FLOOD RECOVERY IN THE SOCIAL MEDIA ERA.AN ASSESSMENT OF SOCIAL NETWORK INFORMATION IN BUILDING SOCIAL FLOOD RESILIENCE

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Abstract

In the face of the social technological revolution the sharing of information has led cities evolving towards always more complex systems. Social media have indeed a strong capacity of connecting people, and several urban self-organized initiatives have been emerging from virtual communities impacting on urban activities organisation. By enhancing communication opportunities, social media could be taken into account to improve urban planning decision making processes, and so they can also play a significant role in flood risk management.
In dealing with urban flooding it is important to know how quickly and efficiently a city can recover from a flood event. Before the event, social media can help increasing awareness by enabling wider risk communication. During and after the calamity, creating easily accessible information sharing platforms, social media are able to increase the disaster recovery capacity of the affected urban system, as a sort of social recovery rate.
Many sets of indicators have been proposed in the literature analysing the social perspective of flood vulnerability and urban resilience. Nevertheless, in these it is not easy to include the impact of using social media coping with floods.
In June 2013 during the flood of the river Elbe, citizens of Dresden (Germany) created a spontaneous Facebook network to require offer aids and assistance.
Building on the experience, we propose a methodological approach aiming at evaluating how the use of social media can affect social flood resilience, and in this way assessing the effectively social function of the media.

1. Introduction

In the today s society, social media -such as blogs, Twitter, Facebook-and other information portals have emerged as dominant communication mechanisms, overcoming any other previous technology.
Sharing information, forming connection, communicate interesting contents (Chui et al., 2012), these media mainly operate in a similar way to traditional human community and they are transforming dynamics, behaviours, and structures of our society (Kaewkitipong et al., 2012). Hence, they are significantly becoming powerful drivers in the current social technological transition. These digital platforms are effective and efficient communication channels (Palen et al., 2009), they are affecting how citizens communicate, collaborate, and coordinate with each other. Social media have indeed the capacity of linking individuals beyond geographical proximity, increasing their ability of instant connectivity for ideas, knowledge and information sharing. Moreover, these communications can be mostly realized with a minimum or non-existing cost. As such, social media can be also considered as a powerful democratization force (Lai and Turban, 2008).
In the last few years social media have been used more and more during disasters, and in particular during extreme flood events. Being powerful instruments for immediate communications and easily accessible information, social media represent a key tool during all disaster phases, from risk communication to recovery. In other words, they have been used as an instrument to increase the

ability of a system to cope and to reorganise itself after the perturbations generated by the flood, hence the system resilience. The need of quantitatively measure such system property has led over the time to several indicators able to reproduce and evaluate social resilience main parameters. However, few works have been found regarding the role played by new digital communication ways during flood disasters.

This paper presents an analysis of the use of Facebook during extreme flood events. Established in February 2004, Facebook currently has more than 800 million users globally, it is available in 70 languages and is growing at around 150% per year. It is a web-based social networking service, allowing registered users the ability to connect and share contents with friends, family and co-workers.

An assessment of the use of Facebook regarding to flood events is presented using an explorative case study. In this paper we try to give an answer to the question: how the use of Facebook can influence the social resilience of a urban system affected by an extreme flood event? The paper is organised as follow: in section 2 the conceptual framework is illustrated; a review of the concept of social resilience and the state of the art of the literature about social media and flood resilience is presented. In section 3 the method and outcomes of the case study analysis are described and discussed. In section 4 the conclusions are described.

2. Conceptual framework

2.1 Social flood resilience

Natural calamities, such as floods, earthquakes and hurricanes, often affect the stability of urban settlements. Cities are defined as complex adaptive system, where physical elements, activities and city users interact one with others in different ways. As complex adaptive systems, cities are not linear cause-and-effect systems, but rather dynamic systems: Variables, the different system s compone and the elements of each component (e.g. people, businesses, governments), are constantly interacting and changing, for better or worse, in response to each other, creating non- linear feedback loops that either promote or deplete the energy upon which their futures depend(Sanders, 2008).This complexity makes extremely difficult the evaluation of the effects critical events could have on the urban system. In fact, both extreme natural events and disasters linked to human activities (e.g. nuclear incidents), can affect a urban system in several respects, determining significant changes in its structure and organisation. Focusing on flood events in urban areas, presence of flooded areas can result into a wide range of related impacts: infrastructural damages, urban functionalities and space perception. A multi-sectorial approach, to be applied to a well defined study area, is needed to achieve an adequately complete overview of flood effects and city's behaviour once affected (Esposito and Di Pinto, 2014).

Social dynamics influence all flood disaster phases, from risk perception and preparedness up to recovery. Social phenomena represent inherent communities' features or long term dynamics, often slowly developing. This circumstance leads to consider that flood duration - on the basis of flood related impacts- actually lasts beyond the time period during which urban areas are flooded.

