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Assessing Post-Disaster Recovery Using Sentiment Analysis. The case of L'Aquila, Haiti, Chile and Canterbury

D. Contreras[(1)], S. Wilkinson[(2)], N. Balan[(3)], J. Phengsuwan[(4)], P. James[(5)]

[(1)] *Research Associate, Newcastle University, diana.contreras-mojica@ncl.ac.uk*
[(2)] *Reader, Newcastle University, sean.wilkinson@ncl.ac.uk*
[(3)] *Postgraduate research student, Newcastle University, N.B.Thekkummal1@newcastle.ac.uk*
[(4)] *Postgraduate research student, Newcastle University, J.Phengsuwan2@newcastle.ac.uk*
[(5)] *Professor, Newcastle University, philip.james@ncl.ac.uk*

Abstract

Memorial days of disasters represent an opportunity to evaluate the progress of recovery. Social media posts from the 10th anniversary of the earthquakes, in L'Aquila, Haiti, Chile, and Canterbury constitute a valuable source of data to mine insights into the progress of their recovery. The sentiments of affected people have the potential to highlight the successes and gaps in the post-earthquake recovery process. We propose a new method to assess post-disaster recovery through sentiment analysis of disaster-related tweets from citizens. The procedure for assessing recovery consists so far of 9 phases namely, hashtag identification, hashtag selection, data collection, data extraction, data processing, classification, feature extraction, features reprocessing and features selection. The data collection starts with social media monitoring, we identify the hashtags related to the memorial of each specific earthquake and then we collect tweets using two sources:1) manually and 2) a third party vendor from which we can collect the tweets related to the selected hashtags seven days around the anniversary of the event. The data process prepares the data to be understood by a machine learning algorithm. The classification phase combines a machine learning algorithm and supervised classification, tweets are categorized as positive, negative and neutral. Based on this classification and the general content of the tweets it is then possible to assess the relative success of the recovery based on the satisfaction of the community with the process. To detect the sentiment of tweets, we have combined supervised classification in the case of L'Aquila and linguistic features in the case of Haiti to classify the text according to the tweeter's assessment of the recovery process. In the case of L'Aquila, whose 10 year anniversary took place on the 6th April 2019, we have obtained 4,349 original tweets between the 5th and the 10th of April 2019 with the hashtag #L'Aquila. In the case of Haiti, the 10 years anniversary took place on the 12th January 2020, we have obtained 8,157 original tweets between the 7th and the 15th of January 2020. So far we have identified more than 40 tweets regarding the anniversary of the earthquake in Chile and two tweets with respect to the anniversary of the Canterbury earthquake. The preliminary sentiment analysis of the tweets for the cases of L'Aquila and Haiti evidences that the negative polarity prevails. We do not yet have a sample big enough to determine the polarity of the twitter posts in the case of Chile and Canterbury. Nevertheless, preliminary results allowed us to demonstrate that sentiment analysis is a feasible tool to evaluate the success of a post-disaster recovery process. Affected communities in L'Aquila and Haiti are not satisfied with the progress of the post-earthquake recovery. In the case of L'Aquila, reconstruction of private buildings is more advanced than public ones and that there has been a delay in the re-opening of schools and other urban facilities in the historical city centre. The complaints about the mismanagement of financial resources and corruption are common in both cases: L'Aquila and Haiti.

Keywords: Post-disaster recovery; earthquakes; machine-learning algorithm; twitter; sentiment analysis.

1. Introduction

On the 6th April 2009, an earthquake with a magnitude of 6.3. M_w and a hypocentral depth of 10 km struck the Italian city of L'Aquila with a population of 72,800 inhabitants at the time of the earthquake. L'Aquila is the capital of the namesake province and the administrative capital of the Abruzzo region in central Italy [1]. Its location is shown in Fig. 1a and b.

