From Victims to Sensors: An Overview of PPGIS Applications in Emergency Planning and Management

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The term public participation geographic information systems (PPGIS) was bo
National Center for Geographic Information and Analysis (NCGIA), meaning to bring GIS technology to a local level in order to increase the data access and allow stakeholders to participate in the knowledge building and decision making process. With the growing popularity of personal computers and electronic personal devises, the contribution from public via the internet has also grown significantly based on the appearance of volunteered geography information (VGI). With the lack of immediate authoritative data, it has applied increasingly to emergency response as citizen became the sensors to report the unknown situations at the disaster area. With the growing amount of sensing and new information source, to what extent PPGIS has engaged in the planning process and changed the ways we defined data and knowledge in emergency planning and management is the core inquiry of this research. This paper takes an overview of the development of PPGIS applications in emergency management mostly in the United States, identifying its roles and functions in the four steps of emergency management mitigation, preparedness, response and recovery- in relationship to types of disaster and level of participation. A classification of PPGIS applications in emergency management is established through reviews of existing literatures, professional magazines and websites. This paper will facilitate further understanding of PPGIS, its trend, and identify new possibility in emergency management from the perspective of spatial planning discipline.

1 Introduction

Public participation is a form of collaboration among public, private and civic sectors, which is also an important process in spatial planning that enables stakeholders to express their views and opinions in the decision making process. Locals are not only the main users of space but also the one with most understanding of local environment. With the contribution from public, professionals and government officials can make a more accurate and relevant spatial plan with the detailed information and advices from locals. Therefore, the communication from bottom to top has been an emphasis in participatory planning process.

Enabled by Web 2.0 which is promoted by the spirit of interaction and sharing, PPGIS (Public Participation Geographic Information System) is presented as a more people-centered GIS (Geographic Information System) compared to traditional rational planning methods, where planners control the majority of data collections, analyses and decision making process. As the new technology enable a new interface of information sharing and public dialogue, PPGIS has become one of the important methods of public participation, attributing to the instant interactions between governments and citizens. As this new field emerges, substantial PPGIS applications have grown in different types of planning process, including most technocratic-led emergencies planning and management.

Emergency planning is aimed to reduce the vulnerability to hazards and adapt with disasters, including both human accidents to natural disasters such as flood, earthquake. The needed information consists of disaster related spatial data such as hydrogeology, topological properties, soil and other geological layers to help analysis and predict where the location of disaster and the needed responses at different geographic scales. GIS has been an essential tool that for data collection, display and analyzes in emergency planning, and it has applied in avoiding damage from climate change as issue of the global warming heightens. In order to acquire the accurate geospatial data and advices from locals, PPGIS has also applied in emergency planning to aid the efforts. Websites with on-line map are provided for public

to achieve and provide the information about disaster planning, acknowledging the location of evacuate areas and routes. The managers can also gain more detailed information in a smaller scale, making the result of plans more reliable.

In recent years, on-line disaster response communities have grown and promoted as a more efficient method compared to traditional planning methods as residents face the immediacy to response to the pre-and post-disaster conditions. The contribution from public via the internet has also changed significantly due to the appearance of volunteered geography information. (VGI) Residents to establish an on-line evacuation maps by using web mapping services. Sites such as Google Map or Yahoo! Maps have created web-based mapping applications more accessible to users. The interfaces of these websites are easy to use and provide achievable, editable content. Take Kaohsiung explosion (2014) in Taiwan as an example, local volunteered residents built an on-line map at once, tagging explosion spots, hazardous area and aid distribution stations one the Google Map. The on-line map not only helps the emergency evacuation but also displays the current situation to relief workers or other people.

This paper intends to document the growing popularity of PPGIS in emergency management in relation to the four steps of emergency management - mitigation, preparedness, response and recovery. Current case studies of PPGIS applying in emergency management are drawn from the United States and some other countries. We will identify its roles and the relationship to types of disaster and level of participation. With this review, the current state of PPGIS function in emergency planning will be conclude, bringing out the new possibility in emergency management with this new technological development available.