Even not claiming to fully analyse related impacts, it needs to be asserted that calamitous events affect cities not only in their physical elements (causing damages in infrastructures or buildings), but also in the social structure made up by city users and human activities.

As adaptive systems, cities have the ability to adapt to changes and learn co-evolve, self-organize and give rise to emergent patterns (Frantzeskaki, 2011). Hence, they show the ability to cope with a perturbation by properly re-organising themselves. UNISDR (2009, p. 24) defines resilience as *the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions*. In the field of urban flood the term resilience is often also to define the capacity of the urban system to absorb disturbances and perform changes without fundamentally altering its functional structure (Walker et al., 2004). Reflecting the several components that set up a urban system, resilience can be evaluated from different perspectives: social and economic resilience (Cutter et al., 2010; Boon et al.,2012; Adger, 2000); infrastructural resilience (de Bruijin, 2004; Cutter et al., 2010); ecological resilience (Holling, 1973, Adger, 2000).Social resilience is closely linked to community and social vulnerability concepts. Social vulnerability can be defined as a characteristic of a person or group in terms of their capacity to anticipate, cope with, resist, and recover from the impact of a natural hazard (Blaikie et al., 2014). As such, it is one aspect of what is meant with the term community resilience, which has been described previously starting from analysing four primary sets of networked resources: economic development; social capital; information and communication; community competence(Norris et al., 2008).

Social resilience can be assessed on different levels of analysis: individuals, human communities, larger societies (Norris et al., 2008). Even remaining unchanged the main general features of social resilience concept, a certain reference level of analysis has to be set. The literature presents several works aimed at analyse the multiple factors which contribute to a proper assessment of social structure reorganisation after an event. Table 1 reports a framework of some significant variables proposed in the literature as indicators of resilience and recovery ability in relation to natural disasters.

Author(s)	Indicator
Tapsell et al. (2002)	"Social Flood Vulnerability Index" (SFVI, based on different social groups and financial deprivation indicators)
Cutter et al. (2003)	"Social Vulnerability Index" (SoVI), based on: -economy (income, rents, median house values; percentage of employers in extractive industries) - demography (age, ethnicity, race) - buildings and infrastructures
Dwyer et al. (2004)	<u>Vulnerability indicators</u> Age Income Tenure type Employment English language skills Household type - family composition Disability House insurance Health insurance Debt/savings Car ownership Gender Residence type <u>Hazard indicators</u> Injuries sustained Damage to residence

FloodSite (2004)	Age Gender Employment/ Unemployment Occupation Educational level Family/household composition Nationality/ethnicity Type of housing Number of rooms Rural/urban
Messner, F., Meyer, V. (2006)	"Susceptibility indicators", based on "social and economic units and systems" and "ecologic units and system" features
Cutter et al. (2008)	Demographics (age, race, class, gender, occupation); Social networks and social embeddedness; Community values-cohesion; Faith-based organizations
Cutter et al. (2010)	Baseline Resilience Indicators for Communities (BRIC), based on social, economic, institutional, infrastructural, physical and natural characteristics and on community capital

Table 1. Social resilience indicators

The need of evaluating social resilience has led to point out indicators as representative measures. The variety of indicators reported in technical literature reflects the effort to define and measure this broad (un-measurable) issue. The main challenges when evaluating social resilience indicators can be that there is no right and no wrong methodology. According to the need of the study, it is important to set the scale on which applying the indicators (e.g. Household, neighbourhood, community, region, nations);and choose the approach (e.g. national indices taxonomic approach , or household sur situative approach) (Schröter et al., 2005).

2.2 Social media and flood resilience

A number of studies about communication and information sharing during extreme events, including floods, has been emerging in the scientific community in the last few years. The literature focuses on three main issues (Ryan, 2013): studies on agency communication (Waymer and Heath, 2007); studies on information seeking as part of a wider aim (Cohen et al., 2007; Hughes et al., 2007); and studies about the use of social media (Kaewkitipong et al., 2012; Kongthon et al., 2014; Vieweg et al., 2010). Social media, defined as internet-based applications that enable people to communicate and share resources and information, are an always increasingly used instrument to ensure communication schemes during flood events. More specifically the term *social media* is used to refer to the broadcasting strategy used by different individuals, institutions and companies to communicate with various stakeholders(Chui et al., 2012; Haegeman et al., 2012; Nielsen, 2012). Such strategies are implemented by using tools know as *social network sites* (SNSs). SNSs are *web-based services that allow individuals to (1) construct a public or semi-public profile within a bounded system, (2) articulate a list of other users with whom they share a connection, and (3) view and traverse their list of connections and those made by others within the system*(Boyd and Ellison, 2007, p.211). SNSs have been used by billions of people all around the world (Hutton and Fosdick, 2011) for a wide variety of purposes, including personal, community, business, politics, and public affairs (Hoffman and Novak, 2012). The use of SNSs emphasises the relations and the communication of an individual within his existing extended social network. Using hastag form of keywords in the contents published, SNSs make the shared messages searchable. As a result, SNSs become able to form online communities, networking people who share similar interests (Lai and Turban, 2008). SNSs are also being used as platforms where people talk about current environmental challenges and give environmental tips (Haider, 2012). Raising awareness around current environmental challenges, such as climate change and increasing urbanization, SNSs are also used to trigger citizens to actively participate in civil environmental activities that are immersed in the everyday life (Bakardjieva, 2009).