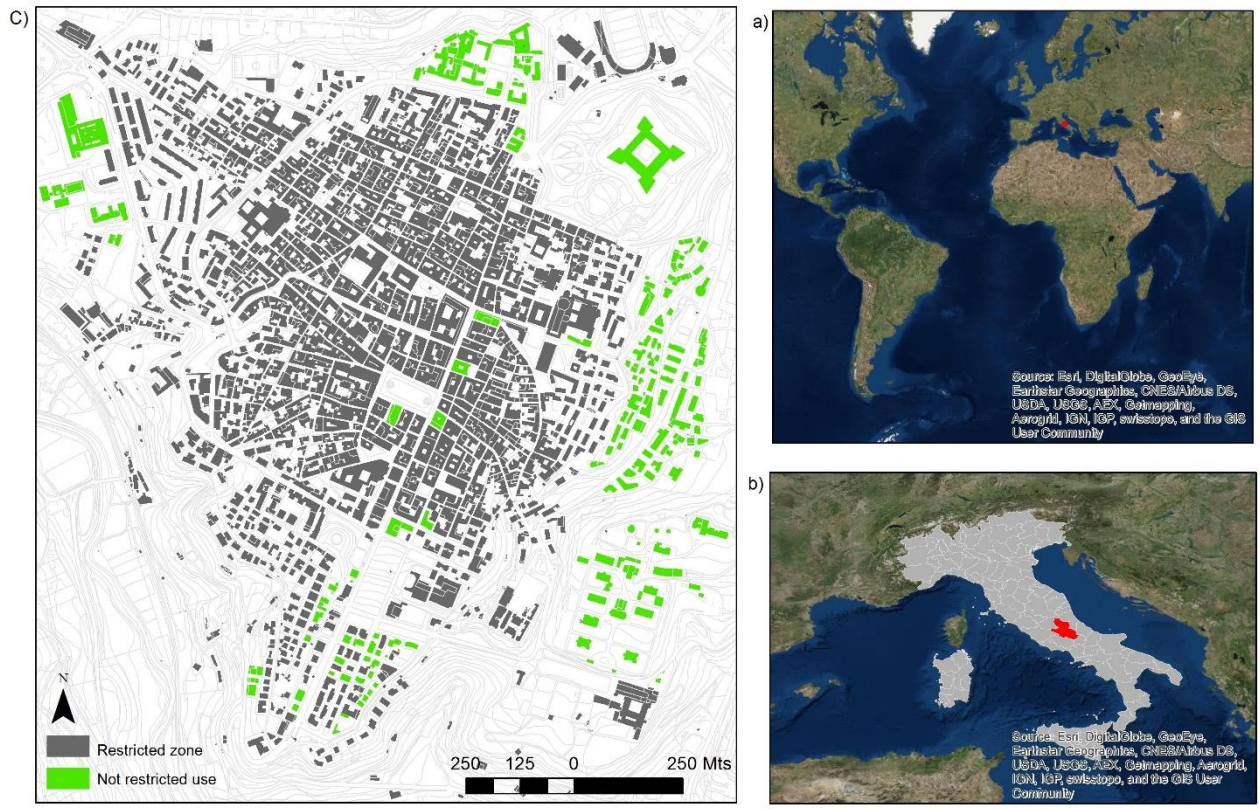

Fig. 1 – L'Aquila location. a) b) Location of the case study area: L'Aquila, Italy; c) restricted zone in L'Aquila after the earthquake on 6 April 2009. Source: [2] Fig. 1,pag. 278

L'Aquila and 56 surrounding municipalities were badly damaged [3]; 67,500 people were left homeless (2010), 1500 people were injured (202 seriously)[4], and 309 people lost their lives. About 10,000 buildings were damaged [1], and between 1.5 and 3 million tons of waste were generated [5, 6]. Electricity, gas supplies and telephone lines were reported to have been damaged by the earthquake [7]. The cost of the damage was estimated at 16 billion Euros [8]. The extent of the damage resulted in the deployment of a massive recovery operation and the implementation of elaborated schemes [9] for the recovery phase [2, 3]. Restricted areas were stablished immediately and some buildings are still cordoned-off after ten years [3]. The recovery process has been severely criticized for several reasons such as excluding the population from the decision-making [10, 11], building new settlements far from the city centre[12, 13], the excessive cost of the apartments in the new settlements[9, 13], their durability and maintenance [13], lack of urban facilities around new settlements [13, 14], and the mismanagement of financial resources [9-11, 13]. All of these factors have contributed to the delay in the reconstruction of the historical city centre, which ten years later is still ongoing [3, 11, 15] see Figure 2d). The consequence is the stagnation of the economy, the reduction in the sources of employment [9, 13] and therefore the dissatisfaction of the inhabitants of L'Aquila with the recovery process, and resulting in a gradual depopulation of the city, can be seen in Figure 2.

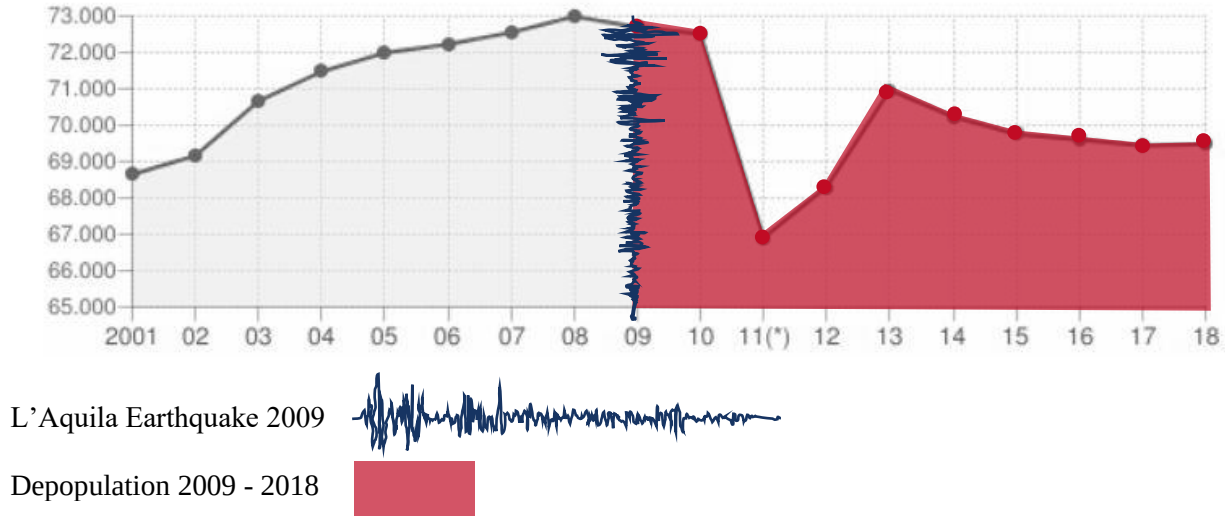

Fig. 2 – Gradual depopulation of L'Aquila after the earhtquake in 2009 until 2018.
Adapted from: https://www.tuttitalia.it/abruzzo/98-l-aquila/statistiche/popolazione-andamento-demografico/