2 Literature Review

2.1 Public Participation

Public participation, also referred to as public involvement, can be defined as a process of allowing people to influence the outcome of plans and working processes. Public participation is the process consulting with the public before making decisions. In order to produce the best possible results, collaborative problems with the goal of achieving more acceptable decisions require adequate discussion with the public. The two-way communication is regarded as a way of empowerment and democratic governance.

The public means an open and unlimited circle of persons. It consists of the affected individuals or groups of people, like residents, house owners and stakeholders. The broad public is everybody. Public participation usually involves those potentially affected by or interested in a decision. The principle of public participation is that those who are affected by a decision have a right to be involved in the decision-making process. The term stakeholder is used for individuals or groups with term goal, like professionals and the non-governmental organizations (NGOs), representing specific interests. Stakeholders and the public can be both involved in public participation projects, but not necessarily at all stages of the project and in the same intensity (EU IPA, 2010).

After identifying the public, participation can be thought of as the specific activities that individu or groups engage in and tend to achieve a suitable and reasonable result. The discussion about participation usually focuses on the approaches of participatory and the depth of involvement. Participation can be done with different degrees of intensity: ranging from information broadcasting to consultation activities up to an active involvement, participating in decision-making process. (Firus et al, 2011) (Figure 1) Overall, understanding who the public is and defining how much the participation works would help operate a public participation project at an appropriate position.

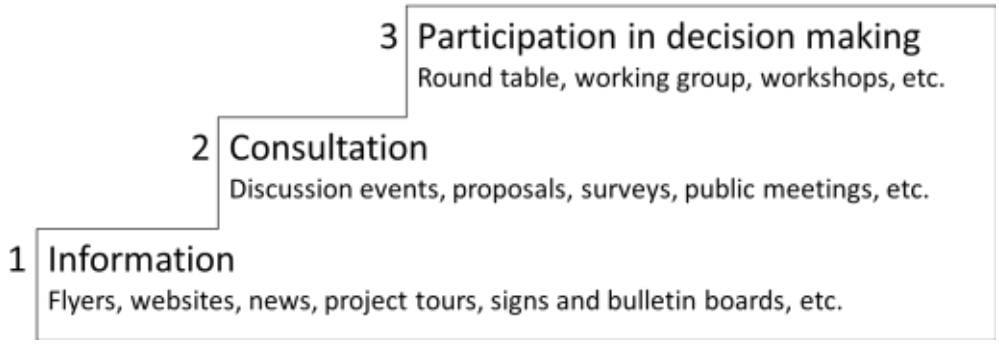

Figure 1. Intensity Degrees of Participation Processes
Source: Arbter et al., 2005

2.2 PPGIS

The term public participation geographic information system (PPGIS) was brought out in 1996 at the meeting of the National Center for Geographic Information and Analysis (NCGIA) in the United States. Same as the literal meaning, PPGIS is utilizing GIS technology to achieve the concept of public participation, in order to include and empower the entirety of population, and avoid marginalization. Among the societal issues, concerns that all voices should be heard in a democracy have sparked these researches in PPGIS. (Obermeyer, 1998) It can be applied to many aspects, as spatial planning is the major applied area that PPGIS provides a bottom-up system for public to join the process of discuss and decision making.

Since the 1990s, the applications of PPGIS has been extensive, ranging from community and neighborhood planning, environmental and natural resource management, mapping traditional ecological knowledge of indigenous people, to measuring change in place value (Brown, 2012). Two formats of PPGIS exist, including workshop PPGIS and web-based PPGIS (Chen and Ding, 2012). Workshop PPGIS is holding workshops for a specific issue one-time or on a regular base. It operates at planning in a smaller scale, like community planning or indigenous living area search. It is a common method in civil panel, start-up workshop, scenario workshop, and annual conference, etc. Using paper map or online map to display layers of information not only inspire the thoughts of locals but also explore issues and identify the problems.