Providing new sources of information and rapid communications, increasing social participation and forming new networks, SNSs are also becoming a useful tool for victims, humanitarians, volunteers, and the general public to communicate during disasters, especially during extreme flood events (Kongthon et al., 2014; Starbird et al., 2010; Vieweg et al., 2010). One of the major issues in extreme flood events is the inability to know on a real time base where help is really needed. The use of SNSs as communication channel could be the answer to this need. SNSs have the characteristic of being accessible via smartphones, which makes them available also when traditional communication channels, such as radio, television but also phone calls and texts, are not able to cope with a higher amount of data processed at the same time (Bird et al., 2012).

During extreme flood events good communication schemes could play a significant role to ensure that the public will behave in a way where appropriate and effective steps to reduce and mitigate the risk are taken(Yamada et al., 2011).

An emerging trend in the emergency management literature indicates the use of SNSs as a way to help building a more resilient community. The basic concept of this tendency can be sought assuming that improvements in communications, risk awareness and preparedness can lead to an improved social resilience (Cutter, 2008). According to White (2011)community resilience should include a grassroots effort where social media is utilized in a number of ways to support the safety of the community. Dufty (2012)states that the use of social media by emergency agencies could assist in learning for disaster resilient communities . The contribution of social media to community resilience lies in the capacity of SNSs in forming the so called community of practices , defined as g share a concern or passion for something they do and learn how to do it better as they interact regularly (Wenger, 2011). According to Dufty (2012)the development of such communities of practices through SNSs helps in building a more resilient community in different ways. SNSs can help in developing social capital (e.g. networks, leadership, support systems) for disaster resilience learning communities; SNSs can be powerful instruments for informing others of the flood risks in their community, discussing and planning what is being done to manage the risks and what they can do; they can be used to provide support to people during and after the flood by communicating warnings and other information to affected communities. In this way, SNSs contribute to coordinate community response and recovery.

SNSs represent a platform to raise spontaneous networks useful in facing a disaster, disseminating information and warning messages. Furthermore, the large ease of access of these platforms makes them a powerful tool also during the recovery phase, as a collector of aid requests as well as to organise relief distribution. As a consequence, they contribute to make the distribution of support both based on the "rule of relative advantage" and inspired by the desirable "rule of relative needs". "Relative advantage" refers to the advantage which could be connected to being part of a community, having political connections and accessibility to resource; "relative needs" is more oriented to distributing support proportionately to the requests(Norris et al., 2008).

Acting *across* and *within* an affected community, these tools permit to share knowledge, information and also to receive/give psychological support. Norris et al. (2008) pointed out three social dimensions of "social capital": "sense of community", "place attachment" and "citizen participation". Structuring aids-network using SNSs improves all them and, in turn, the capacity of collectively react to disaster induced perturbations. It actually means put up a community and lean on community resilience.

3. Case study: the Elbe Flood in the city of Dresden. Methodology and analysis.

Between the 30thof May and the 3rdof June 2013 extreme heavy rains affected large parts of Eastern and Central Europe. The distribution of precipitations in the basin of the rivers Elbe, Moldau and Saale reached values two to three times higher than the normal average of June. The heavy rain resulted in surface runoff causing a severe flood situation. The city of Dresden was one of the flooded urban areas. With some 500.000 inhabitants, Dresden is the capital city of Saxony. The city was already flooded in 2002, when the whole city centre was invaded by the water. Different structural measures taken after the 2002 flood helped the city to better cope with the 2013 flood. Although these circumstances, the2013 flood determined significant impacts.

While the city was flooded, a spontaneous network of helpers was created using a Facebook page called *Fluthilfe Dresden*. This work aims at investigating the effectiveness of *Fluthilfe Dresden* page, aiming at estimating how it served in improving city' ability to arrange available resources in respect to the needs, and how it helped in improving the resilience of the flood affected community.

The analysis can be summarised in the following steps:

1. data collection;
2. post processing;
3. dataset elaboration.