On the 12th January 2010, an earthquake with a magnitude of 7 Mw, hypocentral depth of 13 km and an epicenter near the town of Léogâne, 25 km west of Port-au-Prince caused 200,000 deaths [16] and rendered 1.5 million homeless [17]. This is a controversial post-disaster recovery case because millions of dollars in aid was not expended directly in Haiti or did not arrive at all, and due to an outbreak of cholera caused by members of the United Nations Mission for Justice Support in Haiti (MINUSTAH – now United Nations Mission for Justice Support in Haiti – MINUJUSTH) [18]. The Maule Chile earthquake occurred on the 27th February 2010 at a depth of 35 km. The event was centrered 104.60 km west-southwest of Talca, 322 Km southwest of Santiago and had a rupture zone of approximately 500-600 km. A Tsunami was also triggered by the earthquake hitting the Chilean coast and also traveled to Peru and westward past Hawaii, to Japan and New Zealand [19]. 525 people died, 25 were missing, 440,000 houses were affected and extensive lootings were observed in areas far from the epicentre (500 km aprox). The damage cost was estimated in 30,billions dollars, however, according to official numbers the reconstruction threshold reached 90% in 2014 [20]. At 04:35 (GMT+13) on the 4th September 2010 the province of Canterbury was struck by an earthquake with a 7.1 Mw. The epicenter of this earthquake was approximately 40 km West of Christchurch near the town of Darfield [21]. Only two people were seriously injured out of around 100. This earthquake is particularly remembered by the widespread liquefaction, the large amount of non-structural damage and the damage to unreinforced masonry (URM) structures in the city of Christchurch and its surrounding areas [21].

2. Literature review

The memorial days of disasters represent a window of opportunity not only to remind us of the human and material losses [22] but also to evaluate the progress of the post-disaster recovery process. For the purpose of the present research we are consider four post-disaster phases: relief or emergency, early recovery, recovery and development as depicted in Fig. 3 [2, 23]. There is little information about how long each of these phases are, how variable is their length and what factors contribute to this. One of the few earthquakes that this has been considered for is the case of Kobe.

Four and eight years after the Kobe earthquake, the government of Kobe undertook a comprehensive recovery assessment using the Citizen – Happiness Index. This index covered the 16-point Plan of Action and consisted of 45 individual indices. Twelve workshops were conducted in Kobe to establish: (1) What life recovery means

for earthquake victims; and, (2) what are the factors that citizens consider useful to promote recovery?. The results identified 7 elements in descending order: (a) housing, (b) social ties, (c) community rebuilding, (d) physical and mental health, (e) preparedness, (f) economy, livelihood, and economic and financial situations, and (g) relationship to government [24]. The 6th April 2019 was the commemoration of the 10 years after the earthquake in L'Aquila, the 12th of January was the commemoration of the 10 years after the earthquake in Haiti, the 27th February will be the commemoration of the 10 years after the earthquake in Chile, and the 4th September will be the commemoration of the Canterbury earthquake. In these cases, no survey has been planned to assess the success of the recovery process according to their citizens. As there seems to be little appetite for governments to monitor recovery in a methodical and scientific way, and that recovery is poorly understood [22] there is an argument for employing alternative methods to make post-disaster recovery assessments. One of the possible candidates for achieving this is the use of social media to identify the level of satisfaction of the inhabitants of the case study area with the recovery process by analyzing posts [25] linked media, user reactions, and the relationship between users [26]. This social media (SM) can be Twitter [27-33], Facebook[33], Instagram or Flickr [32, 34].