The second type of PPGIS is web-based PPGIS. The emergence of Web 2.0 improves the implement of PPGIS, providing a new pattern of public participation. Web 2.0 s facilitate a new online participatory platform, where people not only consume content (via downloading) but also contribute and produce new content (via uploading), breaking the barriers between users and data-providers. (Bugs et al, 2010) Web-based PPGIS were developed later on and merged the idea of Web 2.0 technologies which are innovative, collaborative to provide simplified services. Different from the workshop PPGIS taking place in an actual space, most of the web-based PPGIS use internet as a virtual interaction space. With the character of asynchronous, anonymous, open-data, information conservation and etc., web-based PPGIS bring the traditional GIS to the internet surface, making the information sharing more conveniently. Citizens can get the information at once and participate in the public affairs without time and space limits. For example, FEMA (Federal Emergency Management Agency, US) established a Flood Map Service Center website, containing flood risk area map of the US. Residents can type in an address to get the flood risk area map near the site. If they discover a controversy or have some questions about the map, they can send an email to the center to confirm.

Owing to the rapid transmission of internet, the interaction of PPGIS between locals, government and the third party has become instant and transparent. However, there are two main disadvantages about web-based PPGIS, which are identity issues and information accuracy respectively. To avoid these

problems, some projects apply both kinds of PPGIS. Do a local survey by workshop PPGIS and set up all database by professionals on the internet, then establish a website to inform public.

Technically, the application of both kinds of PPGIS needs supplement data updating and data analysis. Take emergency planning and management as an example, before a disaster happens, locals can check the risk area and work on the mitigation or avoid living there. Locals should check the affected area to make a safe escape route and record the first-hand information at once when a disaster happens. Governments and emergency managers should possess the abilities to update data, integrate data, publish information, and make the spatial plan with the local knowledge.

2.3 Emergency Planning and Management

There are three types emergencies divided by its causing factors, which are natural disaster, man-made disaster and both in combined, like fire disaster. According to FEMA (Federal Emergency Management Agency, USA), the definition of emergency is any occasion or instance that warrants acti lives and to protect property, public health and safety, such as a hurricane, tornado, storm, flood, tidal wave, tsunami, earthquake, volcanic eruption, landslide, mudslide, snowstorm, fire, explosion, nuclear accident, or any other natural or man-made catastrophe. After the 911terrorist attacks in 2001, the US revised the context of emergency and started to emphasize the acts of terrorism. Therefore, the content of emergency planning and management has changed, moving from the focus of natural disaster to concluding more and more aspects.

Emergency planning is a continual cycle of planning, training, practicing, and revising, which are referred to a four-phase cycle --preparedness, response, recovery, and mitigation (Haddow and Bullock, 2003). The cutoff points form these phases are not always clear. Some may measure the process into five phases. Due to the need of different expertise and broad area/local knowledge, emergency planning requires collaboration with personnels from locals and other agencies. As for emergency management, it is the process of preparing for emergencies and disasters, mitigates their effects, and responds to and recovers from them. (FEMA, 2002) In short, emergency planning is a systematically method to minor the effect of disaster, and emergency management is to make sure the functions of emergency planning. In order to decrease the damage, both of them should be considered as an integrated project.

The four phases of emergency planning are illustrated in the circle of emergency management. (Figure 2) Mitigation and preparedness are implemented before the disasters happen. Response and recovery are actioned after the damage. Emergency planning and management is linked up by the four phases sequentially and cyclically. The explanation and actual content are in the following table. (Table 1)