3.1 Data collection

In order to collect data to be elaborated, a survey has been carried out pointing out the total number of *posts*, which represent the set of on-line published messages of *Fluthilfe Dresden* page. The dissemination of each post has been analysed on the basis of three basic Facebook functions: "*likes*", "*sharing*" and "*comments*". These functions allow Facebook users to show their support to published messages by approving the contents ("*likes*"), by posting the said messages on the own Facebook profile page ("*sharing*") or by adding comments giving reply and opinions ("*comments"*).

The page has been liked by ca. 43.000 users, who used it to ask, to provide help or to be updated about the flood. Data survey has led to observe that in the time frame from the 3rd of June to the11st of June 2013, 158 posts have been published on the page, with a total of 74652 sharing, 19602 likes and 4632 comments. The time frame has been chosen considering that it corresponds to the main operative period of the page, and it corresponds to the days the city was flooded.

A further analysis has been performed regarding the content of all published messages, distinguishing three main categories of contents: help requests, helping offers and communications. Although a wide variety of posts contents has been founded, requests and offers have been also organised depending on the typology of requested/offered resources (willingness/need to help or assist affected people as a volunteer; material aid offers or requests, e.g.: food, accommodations, blades, blankets).

The whole set of 158 post has resulted being made up by 59 help requests, 41 helping offers and 58 general communications.

Leaving aside communications, the set of offers and requests is resulted composed as follows:

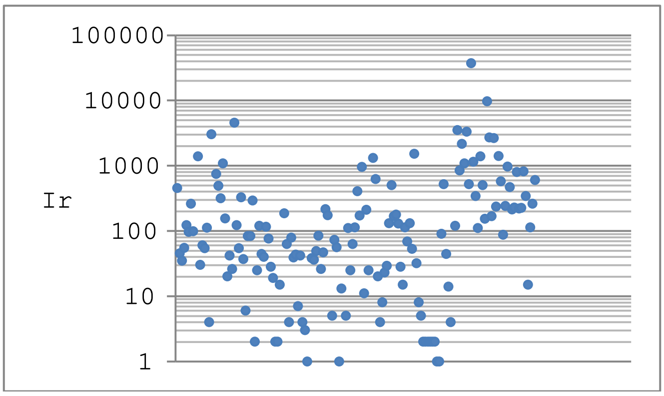
– volunteers help: requests,28.7%; offers, 22.2%;
– material needs: requests, 30.6%; offers, 18.5%

3.2 Post processing

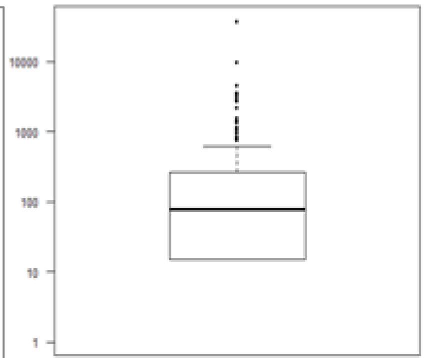
Likes, sharing and comments represent a way to virtually support, deal with and disseminate post contents. In accordance with this consideration, during post processing operations ithas been assumed that the more a post received likes, sharing, and comments, the more its contents were disseminated on line. And hence, more likely the offer/request could be satisfied.

For each post, a *response index* (I_R)has been defined as the sum of relative likes, sharing and comments. The I_R value has been assumed as a measure of the efficacy of a certain post in terms of its spread within the Facebook users' community.

Dataset has resulted to hold both a large set of elements similar in their values and some others significantly different from the previous regarding to I_R order of magnitude (Graph 1).