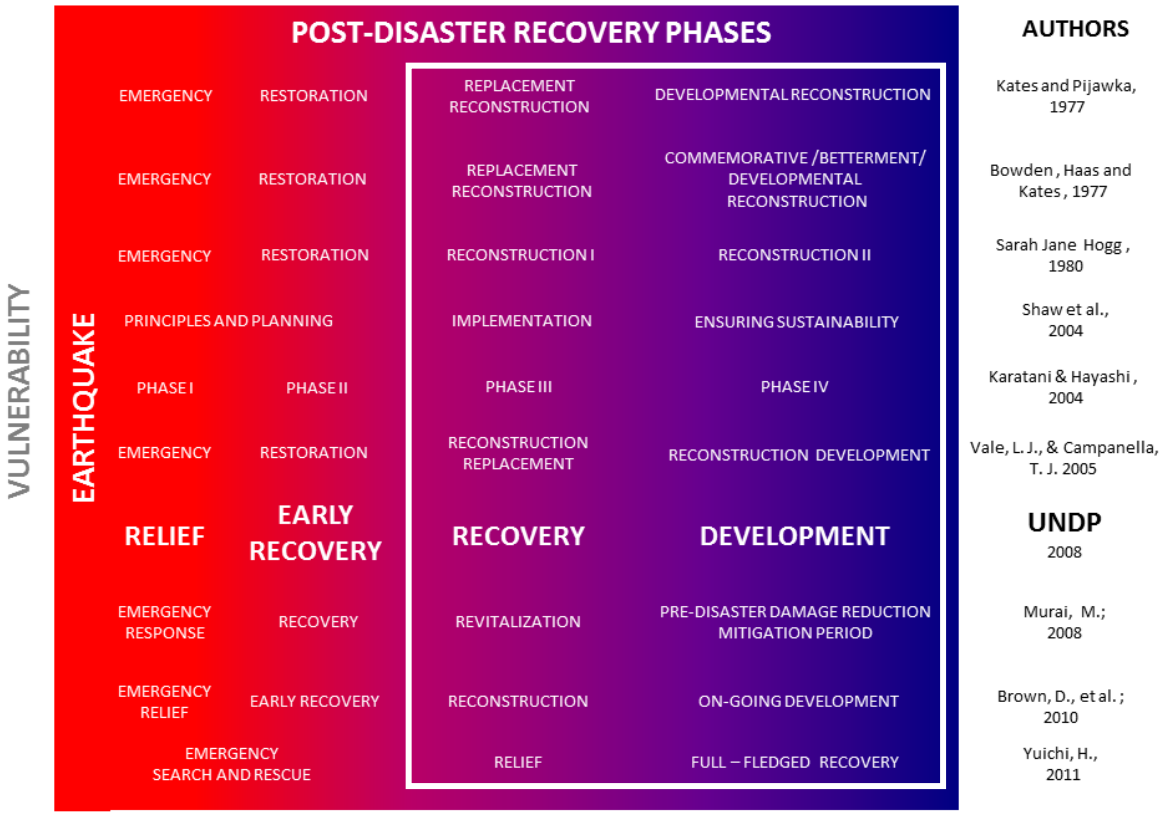

Fig. 3 - Names assigned to post-disaster recovery phases by different authors and the post-disaster phases of the case study areas. Adapted from: [2].

Twitter has been used during the emergency phase to share information about needs such as water, food, shelter, medical emergency and electricity [35]. Neppalli, Caragea, et al. [31] identified the divergence of sentiments expressed during Hurricane Sandy and displayed the sentiments of twitter users geographically. The authors demonstrated how the user's sentiment changed according to their locations and the distance from the disaster. They also found that the polarity of sentiments expressed in the tweet affects the retweetability of the tweet. The extraction of sentiments during a disaster contributes to a stronger situational awareness of the

dynamics in the disaster zone. Wu and Cui [29] used sentiment analysis to measure the emotion or mood expressed in each tweet and classified it as positive, negative or neutral and then used this data to quantify specific features (sentiment analysis is the method to segregate text into positive, negative and neutral texts and segregated according to its content [36]). In this conference paper, we will focus on tweets to assess the progress of the post-disaster recovery process follow the principle of the citizen as a sensor formulated by Cervone and Hultquist [37].

3. Methods

The methodology is comprised 9 steps as is described in Figure 4. First, we identify the hashtags related to the memorial of the tenth anniversary of the L'Aquila, Haiti, and Chile or Maule earthquake. Second, we select one particular hashtag. Third, we purchase tweet data from a third party vendor named 'tweet binder'[38] with the selected hashtag.