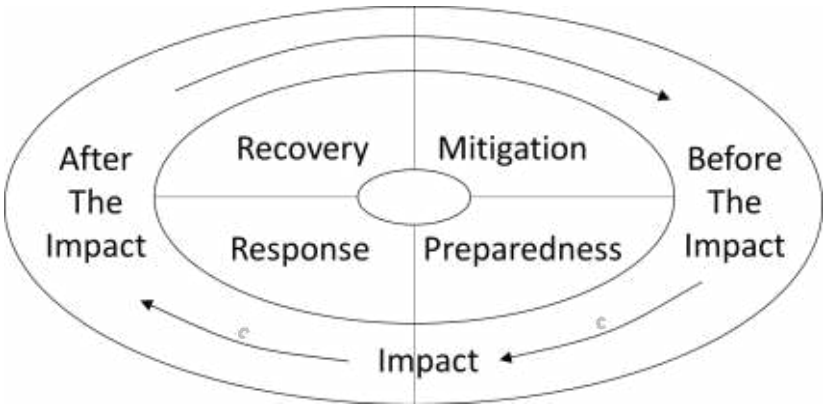

Figure 2. The Process Image of Emergency Planning and Management

Table 1. The Four Phases of Emergency Management
Source: Cova, 1999

Phase	Explanation	Content
Mitigation	Prevent future emergencies or minimize the effects.	To avoid or to decrease the damage of disaster, governments draw up and implement emergency plans through policies, usually designed as long-termed plans or procedures. Mitigation measures can present in two types, structural and nonstructural respectively. For example, in earthquake risk areas, the structural measures might include changing the materials and structure of buildings and installing securing facilities. The nonstructural might include comprehensive plans and land use zoning.
Preparedness	Prepare to handle the occurrence of emergency before it happens.	Preparedness is to take a prevention action in case an emergency occurs, including training, planning and warning. Training maintains the ability of resilience. Preparedness plans ensure that when a disaster strikes, emergency managers will be able to provide the best response possible. Warning provides a longer time to prepare and face the disaster.
Response	Respond to an emergency safely during or after it happens.	Response activities take place during an emergency. Response is to put the preparedness plans into action, including saving lives, preventing further property damage and adjust the plans based on the instant emergency situation.
Recovery	Recover from an emergency.	After an emergency, recovery activities are taken to return the area to a normal or safer situation. The sort-term goal is to conduct lifeline systems and get assistance to help maintain the basic needs of life. The long-term goal is to recover economic activities, rebuild public infrastructure and living environment.

3 Current Status of PPGIS in Emergency Planning and Management

3.1 Public Participation in Emergency Planning and Management

The reflections in this paper derive from seven selected PPGIS case studies which are related to emergency planning and management in the United States, Haiti, Philippines and Vanuatu (see Table 1). Among them, four cases were applied in USA which represents the development in the past decades because USA is the country with the longest history in PPGIS. The other cases are from different countries which stand for the critical evolution of PPGIS in recent years. All of the application name were identified and divided into three degrees of public participation inform, consult and participation in decision making.

Numbers of websites applying PPGIS are presented on the internet and open to public. Most of the cases were searched via on the internet, including OnTheMap for Emergency Planning, Flood Map Service Center, NYC open data and Vanuatu disaster response. OpenStreetMap of Earthquake in Haiti and Micro Mappers of Typhoon Ruby not only take the internet browser as a surface but also applied the app technology on the personal devices. Geocollaboration Software Architecture was the only case capturing from existing literature.

OnTheMap for Emergency Planning and Flood Map Service Center are both national websites. OnTheMap is an integrated platform with various resources. Among them, emergency management is one of the public data tools that provides a web-based interface for viewing the potential effects of disasters on the U.S. workforce and population. The website lists the hazard event areas and sorted by different kinds of disaster. Then, users can click the area and see the map with optional layers and information to view the detailed workforce, population, and housing characteristics for hurricanes,

floods, wildfires, winter storms, and federal disaster declaration areas. This application of PPGIS is functioned with inform. Users can only get the information but can t reply by the syste

Flood Map Service Center (MSC) contributed by FEMA (Federal Emergency Management Agency) is an official public source for flood hazard information. Users can type in their address to get the official flood map and receive a better understanding flood risk. The whole country map was divided into same size of grids with numbers. The information is presented on each grid map. If anyone has question about the flood area, he can send emails to MSC to confirm the information. The function extend the concept of public participation from inform to consult, accepting the corrective and advisory forms of its users.

In addition to the national official website, some states or administrative areas set up their own web-resources with more detailed data. Take New York City as an example, NYC Open Data collected different types of public data generated by various New York City agencies and other City organizations available for public use. The data are presented by different machine-readable formats, such as datasets, charts, maps, documents and etc. Descriptions of the data, the collection method, and other contextual material, called metadata, are recorded and make the data sets easier to understand and use. All of them are arranged by types, category and reference city agency. Among these classifications, the maps have applied the concept of PPGIS, providing the datasets about public safety, including population, tornado, hurricane and fire disaster. The website is full of basic and advanced datasets, also possesses the function of discussion, so users can leave messages corresponding to each dataset. When citizens review the map, they can select different kinds of layers and even add new dataset on the map, then export the map. The application of PPGIS not only reaches the degree of consult but also enhances the convenience of spatial analysis. Anyone can use these datasets to participate in and improve environment by conducting research and analysis or creating applications.