Graph 1.Scatter plot of "*Response index*" (**I_R**) values



Graph2.Boxplot of **I_R** values in logarithmic scale

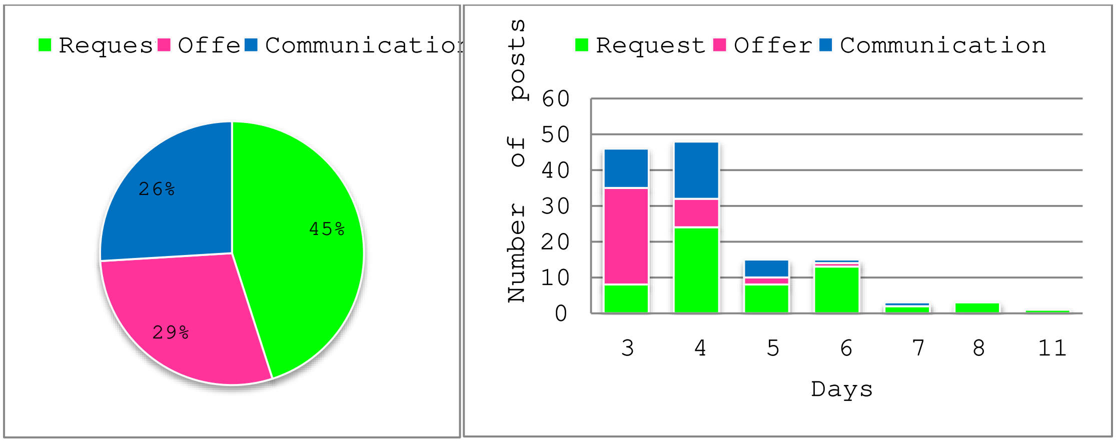
In order to substantiate the analyses, statistical based evaluations have been carried out. I_R has been assumed as an observed variable and the set of its numerical value as a sample. Values dispersion has been investigated starting from quartiles, using boxplot representation. More in details, defining q_1 and q_3 respectively the first and the third quartiles, interquartile range h can be obtained ($h = q_3 - q_1$). Outliers have been identified as values exceeding the range [q_1 -1.5 h; q_3+ 1.5 h] (Graph 2).

3.3 Data elaboration and outcomes

Once identified the outliers, they have been kept out from the reference dataset. Having pointed out 23 outliers, the original set of 158 posts has been reduced to 132 posts. The updated dataset has allowed not to taking into account outliers in all the following evaluations, ensuring an adequate significance to processed values. Main statistical moments of I_R values for revised dataset have been evaluated (Table 2).

Minimum value	0
Maximum value	520
Average value	83.1
Mode	2
Standard deviation	128.2

Table 2. Main I_R statistical moments



Graph 3.(a) Percentage of requests, offers and communication; (b) Posts by day classified in requests, offers and communications

The outliers' elimination has made the whole dataset composed by: 59 help requests, 38 helping offers and 33 general communications (table 4 and graph 3 (a)).Help requests represents a large part of the whole dataset, higher than the two comparable quantities of help offers and communications.

Further consideration can be deduced from deeply examining how posts are geographically distributed as well as within the chosen time frame.

Based on the posts' publishing date on *Fluthilfe Dresden* page, time trends have been deduced (Graph 3 (b)).Globally, the highest number of activities on the page has been registered on the 4th of June. As regards the Elbe River, the maximum water level was reached on the 6th of June. This matching shows that several factors determine the number of page users, such as: hydraulic levels and flooded zones localisation, number of affected people and their ability to be connected to Internet (as regards help requests), fame and knowledge of *Fluthilfe Dresden* page within Facebook users (as regards help offers and communications).

The distribution of these three categories through the different days is resulted to be not homogenous. On the 3rd of June the number of registered helping offers is much higher, while in the other days the number or requests is more relevant (Graph 3(b)).Help requests have resulted to be generally the most significant rate of posts' contents.

Some posts included the exact location of the concerned request, offer or communications. Thus, data collection has led to register the geographical position for the said posts. More in details, 82 posts have been geographically placed according to Dresden city districts divisions ("*Ortsamtsbereich*") (Table 3; Fig 1).

Ortsamtsbereich	Requests	Offers	Communications
Schönfeld-Weißig	0	1	0
Radebeul	2	1	0
Leuben	12	3	0
Neustadt	10	5	2
Plauen	1	1	0
Loschwitz	4	1	0
Pieschen	10	3	5
Cossebaude	2	0	1
Altstadt	7	2	2
Freital	1	1	0
Altfranken und Gompitz	0	1	0
Cotta	2	0	0
Pirna	0	1	0
Blasewitz	0	1	0
Total value	51	21	10