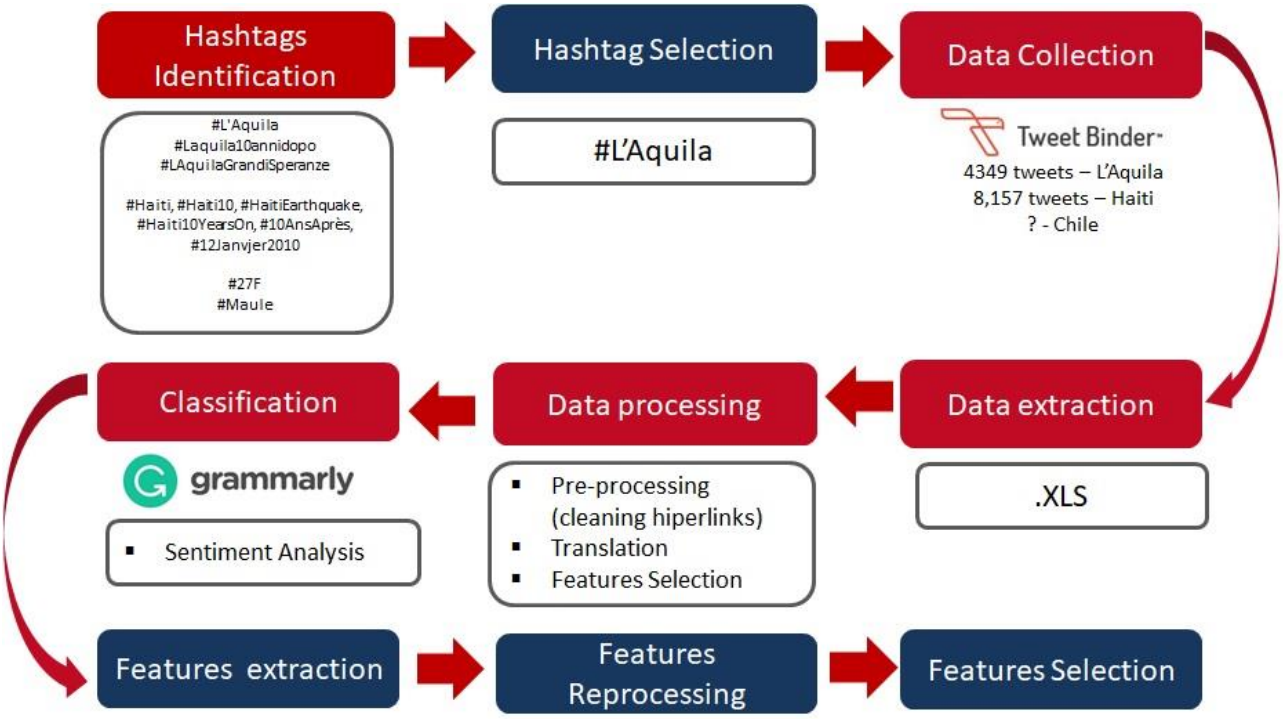

Fig. 4 – The sentiment analysis process. Adapted from [36].

Fourth, we get a file with the transcription of the tweets (among other information). Fifth, we start with the data processing, checking manually the transcription, cleaning the twitter handles (@), hashtags (#), punctuation marks, emoticons and hyperlinks and translating the tweets from Italian, German, French, Japanese, Spanish, Dutch, Portuguese, Greek, Corsican, Polish and Norwegian into English for the identification of topics [27] to select those, which are really related to the memorial day. We discard tweets that are not related to the memorial of the earthquake.

Sixth, at the same time that we translate the tweets to English, we made use of the *Grammarly* tones detector feature [39] to support the identification of their sentiment polarity [36]. This new feature can detect 40 different tones covering a large range of emotions from more than 120 characters that we classify as it is described in Table 1.

Table 1- Polarity classification based on *Grammarly* tones detector

POSITIVE	NEUTRAL	NEGATIVE
Admiring	Confident	Angry
Appreciative	Curious	Anxious
Friendly	Frank	Cautionary
Joyful	Formal	Confused
Optimistic	Informative	Dissaproving
	Informal	Dissatisfied
	Neutral	Sad
	Objective	Skeptical
	Compliant	Worried
		Accusatory
		Disheartening

The content of each tweet was checked in order to categorize it for sentiment analysis. We are interested in the polarity of the content (i.e. whether it contains a positive, negative or neutral opinion) and emotion recognition type (e.g. joy, anger, fear and so forth) to support the evaluation the success of the recovery process [36]

Seventh, features that allow assessment of the progress in the recovery process can be extracted using tools such as word clouds. However, first, some frequent words such as the name of the where the earthquake took place, the time and the date of the earthquake, the date of the anniversary, the word 'earthquake' and all the reference to the time such as '10 years later' or 'ten years later' must be eliminated to extract the useful features for the post-disaster recovery assessment. We have no progress yet on the eighth and ninth step which are features reprocessing and features selection, respectively.

3. Results

In the case of L'Aquila, we identified three common hashtags: #L'Aquila, /#laquila10annidopo, #LaquilaGrandiSperanze and #PortamiDoveSeiNata. In the case of Haiti, we identified more: #Haiti, #Haiti10, #HaitiEarthquake, #Haiti10YearsOn, #10AnsAprès and #12Janvjer2010. In the case of Chile, so far we have identified five hashtags: #27F, #Maule, #PorUnaLeyDeCostasEnChile, #Chile and #Terremoto. We selected one particular hashtag for the case of L'Aquila: #L'Aquila to carry out the analysis. We have not yet selected a particular hashtag in the case of Haiti and as soon as we have enough data for the earthquake in Chile and Canterbury, we will decide the best approach.

For the hashtag #L'Aquila, we obtained a sample of 4,349 original tweets, from the third party vendor, within the period 4th to the 10th of April 2019. The tweet activity in this period is depicted in Figure 5. In the case of Haiti, we obtained a sample of 8,157 original tweets considering all the aforementioned hashtags in the period between the 7 th to the 15th January 2020 from the third party vendor. The tweet activity in this period is depicted in Figure 6. So far we have identified more than 40 tweets regarding the anniversary of the earthquake in Chile and only two tweets about the Canterbury earthquake without any particular hashtag.