Except for the official application of PPGIS with matured technology and rich data mentioned above, there are some case studies from other areas which were contributed by NGOs with different participation process. OpenStreetMap of Earthquake in Haiti was contributed by Community OpenStreetMap Haiti (COSMHA) and Humanitarian OpenStreetMap Team (HOT). Due to the serious damage from the earthquake, roads and landscapes had a radical change. To complete a functional map, the organization collected the scanned historic map and the satellite imagery from UN, GeoEye and Digital Globe which was released to the public. The largely empty and incomplete map gathered thousands of volunteers, developers, and organizers to generate the most complete map of the country of Haiti currently. They also used cell phones or devices with GPS to record the extant roads and rivers, building a new on-line map according to the current landscapes. In addition to marking roads and transit information, there was analysis of damaged buildings, displacement camps, and emergency service centers. The free and open on-line map serves more than merely a digital, web-based map for viewing the decimated region. It not only provides accurate road information for citizens calling for aid, but also make numerous contribution to the actions of rescue and recover to the response organizations and government agencies.

Vanuatu disaster response faced a similar situation with Haiti and also only reach the phase of inform, but they applied PPGIS in another method. On March 2015, cyclone Pam hit Vanuatu, left a path of destruction. The disaster response in Vanuatu was led by UNICEF Pacific, trying to provide clean water, sanitation and basic infrastructure, so the need of open data emerges. They combined existing data sets which were conducted by Akvo before the disaster happened, to help the teams to allocate their assistance accordingly. The datasets was collected from public and contained the proportion of households with no toilet, proportion household with water sealed and flush latrines, Vanuatu household size and water point functionality and etc. These combined datasets present useful information to relief teams and emergency managers to hand out in the field.

For the purpose of aiding data collections, smart phone APPs are invented and applied in emergency planning. Take Micro Mappers of Typhoon Ruby in Philippines for instance, digital humanitarian volunteers tagged images on the map by using Micro Mappers Image Clicker and rated the level of damage they saw in each location. Those that are tagged as Mild and Severe c

Table 2. Case Studies of PPGIS Application in Emergency Planning and Management

Established Year	Application Name	Implementation Mode	Participation	Location	Organization	References
-	OnTheMap for Emergency Planning	Internet (Google Maps)	Inform	USA	Department of Commerce, US	http://onthemap.ces.census.gov/em/
-	Flood Map Service Center	Internet (esri)	Inform Consult	USA	Federal Emergency Management Agency, US	http://msc.fema.gov/portal
-	NYC open data	Internet (Google Maps)	Inform Consult	New York City, USA	various agencies in New York City and other organizations	https://nycopendata.socrata.com/
2007	Geocollaboration Software Architecture	A software architecture	Participation in decision making	Lower Swatara township and Centre Region, Dauphin County, Pennsylvania, USA	The Pennsylvania State University	Schafer, W. A., Ganoe, C. H., & Carroll, J. M. (2007). Supporting community emergency management planning through a geocollaboration software architecture. Computer Supported Cooperative Work (CSCW), 16(4-5), 501-537.
2010	OpenStreetMap of Earthquake in Haiti	Internet (OpenStreetMap)	Inform	Haiti	Community OpenStreetMap Haiti (COSMHA), Humanitarian OpenStreetMap Team (HOT)	https://opensource.com/osm
2013	Micro Mappers of Typhoon Ruby	APP, Internet (OpenStreetMap)	Inform	Philippines	Standby Volunteer Task Force (SBTF)	http://irevolution.net/2013/11/11/live-crisis-map-of-disaster-damage-reported-on-social-media/
2014 2015	Vanuatu disaster response	Internet (CartoDB)	Inform	Vanuatu	Water, Sanitation and Hygiene (WASH) sector of United Nations International Children's Emergency Fund (UNICEF) Pacific & akvo.org	http://programmes.akvoapp.org/project/2100/update/8882/#

geocoded by members of the Standby Volunteer Task Force (SBTF). The application shows the current situation immediately and offers images to social media, applying the step of inform in public participation.