Table 3. Summary table on the basis of geographical available locations

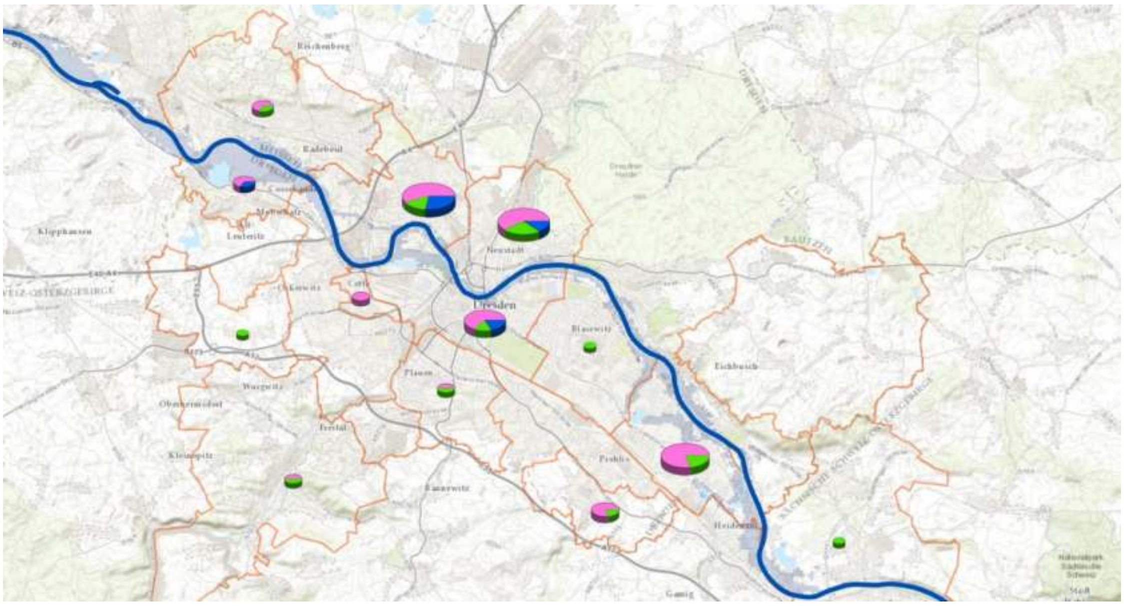


Figure 1: Thematic map (Scale: 1:150000). Dresden city districts administrative boundaries ("*Ortsamtsbereich*") (orange lines). Pie charts dimensions increasing with number of posts, representing help requests (pink), help offers (green) and communications (blue); maximum flooded area in June 2013 (light blue) based on PERILS data.

Being not possible to associate the exact place referring to all *Fluthilfe* registered posts, the cartographic representation of dataset values has resulted limited. However, data allow to point out that the webpage was especially used in the northern part of Dresden city (Pieschen and Neustadt districts). This circumstance could be related to the characteristics of this district to be mostly residential areas, easily accessible with public transport (e.g. Train station Bahnhof Neustadt and several tram stops), and to their location very close to the city centre.

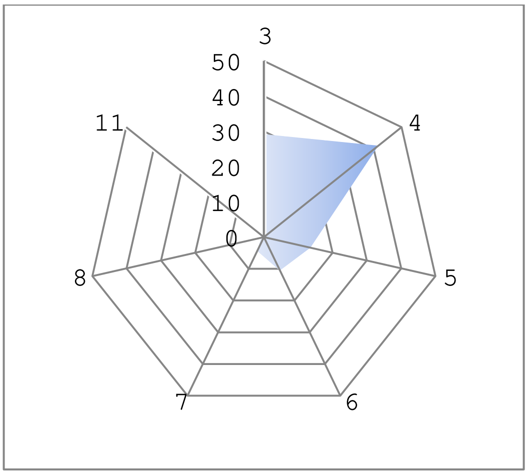
A first measure of *Fluthilfe Dresden* page efficacy can be assumed as the response index average value, equal to 83.1. Therefore, each post has resulted to be read by 83 Facebook users on average. It has to be specified that this I_R average value is just an approximate estimate. Due to characteristics of dataset values, I_R considers only likes, sharing and comments reported on *Fluthilfe Dresden* page, not also all Facebook users that became aware of a certain post after the latter has been shared on users' profile pages. It is clear that this observation not necessarily means that each help request or offer received 83 replies. However, I_R mean value helps in highlight the high potentiality of a tool such as *Fluthilfe Dresden* page in disseminating information and needs.

The response index has been calculated for each day (Table 4). Having defined I_R as indicative of the web page global efficiency, the latter results more significant in the time frame from the 3rd of June till the 5th. Registering an I_R value of ca. 40 %, the 4th of June can be identified as the most page efficiency day (graph 3).

The response index has been also calculated for each of the three categories requests, offers and communications (Table 4). The most efficient posts result those classified as communications, with a I_R of ca. 60%.

	Requests	Offers	Communications	**Tot.**	**I_R (%)**
June, 3	8	28	11	47	29.2
June, 4	24	8	16	48	41.6
June, 5	8	2	5	15	13.6
June, 6	13	1	1	15	10.6
June, 7	2	0	1	3	4.3
June, 8	3	0	0	3	0.7
June, 11	1	0	0	1	0.0
Tot.	59	39	34		
I_R (%)	26.9	16.5	56.6		

Table 4. Response index per day and per post category



Graph 4. Response index (%) daily distribution

4. Conclusions

Besides economic losses and damage in infrastructures and buildings, flood events and related effects act as a stressor for affected people in regard to psychological and social issues. Individuals can better face a perturbation leaning on help and support that can come from the communities they are member of. Being able to create virtual communities , SNSs holds a strong potent instrument for disaster management.

