in a short period of time causing severe harm. After the Bohol earthquake had hit the Philippines on October 15th and caused more than 200 casualties, from November 8th, Typhoon Haiyan caused more than 6000 casualties, nearly 30 000 people to suffer injuries, and around 3.5 million people to be affected in general (Mas et al., 2015). The analyses are focusing on these two events and the time before the disasters as well as the aftermath period.

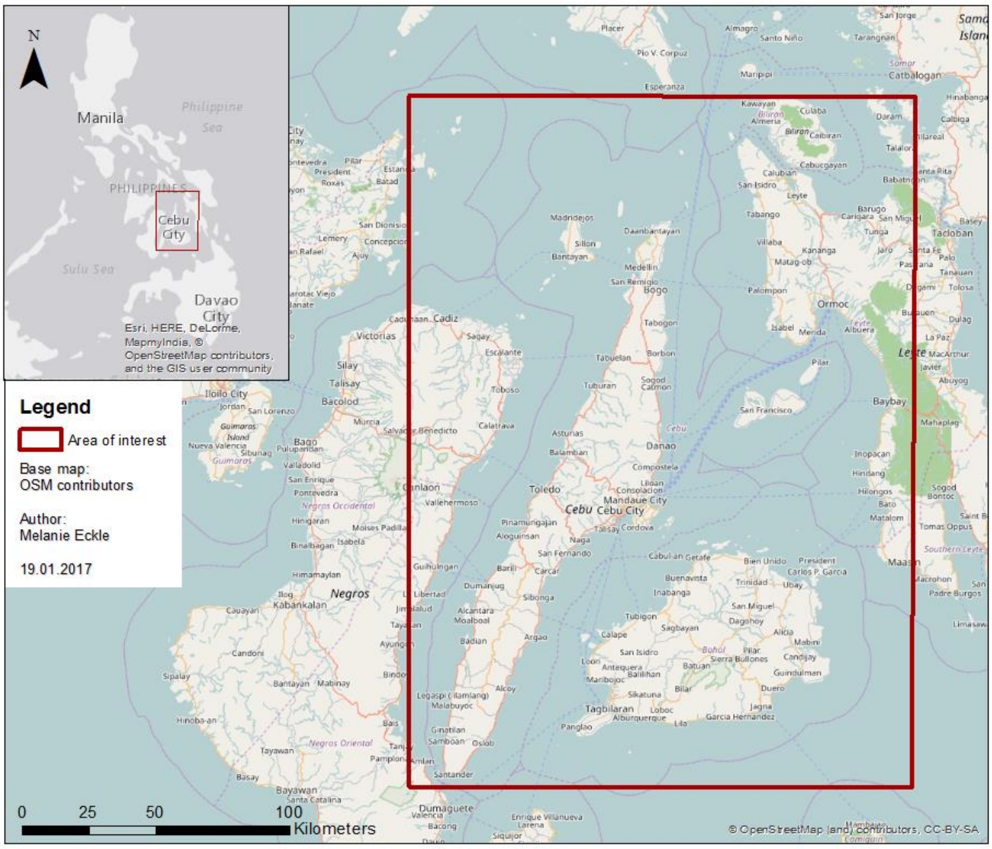

Figure 3. Area of interest

DATA SETS

The VGI data for the case study of the Bohol earthquake and Typhoon Haiyan was extracted from the region around the Central Visayas in the Philippines, one of the main impact areas of the events.

OSM data

All tourism and disaster related OSM data was extracted from the area of interest using overpass turbo. The area of interest was hereby used as a bounding box for our queries using the overpass-API and the current OSM database.

Flickr data

The Flickr photo data collection was done by using a self-developed tool, a FlickrPhotoCrawler, which is developed based on a PHP script and follows the access policy and regulation of the Flickr API. The tool enables the automatic fetching of the Flickr photos including photo ID, owner ID, owner name, title, location (longitude and latitude), accuracy, and the URL for image acquisition and its Exif file recording rich time information of photos, e.g. original datetime, modified datetime and GPS datetime, by flickr.photos.search and flickr.photos.getExif methods, respectively. The FlickrPhotoCrawler fetches Flickr photos by a 0.5 degree x 0.5 degree moving window starting from the upper left corner to the bottom right corner of the study area to completely scan the whole area of interest. Due to the fact that maximum results from each search query of the

[9] http://www.preventionweb.net/countries/phl/data/ 3.1.2017

Flickr API are limited to 4,000, the FlickrPhotoCrawler is recursively doing fetches following the division of quadtree in each grid while the results are over its limitation. Via the FlickrPhotoCrawler, 140,451 non-duplicated photos contributed by 4,744 individual users through July 6th, 2016 are collected in the study area (WGS 84 lat/long, bounding box: 123.220, 9.371, 124.696, 11.604).