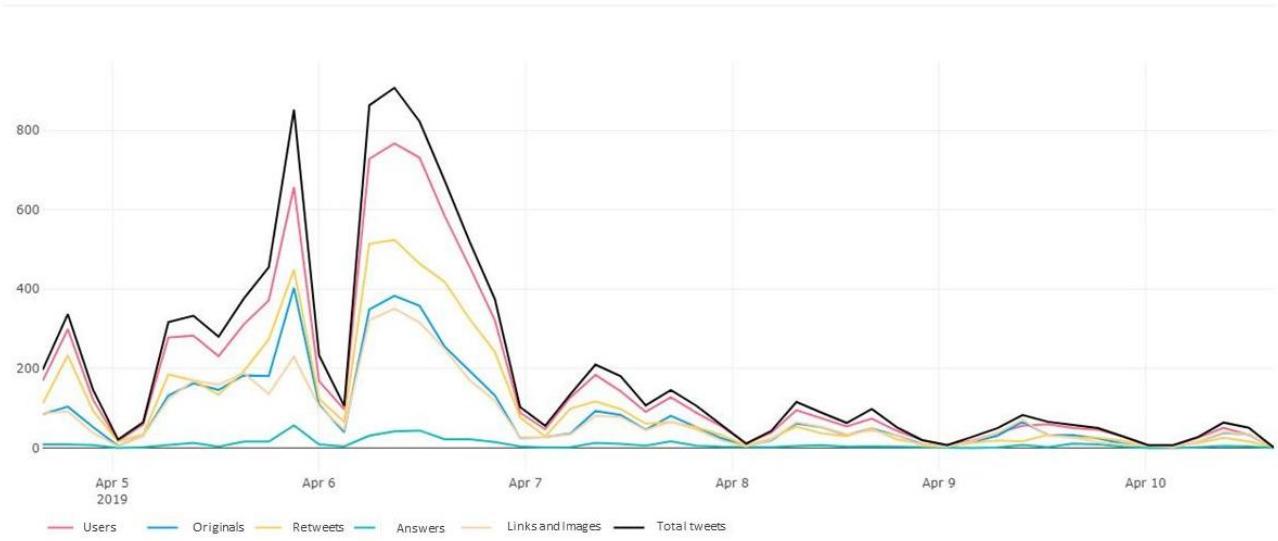

Fig. 5 – Tweets activity from the 4th to the 10th April 2019 with the hashtag: #L'Aquila.
Source: https://www.tweetbinder.com/

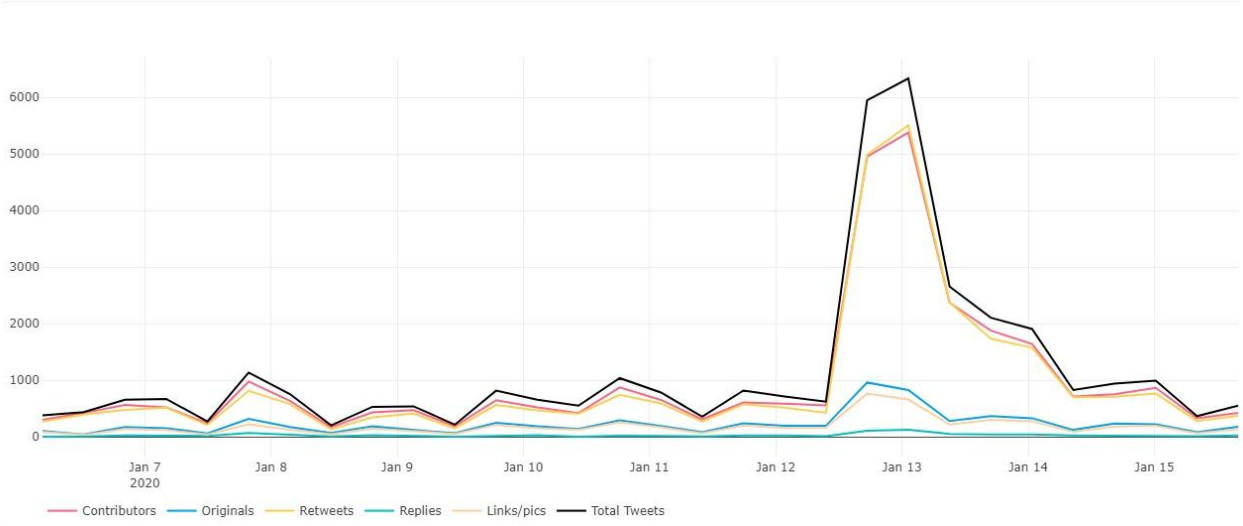

Fig. 6 – Tweets activity from the 7th to the 15th January 2020 with the hashtags: #Haiti, #Haiti10, #HaitiEarthquake, #Haiti10YearsOn, #10AnsAprès and #12Janvjer2010.
Source: https://www.tweetbinder.com/

The 78.18% (3,400) of tweets related to the 10th anniversary of the earthquake in L'Aquila have been already processed. We found that the 34.5% (1,176) of the tweets have a negative polarity, followed by 31.5% (1,071) of neutral tweets, then 27.9% (950) tweets with a positive polarity and 5.9% (203) tweets not related the 10th anniversary. After preliminary processing of the tweets, we can already extract some features using a word cloud which is depicted in Figure 7.