According to the aforementioned cases, PPGIS applications perform in different kinds of format but the majority only reach the degree of inform in public participation. The last case is an academic research about Geocollaboration Software Architecture conducted by The Pennsylvania State University. Through the study in Lower Swatara Township and Centre Region, the concept of community emergency management planning is exemplified, explaining how emergency planning is a community activity with local area stakeholders, resources, and threats. They held the emergency planning meetings to bring all of the emergency-related stakeholders together in the region. After setting scenarios, applying geospatial representations and providing information about infrastructure and land use, they provide a forum for the citizens and agency leaders to reflect on how to improve their coordination and communication, based on past experiences, in order to be prepared for a large-scale emergency event in the future. Later on, Geocollaboration Software Architecture was proposed, using GIS interface to generate a geospatial representation. Every individual data layers are reusable and can be combined to produce multiple representations, and linked to other online content. The software is open to everyone and the information will be transmitted to the emergency planning and management. In their demonstration of the Geocollaboration Software Architecture, it allows public participate in decision making, which reached the ideal goal. The creation of the PPGIS software is based on the opinion from possible users. However, the application still just an experiment in the academics research so far.

3.2 PPGIS Applications in Four Phases of Emergency Planning

Geographic information system has played an important role in emergency planning for decades. If the concept of public participation is integrated into the technic of GIS, how will it be presented in emergency planning? Carrying on the discussion of PPGIS case studies, PPGIS application can appear in diverse forms and contributed in different phases of emergency planning, including mitigation, preparedness, response, and recovery. After case studies, we array the cases into the matrix of public participation and emergency planning. (see Table 2)

Table 3. The Case Studies Matrix of Emergency Planning and Public Participation

<table>
<tr><th>Emergency planning / Public Participation</th><th>Mitigation</th><th>Preparedness</th><th>Response</th><th>Response</th></tr>
<tr><td rowspan="3">Inform</td><td colspan="2" rowspan="3">On The Map for Emergency Planning</td><td colspan="2">Vanuatu disaster response</td></tr>
<tr><td colspan="2">OpenStreetMap of Earthquake in Haiti</td></tr>
<tr><td colspan="2">Micro Mappers of Typhoon Ruby</td></tr>
<tr><td rowspan="2">Consult</td><td colspan="2">Flood Map Service Center</td><td colspan="2" rowspan="2">Only volunteers (broad public) involved.</td></tr>
<tr><td colspan="2">NYC open data</td></tr>
<tr><td>Participation in decision making</td><td colspan="2">Geocollaboration Software Architecture</td><td colspan="2">None
Website
Website and App
Academic Essay</td></tr>
</table>

In most cases, PPGIS is applied in the phases of mitigation and preparedness before the disaster happens. On The Map, Flood Map Service Center and NYC open data take the internet as a surface to present the information by online interactive mapping. Sufficient data related to emergency planning are collected for public to acquire accurate information conveniently. These websites have established for a few years. Citizens can surf on them and acknowledge the information about emergency planning in their daily life. However, if the websites haven t been well-promoted, the interaction process would be passive because not every citizen obtains the passion to learn the knowledge of emergency planning initiative. Though Flood Map Service Center and NYC open data obtain the function of consultation, the usage rate and effect is still not notable.

Geocollaboration Software Architecture has an integral and mature process of applying PPGIS, beginning from awareness presentations, to staging area planning, to software conducting. The Geocollaboration Software Architecture is not just software but include a complete process with different methods of public participation. It reached the degree of participation in decision making, applying PPGIS in the phases of mitigation and preparedness of emergency planning. The software collects the advices from public in order to organize the spatial planning. Although the paper didn t mention the possibility of applying the same concept after disaster happens, the software architecture may be a great helper in the action of response and recovery as well.