This paper seeks to understand how the use of SNSs, such as Facebook, can influence the social resilience during extreme flood events. More in details, the case of *Fluthilfe Dresden* Facebook page has been deeply investigated. During 2013 Elbe River flood, this web page created a spontaneous virtual network of helpers which turned into a real and effective aids network requests, offers and disseminating useful information, *Fluthilfe Dresden* page served to coordinate aids network and to provide a better and easily accessible communication network. The page has resulted to have reached a large popularity among the Facebook users community. This fame has been in this work estimated through a survey of all published posts, and defining a "response index" as a measure of page effectiveness.

Even being an explorative case study, *Fluthilfe Dresden* page demonstrates that the creation of social virtual communities via SNSs can generate effective platforms for informa knowledge building. Both these aspects play a significant role during calamitous events. In fact, the spontaneous *Fluthilfe Dresden* aggregation of people sharing problem/needs/opportunities turned into a useful tool, serving to coordinate aids network and provide a better and easily accessible communication network. As the case of Dresden shows, it can be stated that such virtual communities, created form the spontaneous aggregation of people sharing the problem/needs, can contribute to provide support and give assistance to the real community during and after flo

These observations lead to extend the already known wide potential of SNSs, as supporting instruments for disaster management, they are able to contribute to globally improve recovery and resilience of affected communities.

Optimising use and allocation of available resources (both materials and not) and contributing to making the city system globally capable of responding to the emerging needs (acting as a community), SNSs can represent a strategic element during and after the event. *Fluthilfe Dresden* page was spontaneously created during the event recognising the considerable entity of the event and its impacts. With reference to settlements located within flood prone areas, aids networks based on SNSs could be properly arranged also before the event. Organising a web based platform able to collect help's offers -before the event- and SOS messages and requests -during and after the event- results considerable in defining community behaviour facing with the disaster.

SNSs based tools create bottom up aid networks which could integrate institutional measures. Advantages could interest all actors involved in disaster management as well as affected people: institution, organisation and bodies in the area of Civil Protection obtain a structured useful collection of "helpers" availability and their location; affected people can communicate their needs and, at the same time, receive support and help as well as real time information about the flood event and operative issues.

Improving both efficiency and efficacy of aids networks, structuring SNSs based tools help in improving community readiness to the risks they have to cope with, contributing to building flood resilience communities. This view descends from and has its roots in considering community resilience as a process to be suitably made up before the perturbation occurs, ready to be performed during emergency situation.

5. References

- Adger, W. N., 2000. Social and ecological resilience: are they related?. Progress in human geography, 24(3), 347-364.
- Bakardjieva, M., 2009. Subactivism: Lifeworld and Politics in the Age of the Internet. Inf. Soc. 25, 91 104. doi:10.1080/01972240802701627
- Bird, D., Ling, M., Haynes, K., 2012. Flooding Facebook-the use of social media during the Queensland and Victorian floods. Aust. J. Emerg. Manag. 27, 27.
- Blaikie, P., Cannon, T., Davis, I., Wisner, B., 2014. At Risk II-: Natural Hazards, People s Vulnerability and Disasters. Routledge.
- Boon, H. J., Millar, J., Lake, D., Cottrell, A., & King, D., 2012. Recovery from disaster: resilience, adaptability and perceptions of climate change. National Climate Change Adaptation Research Facility, Gold Coast, 467.
- Boyd, D.M., Ellison, N.B., 2007. Social network sites: Definition, history, and scholarship. J. Comput. Commun. 13, 210 230.
- Chui, M., Manyika, J., Bughin, J., Dobbs, R., Roxburgh, C., Sarrazin, H., Westergen, M., 2012. The social economy: Unlocking Value and Productivity through Social Technologies: McKinsey & Company. Retrieved Febr. 1, 2013.
- Cohen, E., Hughes, P., White, P.B., 2007. Media and bushfires: A community perspective of the media during the Grampians Fires 2006. Environ. Hazards 7, 88 96.
- Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J., 2008. A place-based model for understanding community resilience to natural disasters. Global environmental change, 18(4), 598-606.
- Cutter, S. L., Boruff, B. J., & Shirley, W. L., 2003. Social vulnerability to environmental hazards*. Social science quarterly, 84(2), 242-261.
- Cutter, S. L., Burton, C. G., &Emrich, C. T. (2010). Disaster resilience indicators for benchmarking baseline conditions. Journal of Homeland Security and Emergency Management, 7(1).
- De Bruijn, K. M., 2004. Resilience and flood risk management. Water Policy,6(1), 53-66.
- Dufty, N., 2012. Using social media to build community disaster resilience. Aust. J. Emerg. Manag. Peer Rev. 27, 40 45.
- Dwyer, A., Zoppou, C., Nielsen, O., Day, S., & Roberts, S. 2004. Quantifying social vulnerability: a methodology for identifying those at risk to natural hazards (pp. 2-3). Canberra,, Australia: Geoscience Australia.
- Esposito, A. and Di Pinto, V. 2014, Urban resilience and risk assessment. How urban layout affects flood risk in the city. In: Proceedings of ICCSA 2014. The 14th International Conference on Computational Science and its Applications, Guimarães, June 30-July 3 2014, p.204 207, doi:10.1109/ICCSA.2014.46
- FLOODsite report T11-07-01. Social Indicator Set. Available at: www.floodsite.net (accessed 13/05/2015),Tapsell Sue, 2007
- Frantzeskaki, N., 2011. Dynamics of societal transitions; driving forces and feedback loops. TU Delft, Delft University of Technology.
- Haegeman, K., Cagnin, C., Könnölä, T., Collins, D., 2012. Web 2.0 foresight for innovation policy: A case of strategic agenda setting in European innovation. Innovation 14, 446 466.
- http://www.perils.org/web/products/earth-observation (accessed 23/04/2015)
- https://www.facebook.com/FluthilfeDresden?fref=ts (accessed 10/04/2015)
- Hughes, P., White, P.B., Cohen, E., 2007. Bushfires and the media: a cultural perspective.
- Kaewkitipong, L., Chen, C., Ractham, P., 2012. Lessons learned from the use of social media in combating a crisis: A case study of 2011 thailand flooding disaster.
- Kongthon, A., Haruechaiyasak, C., Pailai, J., Kongyoung, S., 2014. The role of social media during a natural disaster: a case study of the 2011 thai flood. Int. J. Innov. Technol. Manag. 11.
- Lai, L.S.L., Turban, E., 2008. Groups Formation and Operations in the Web 2.0 Environment and Social Networks. Group Decis. Negot. 17, 387 402. doi:10.1007/s10726-008-9113-2
- Messner, F., & Meyer, V., 2006. Flood damage, vulnerability and risk perception challenges for flood damage research (pp. 149-167). Springer Netherlands.