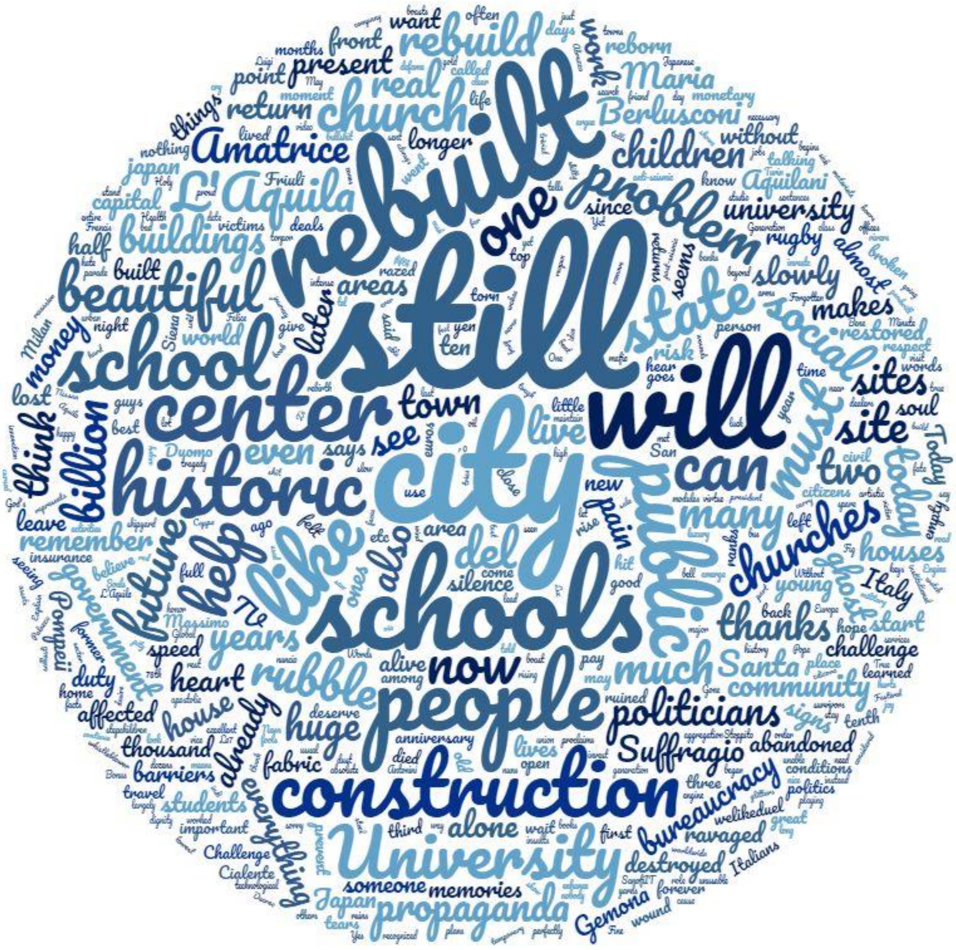

Fig. 7 – Word cloud for the 10th anniversary of the L'Aquila earthquake.

The tweets with positive polarity are based more on the hope of the final reconstruction of the city, particular buildings already reconstructed (mainly churches), callings for reconstructing for the future and learning the lesson, solidarity messages, stories of survivors, social initiatives, praises to the value of the renaissance architecture in the city, memories about how beautiful L'Aquila used to be and calls to not forget what happened, the role and the importance of the University of L'Aquila in the existence of the city with its students and projects, rather than concrete achievements related to the recovery of the city. The exception is positive tweets related to the increase in the enrolments at the University of L'Aquila (which is consistent with L'Aquila being a university town). The neutral tweets are to invite people to the torchlight procession, to watch the TV program about the anniversary, and to remember the students who died due to the collapse of the student hostel in the city. The tweets with a negative polarity report the inability to forget the impact of the earthquake, the delay in the reopening of schools, the comparison of the time required to finish the reconstruction of private buildings and public, the existence of cordoned houses, rubble and barriers still 10 years after the earthquake, the depopulation in the city centre despite the reconstruction (4,000 inhabitants), the amount of money designated for the reconstruction of churches, the number of financial resources already spent in the reconstruction (€10 to 21 billion) and the financial resources still needed (€7 billion), to mourn the promising players from the L'Aquila rugby team (one of the most famous and successful clubs in Italy) who died due to the earthquake, to compare the reconstruction of L'Aquila with the reconstruction of other Italian cities that have also been affected by earthquakes, to complain about the management of the financial resources and the emergency, and to claim for an effective prevention and disaster risk reduction (DRR) policy. Tweets from officials and institutions always have a positive polarity, while tweets from citizens could have apositive,

neutral or negative polarity. In some cases, it is necessary to check the links in the tweets to establish the polarity of them.

Some tweets compare the different funding sources for the reconstruction of specific buildings such as churches and the speed of their reconstruction compared with public buildings such as schools. One gap that the population identifies during the recovery/redevelopment phase in L'Aquila is that reconstruction of private buildings is more advanced than public ones and that there is a delay in the re-opening of schools and other urban facilities in the historical city centre, while the reconstruction of churches is advanced. Another aspect is that it seems that citizens identify the continued existence of rubble and barriers in the street as an open wound due to the earthquake. The governments and institutions in charge of managing the recovery processes need to invest more effort to promote the progress on the recovery progress to avoid the feeling that nothing has been done. The topic of improvement in construction practices is not considered in any of the twitter posts collected.

4. Discussion

The added value of the present research lies in the fact that we use twitter data for assessing recovery during the recovery phase, while previously it has been mostly used during the relief or emergency phase for Post Disaster Needs Assessment (PDNA). It is necessary to analyse each case to decide the best approach to select a sample. In the case of L'Aquila, we could have selected for the sample only the tweets in Italian, but then we would have missed the external view of the progress of its recovery process. The sentiment analysis will consider the frequent expressions on twitter posts. For example, in the case of the tweets related to the tenth anniversary of L'Aquila it is very frequent to read expressions such as: 'open wound', 'forgotten generation', 'construction site', 'I do not forget it', 'not to forget', 'I wasn't laughing','continue to die' and 'Draquila'. The set of these expressions reveal gaps in the recovery process. The majority of the tweets in the sample have a negative polarity, followed by tweets with neutral, then tweets with positive polarity and in the last place tweets without any relations with the 10th anniversary. However, it is necessary to compare the content on the twitter posts with the evidence, because those tweets that state that nothing has been done in 10 years, do not recognize the progress in the recovery process of L'Aquila, such as that reported by Fois and Forino [10] and Contreras et. al. in 2104 [40] and 2016 [1].