Vanuatu disaster response, OpenStreetMap of Earthquake in Haiti and Micro Mappers of Typhoon Ruby are the PPGIS application after disaster happens. No matter what kind of emergency, disasters may cause the rapid destruction of landscape and physical environment. One of the important points of response is to collect the instant information. So as to control the damage and help the victims to settle down, relief workers need to arrive in the distress area immediately. The correct status about traffic, basic facility, natural resources and other needed information would contribute great favor to the agencies. Vanuatu disaster response and OpenStreetMap of Earthquake in Haiti collected data by internet and independent devices then established a functional on-line map. To take it up a notch for the convenience, Micro Mappers of Typhoon Ruby and used cell phone app to record the situation and rate the damage as Mild or Severe . The combination of cell phone and internet bring a better flexibility and convenience to building the database. When the users arrive in the distress area, they can open the GPS to record the location, even tag photos to spread out the current images. Though most victims didn t possess adequate equipment to build the dataset, volunteers from other places can be the sensors to facilitate the data collection. These cases consult the broad public in public participation without local residents.

OpenStreetMap is an openly licensed map of the world being created by volunteers using local knowledge, GPS tracks and donated sources. Its app makes use of the smart phone owners, recording the moving routine by GPS and turning the highly-used paths into roads. OpenStreetMap not only can be applied in daily life but also catastrophe. Except for the earthquake in Haiti, the system was also applied in the earthquake of Nepal. In serious unprecedented events, the maps and information that are needed for doing the groundwork at the local scale immediately after the event are often not available. (Laituri & Kodrich, 2008) So volunteers in worldwide started to draw the map on the internet according to the satellite image. This gain a great attribute to disaster response because others can know the new terrain by updating on-line map and making the rescue action become more efficient. Because of the different conducting process, the result of map would be more close to the local users and the traffic can be calculated according to the actual usage rate of each road as well.

3.3 PPGIS Applications in Emergency Planning and Management

According to the case studies, present PPGIS applications are well-functioned to inform the public before disaster happens. The GIS technology is applied fully well in emergency planning in most of the developed countries. The information is provided on the websites and open to everyone. In recent years, applying PPGIS during or after disasters are more and more common. After the experiences of Indian Ocean tsunami (2004), Hurricane Katrina (2005), Haiti earthquake (2010) and etc., the on-line disaster response operation systems have improved over these years.

Most of the PPGIS applications in emergency planning and management haven t reac participation in decision making. Some websites possess the function in the phases of mitigation and preparedness but the appliance is still unformed. So far most applications consult the volunteers with proper devices but there is still no application about consulting the advices of local residents after disaster happens. However, the action of response and recovery truly need the information from victims because they are the first responders who know the best of the local situation of that time. The spatial planning should accede to their opinion because they may also be the people who will continue to live in the environment.

On the whole, the PPGIS application in emergency planning and management is lack of two-way communication. The most common form of interaction is that the public collects and provides data to managers. Then the data managers will confirm, arrange and publish the data. (Figure 3) When different people upload data in the same location but with different description, the managers need to correct the mistakes and judge the accuracy. (Chen and Ding, 2012) Afterwards, the public not only can use the information but also be the role of supervisor and corrector if the information got mistakes. Take OpenStreetMap as an example, the map is divided into grids for users to choose the area they want to edit. The grids are colored into three colors, which mean complete, verification, verify invalid, high priority and currently worked on. The users can know the integrity of the map by different colors.

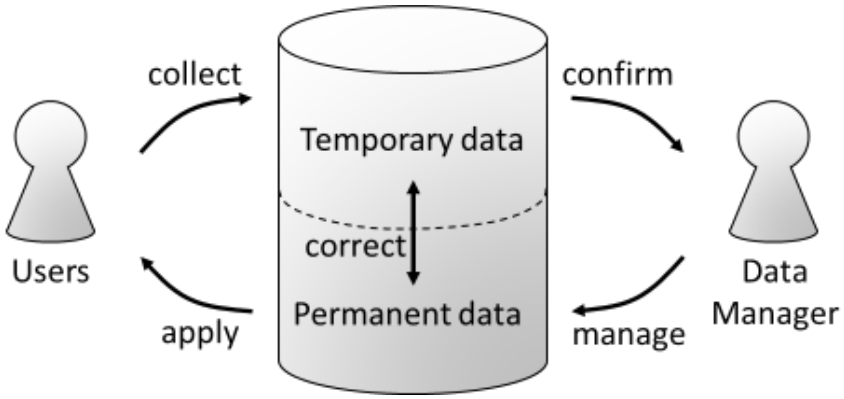

Figure 3. The process of current web-based PPGIS application
Source: Chen and Ding, 2012