RESULTS

Monitoring of reconstruction using OSM data

Our initial results show that there was an increase in ways marked as "status=impassable" as well as "landuse=brownfield" in the aftermath of the two disaster events. More than half of the highways tagged as "status=impassable" were updated after July 2015, the number of tags decreasing from 72 to 30. The number of highways tagged as impassable stayed constant afterwards (status 1/01/2017). A steady decrease of brownfield tags can also be detected after 12 to 18 months. During this time the number of features tagged as "landuse=brownfield" decreased from 247 to 220 and then remained nearly constant after June 2015 (status 1/01/2017: 207 ways, Figure 4). These updates do not seem to be related to changes on the ground, but rather to the attention of individual users. All updates regarding the impassable highways were done by only one local mapper.

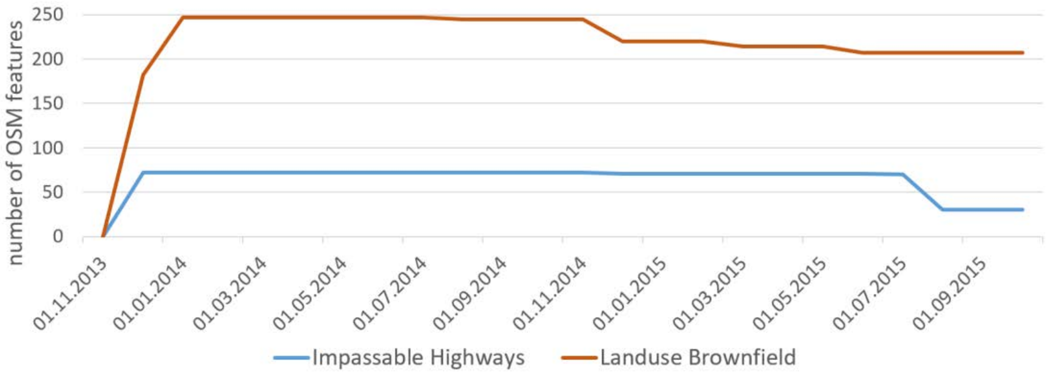

Figure 4. Number of OSM way tagged as "status=impassable" or "landuse=brownfield"

While there was some updating of the impassable highways and brownfield areas, there was less updating of damaged and collapsed buildings tags. Likewise to the other disaster related tags, there is a steady increase in damaged and collapsed building tags at the beginning of the response phase after the disaster. There is however nearly no update of this data afterwards. Around 3% (183 of 5887) of the collapsed and 6% (203 of 3322) of the damaged buildings were updated to date (status 1/01/2017). Only two ways/ seven nodes were marked as "barrier=debris", their count still being constant till the beginning of the year. Due to the fact that all temporal tags show the same pattern regarding lack of data updating, the latter were not covered in additional figures.

Monitoring of tourist activity

Altogether 544 users provided data as well as a residential or home address in the Flickr data set for the area and time of interest. The *location field approach* in which the users were assessed based on the residential and home address provided in the user profile shows that 140 of these users, can be classified as locals, 404 users in contrast can be classified as tourists. For users within the Philippines, apart from the country, the city of residence was assessed, too. All users, whose city of residence is not within the area of interest, were also classified as tourists. Users that did not provide a location in their user profile were not included. Following the *n-days approach* and setting the duration to 10 days, 252 contributors are classified as local and 1054 as tourists.

When comparing the results of the *location field* and *n-days approach*, there is consent in the data classification for 354 of the overall 544 contributors, which corresponds to around 65%. 328 contributors were classified as tourists considering both approaches. Looking at the number of users that contributed Flickr data in the years before and after the disaster events, changes in the tourist activity become apparent, as shown in Figure 5. The red lines show the time of the Bohol earthquake and Typhoon Haiyan.