Although we did not get the geographical location of people who wrote the twitter posts, we can get proxy data based on the information regarding the top languages on which the tweets were written and looking at the location of the twitter accounts will give us a reasonably accurate assessment. In the case of L'Aquila, it is observed that there is some variation in the topics of the tweets through the days going from tweets with a positive polarity on the eve and after the anniversary to messages with neutral and negative polarity on the exact day of the anniversary. The tweets with negative polarity relate to delays in the reconstruction, politics, bureaucracy, corruption, and a few include xenophobic messages. Comparisons of the recovery process in L'Aquila with the recovery process of Portofino (2019) after the coastal storm, Norcia and Amatrice (2016), Molise and Apulia (2002), Irpina (1980) and Friuli (1976) after the earthquakes and even with the oblivion of Pompeii (AD 79) after being buried by eruption of Mount Vesuvius are quite frequent on the tweets.

The tweets from the citizen and news agencies are more useful to assess recovery since they express the reality they experience and the gaps that they observe, while official sources focus on any achievement e.g. the Mayor of L'Aquila highlights that it is the province with the highest number of graduate students in Italy and that they have returned the life to the suburbs. One citizen posted: 'the days after the earthquake in L'Aquila, bottled water was as expensive as meat'. These tweets are a valuable source of information to improve the humanitarian aid supplies plans after earthquakes during the relief or emergency phase. It also allows us to know the first hand experiences of the affected people during the emergency phase and to learn lessons to improve the emergency response to these events.

5. Conclusions

This outcome of this research allows us to understand the relevant window of time to look for twitter posts related to the memorial of disasters in order to undertake sentiment analysis. The tweets regarding the memorial of disasters are not necessarily trending topics like the tweets related to the disaster itself. Since the emergency or relief phase took place 10 years ago, rather than collect data of damages in building, we undertook a post-disaster recovery assessment of an urban area affected by an earthquake (such as L'Aquila in this case) based on sentiment analysis. We cannot elaborate on conclusions regarding the case of Haiti, Chile, and Canterbury yet, because in the earliest case the data has not been processed and in the latest cases, the data necessary for analysis still needs to be acquired. We can conclude that anniversaries reawaken the memory in citizens and motivate them to comment on their own experiences and to compare the success or failure of other post-disaster recovery processes near to the affected area.

Tweets with positive polarity address call for hope and not to forget, solidarity, reconstruction, encouragement, memories, acknowledgment of contributions, job and service offers, social initiatives, sense of belonging, survivors' stories entrepreneurship, or highlight achievements in the recovery process. Neutral tweets invite people to remember the victims and their families, to acknowledge the work done by the members of the search and rescue teams, to attend the commemoration ceremonies, to watch the TV programs about the anniversary or provide information about the recovery process. Negative tweets are those who still express post-traumatic stress, criticize the commemoration ceremonies and complain about delays in the reconstruction process, the continued existence of cordoned-off areas and rubble in the streets or the mismanagement of the financial resources for the reconstruction.

The machine learning algorithm on which the *Grammarly* tone detector [39] relies on, is very good in recognizing messages with a neutral tone, but still needs training and supervision by someone experienced in the recovery processes or at least the recovery process of L'Aquila because it does not recognize sarcasm (for example) in the messages. In this case, the messages that the algorithm recognizes with a friendly, joyful and forceful tone have a completely opposite message. Some messages have negative polarity but as they do not use negative words, the algorithm recognizes them as neutral, and sometimes also happens with positive tweets this is another reason to use supervised classification. There are several tweets about the cost of the reconstruction with different numbers, which could be interpreted as a lack of proper official information, which is essential for assessing a post-disaster recovery process.

This preliminary exercise has allowed us to demonstrate that sentiment analysis is a feasible tool to evaluate elements of the success of a post-disaster recovery process through the identification of achievements and gaps detected by citizens as sensors. According to the tweets we can state that L'Aquila is still in the recovery phase without yet reaching a developmental one.

6. Future work

The tweet with the highest number of days in advance with respect to the 10th anniversary of an earthquake was identified for the Canterbury earthquake (227 days), then Chile or Maule earthquake (78 days), Haiti (8 days) and then L'Aquila (4 days). To be able to perform cross comparisons, it is necessary to do research into the factors that influence the level of awareness and what motivates people to tweet about the 10th anniversary in each case study area and who writes these posts.

According to the evidence provided by this research, it would be necessary to check twitter posts related to other anniversaries to establish if the concept of 'citizen as a sensor', can be considered a systematic source of data to assess post-disaster recovery processes, revealing achievements and discovering gaps. To test that hypothesis we plan to monitor also the tweets related to the anniversaries of earthquakes such as Nepal (2015)[41, 42] and Christchurch New Zealand (2011)[21].

So far we are working on the sentiment analysis of the twitter posts, but these often include images to emphasize their messages, and so it should be possible to apply a multimodal sentiment analysis [39] to mining data from both visual and written content and undertake an even more comprehensive and accurate post-disaster recovery assessment. Other social media such as Instagram are also valuable sources of information to explore in the future.

It is also important to understand potential biases between different sites (e.g. if there is a correlation between the access to the internet, the literacy and/or digital literacy rate among populations, losses (US dollars) and the activity on twitter, and the sentiment expressed on the tweets).

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5. Copyrights

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