The reason of lacking PPGIS application in consult and participation may be the necessary to identify users and arranging diverse data. The broad public should involve in the planning process when the emergency planning implements a spatial plan. Though the environment belongs to everyone, but if taking all the advices from everyone into consideration, it will take a long time and cost more money for sure. Therefore, identifying the participants turns important in reality, especially when governments need to select the proper public and stakeholders.

4 Conclusions

Emergency planning and management requires a visualization of detail information from roadways, bridges, buildings, and even parking lots of a local community. GIS is the system which is suitable to present a huge amount of information to everyone. As a result, GIS has been applied in emergency planning for decades. PPGIS applications merge the public participation into GIS, mostly functioning in spatial information collection and display. Though the current PPGIS applications are lack of consultation and decision making, the technics in information delivery is well-developed, especially in mitigation and preparedness phases. Most of the countries establish the internet GIS platform to present the spatial information. Until now, there are some GIS websites providing free platform and easy surface for public to edit information on the map or produce their own maps, like Google Map and Yahoo! Maps, allowing everyone to achieve and manage the spatial knowledge.

PPGIS can be applied in every phases of emergency planning, no matter before or after disaster happens. The applications in mitigation and preparedness usually perform the information on websites and have less interaction with public. Due to the increasing penetration of private internet device, the PPGIS technic applied in response and recovery are thriving in recent years. More and more apps are invented for emergency planning and management by government agencies (e.g. FEMA App), nonprofits (Disaster Alert, Your Plan) and donation partners (Esri ArcGIS app, HelpBridge), making the local become the sensor of various data. Some of these apps collect user general content and manage the information methodically. Some of these apps provide instant information before disaster occurs to improve the preparedness of individuals. For instance, FEMA created several GeoPlatform to provide geospatial data and analytics in support of emergency management. The GeoPlatform has seven main subjects, which are hurricanes, floods, tornadoes, winter storms, earthquakes, biohazards and man-made disaster. Users can obtain the weather report, set the disaster alarm and follow the new FEMA news. When a disaster occurs, users can also upload photos and tag them on the map through the app by GPS to spread out the image of current situation in local.

However, when most of the PPGIS applications are web-based PPGIS, the limitation of possessing devices appears. Some cases like Micro Mappers of Typhoon Ruby require using smart phone and install the specific app to collect data. In another word, the limited of devices restrict the user range. People without smart devices or computer are excluded, such as people from developing countries, elderly people and the poor. Disasters often include relocation and movement of large numbers of people to another area, the establishment of refugee camps, and the infusion of different groups of people into new areas that may not have the necessary infrastructure to support them. (Laituri and Kodrich, 2008) However, in the most of time, they are the vulnerable groups that need help and be heard in emergency planning and management. The information asymmetry and shortage situation may be a problem during the emergency planning and management. That may also be the reason why the users of PPGIS applications in response and recovery mostly are volunteers, not local residents, turning the PPGIS concept into VGI (volunteer geographic information).

To respond the unbalance problems, workshop PPGIS should be implemented in the process of PPGIS, avoid relying on the web-based PPGIS. Workshop PPGIS not only can fix the accuracy and reality during the process but also build the trust among the locals. With a coming disaster, local users can provide the updated data and opinion for spatial planning by their daily experience and observation in local through the workshops. Emergency managers can help to manage the data. The information gathered from the public will help to make the decisions more accurate at different phases of emergency planning and management. Future research should pay attention to the information gap in every related individual and group. When the technology of cell phone apps is improving rapidly, the whole public

should be considered completely as well. The concept of public participation c
PPGIS applications in emergency planning and management, continuing to bring the technology into play to decrease the damage of disasters in the coming future.

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