- Nielsen, 2012. State of the media - The social media report 2012.
- Norris, F. H., Stevens, S. P., Pfefferbaum, B., Wyche, K. F., &Pfefferbaum, R. L., 2008. Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. American journal of community psychology, 41(1-2), 127-150.
- Norris, F.H., Stevens, S.P., Pfefferbaum, B., Wyche, K.F., Pfefferbaum, R.L., 2008. Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. Am. J. Community Psychol. 41, 127 150.
- Palen, L., Vieweg, S., Liu, S.B., Hughes, A.L., 2009. Crisis in a networked world features of computer-mediated communication in the April 16, 2007, Virginia Tech Event. Soc. Sci. Comput. Rev. 27, 467 480.
- Ryan, B., 2013. Information seeking in a flood. Disaster Prev. Manag. Int. J. 22, 229 242.
- Sanders, T.I., 2008. Complex systems thinking and new urbanism. New Urban. Des. Cities Future Rizzoli N. Y. 275 279.
- Starbird, K., Palen, L., Hughes, A.L., Vieweg, S., 2010. Chatter on the red: what hazards threat reveals about the social life of microblogged information, in: Proceedings of the 2010 ACM Conference on Computer Supported Cooperative Work. ACM, pp. 241 250.
- Schröter, D., Polsky, C., &Patt, A. G., 2005. Assessing vulnerabilities to the effects of global change: an eight step approach. Mitigation and Adaptation Strategies for Global Change, 10(4), 573-595.
- Tapsell, S. M., Penning-Rowsell, E. C., Tunstall, S. M., & Wilson, T. L., 2002. Vulnerability to flooding: health and social dimensions. Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences, 360(1796), 1511-1525.
- United Nation International Strategy for Disaster Reduction. 2009 UNISDR Terminology on disaster risk reduction. United Nations: Geneva; 2009.
- Vieweg, S., Hughes, A.L., Starbird, K., Palen, L., 2010. Microblogging during two natural hazards events: what twitter may contribute to situational awareness, in: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. ACM, pp. 1079 1088.
- Walker, B., Holling, C.S., Carpenter, S.R., Kinzig, A., 2004. Resilience, adaptability and transformability in social--ecological systems. Ecol. Soc. 9, 5.
- Waymer, D., Heath, R.L., 2007. Emergent agents: The forgotten publics in crisis communication and issues management research. J. Appl. Commun. Res. 35, 88 108.
- Wenger, E., 2011. Communities of practice: A brief introduction.
- White, C.M., 2011. Social Media, Crisis Communication, and Emergency Management: Leveraging Web 2.0 Technologies, CRC Press. ed.
- Yamada, F., Kakimoto, R., Yamamoto, M., Fujimi, T., Tanaka, N., 2011. Implementation of community flood risk communication in Kumamoto, Japan. J. Adv. Transp. 45, 117 128.