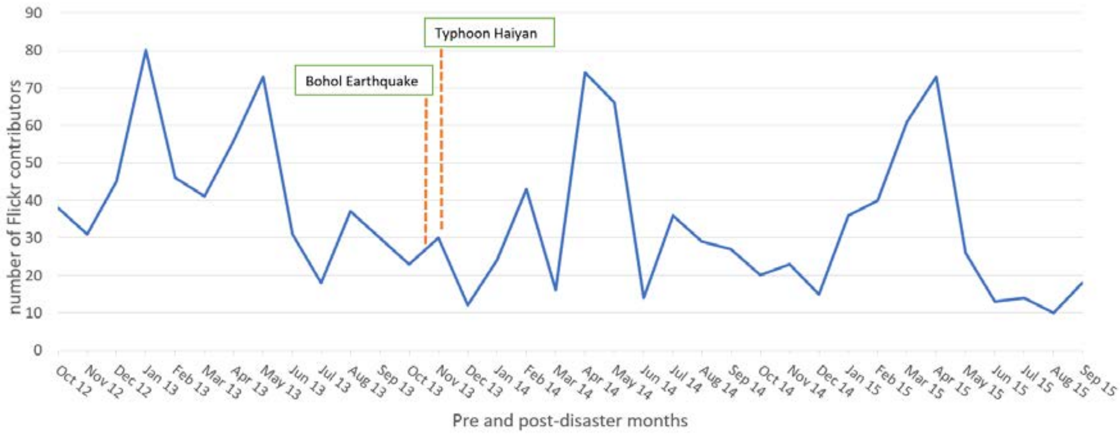

Figure 5. Overview of tourist count in Flickr data before and after the disaster events

The temporal overview shows that there was a decrease in tourist numbers within the Flickr users after the two disaster events. In general, the temporal distribution of Flickr contributors follows the seasonality of the tourist activity. Most tourists visit the area between November and April during the dry season, less tourist come in the rainy season from May to October. For April, the end of the main tourist season, we see a peak in the number of Flickr contributors (with a maximum around 75 contributors per month) for all years. This may lead to the assumption that tourism did not suffer from the two disastrous events. Nevertheless, when looking at the number of Flickr contributors for the months of November and December, differences are visible. In November 2012, our dataset shows a high number (80) of Flickr contributors compared to around 30 in November 2013 and around 25 in 2014. The data suggests that the overall number of Flickr contributors was lower after the disaster events in comparison to the number of contributors before the events, reaching the lowest number of Flickr contributors in December 2013 directly after Typhoon Haiyan had hit the Philippines. The low numbers for the years after the disasters may indicate a drop in the overall tourist activity, which could be an indicator for the unfinished recovery process.

DISCUSSION

OSM data shows potential for being utilized to estimate the level of reconstruction of highways and buildings, Flickr data could, in turn, facilitate the monitoring of tourist activity. While the results of the data assessment conducted with Flickr data indicate a potential of VGI for recovery monitoring, the analyses of data from OpenStreetMap show, that this form of VGI requires further quality assurance. For this reason, there are several further steps that need to be taken into consideration to allow better usability of the data.

Monitoring and updating of temporal OSM data in former disaster regions has already been recognized as an issue and is currently discussed in the OSM community (Anhorn et al., 2016). The results of this study emphasize that especially the disaster related OSM features are not regularly updated or not updated at all. The work of local organizations like Kathmandu Living Labs[10] in the direct aftermath but also during the long term recovery after the Nepal Earthquake 2015 confirms the value and importance local volunteers have regarding data updating and maintenance and, thus, OSM data quality.

Furthermore, Westrope et al. (2014) show that the quality of the damage mapping in OSM is rather poor. In their study only 36% of the damaged buildings were tagged correctly. This is backed by Kerle and Hoffman (2013) who show that collaborative damage mapping poses several challenges regarding the mapping instructions, the resolution of the satellite imagery, and the coordination of volunteers. Platt et al. (2016) furthermore state that a lack of interest in the post response phase causes a decrease in the mapping activity. Taking this into account, the results of this initial study also show that OSM needs to undergo further data quality assurance before being useable for the monitoring of reconstruction or recovery.

The monitoring of the activity of tourists within the Flickr users indicates different patterns before and after the disaster events. While the tourist season in general starts in November and lasts till April/ May, in the year of the disaster the tourist activity seemed to be delayed and dropping again before reaching a similar count as the year before and after the disaster events. Therefore, the results of this study underline the findings of Sun et al. (2013) that Flickr photos can help to get deeper insights into tourist accommodations and can illustrate seasonal tendencies. While this initial study did not include spatial analyses, future work should investigate whether the detected tendencies can be described in more detail by taking spatial correlations into account. The spatiotemporal analyses could also help to detect further patterns as post-disaster recovery may not be uniform in the whole disaster area (Brown et al., 2008).

CONCLUSION AND OUTLOOK

The presented study provides an example for integrating VGI data into disaster recovery monitoring in tourist destinations. However, to enable putting the presented approach into use and getting dependable results, further assessments are needed including quality assurance and taking different aspects into account, e.g. intrinsic data quality parameters. An active local OSM mapping community and regular updates on other, non-disaster related OSM features, may allow predictions about the quality of damaged buildings and impassable highways. This is relevant as a lot of the data updating can only be done by local mappers who collect data locally without being dependent on current satellite imagery.

In the past, activations of the Humanitarian OpenStreetMap team mostly focused on the disaster response phase. In this phase, HOT develops specific mapping tasks and coordinates the efforts of thousands of OSM contributors. Community working programs, local chapters of HOT in different parts of the world, increasing support of local mapping communities, e.g. through Microgrants[11], and the cooperation with humanitarian aid organizations in the Missing Maps projects however also facilitate local mapping, updating and validation of OSM data, and therefore more sustainable data maintenance. Extending this approach can help to improve the current database in different parts of the world without exclusively relying on remote mappers. The latter could moreover be included by making use of already existing OSM tools, e.g. MapRoulette[12], which could be used to remotely detect errors and also identify temporal data that is due to be updated. Other already existing tools that could be adapted for this approach are the OpenFloodRiskMap (Eckle et al., 2016) and OSM Analytics[13]. While the OpenFloodRiskMap enables filtering and identifying critical infrastructures in an area of interest using the OSM database, OSM Analytics enables monitoring differences in building and highway numbers over time by displaying the last edit of OSM features. Extending the feature catalogue of OSM Analytics or integrating OSM history functionality and temporal OSM tags into the OpenFloodRiskMap feature catalogue could help enable more OSM contributors to easier monitor performed and neglected data updates. Yet, to facilitate this remote mapping support, a more frequent update of the satellite imagery covering the disaster prone and less mapped regions of the world is needed. In the direct aftermaths of a disaster, such as Typhoon Haiyan, such imagery is provided due to the International Disaster Charta[14], current imagery is however less accessible for other disaster phases. In the presented area of interest in the Philippines, post-disaster Bing imagery is only available for a small part of the area[15]. While imagery, e.g. for the southern part of Bohol, is available for December 2014, the imagery in the other areas dates back to 2011 and 2012. This limited accessibility of imagery hinders the remote mapping in the recovery phase.

Regarding the Flickr data assessment, the *location field* and *n-days approach* limited our analyses to users that provided information about the home or residential address and were providing data for a similar range of time in the area of interest. Future research could also include other localness approaches that allow coverage of further aspects of the users. Future analyses could also consider the content of the social media data, in our case the Flickr images, which can help to get an idea not only of the tourist activity, but also of the situation on the ground and how it is perceived.

In general, the representativeness of Flickr photos is of great concern for this research as Sun et al. (2013) showed that it is not very well. This poses a serious limitation to the results of this study. Further analysis could be conducted using different forms of social media and a larger study area to enable confirming the potential trends. The limitations also suggest that VGI data from Flickr are not an exclusive source of geographic information to monitor tourist destination recovery. VGI could hereby be rather used as a complementary source of information to validate official information or add details. Thus, further research could also expand the approaches proposed in this paper to combine VGI and other data sources and thereby help to improve existing resources.

In general our approach can help to identify which areas are more and less recovered. Consequently, the results support decision making regarding places that need special attention for reconstruction activities. Moreover, the

[11] https://www.hotosm.org/updates/2016-12-06_funds_for_community_led_projects_the_2017_hot_microgrants_program 19.3.2017.
[12] http://wiki.openstreetmap.org/wiki/MapRoulette 19.3.2017.
[13] http://osm-analytics.org/ 19.3.2017.
[14] https://www.disasterscharter.org 19.3.2017.
[15] http://mvexel.dev.openstreetmap.org/bing/ 15.1.2017.

approach enables the detection of better recovered areas and, thus, supports decision makers in tourist agencies to decide which places to advertise for tourists. Additionally, our findings facilitate the monitoring and assessment of disaster recovery and reconstruction by local and international non-governmental organizations and government agencies.

This study shows that apart from traditional approaches, there are also additional ways to monitor the level of reconstruction using less time and cost-intensive data and tools. The data that was used in our approach is openly available and can be accessed using the open-source tool overpass turbo in the case of OpenStreetMap and using the Flickr API in the case of the Flickr data. Likewise, the scripts that were used to access and process the data have been written in Python, an open-source programming language, and are available in the GIScience GitLab repository[16]. Using the presented data and scripts, our approach could be applied and replicated without additional cost in sense of data and software in other touristic places by updating and adjusting the bounding box in the overpass queries. Unlike Twitter and Facebook, Flickr is a picture based social media data platform, and therefore users of our approach do not have to mind linguistic restrictions. Adjusting the time in the provided scripts enables users to moreover adapt the assessed timeframe. The flexibility in terms of time and space enables users to benefit from this approach in different contexts and scenarios, also including other natural and man-made disasters. Before putting our approach in practice, the results could be furthermore validated using the discussed methods and tools and moreover using e.g. available tourism statistics and results of traditional approaches.

Presenting our approach and initial results to an international audience at conferences and the close cooperation of our project partners with tourism associations will enable raising awareness regarding this alternative approach for monitoring tourist activity and the level of reconstruction. This can also facilitate detecting potential beneficiaries who have to face challenges regarding lack of resources and professional expertise.

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