The use of geographic information systems(GIS) for rapid assessment of health facilities following a disaster: the case of the tsunami disaster in the province of Aceh

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Abstract

Background: *The tsunami disaster in the province of Aceh in December 2004 caused more than 200.000 casualties, 500.000 people became homeless and a lot of infrastructures was destroyed including health facilities. A health facilities assessment was needed to provide detailed information with regards to rehabilitation and reconstruction of health services provision after the disaster. This article aims to describe the process of the rapid assessment, analyse the field results and discussing the use of free GIS sofware during the whole process.*

Methods: *A cross sectional survey in 326 out of 354 health facilities (92,1%) in 20 of the 21 districts in the province of Aceh was conducted two months after the disaster. Data concerning health staff, medical equipment, functional services as well as geographic coordinates of each health facility were collected. Spatial data were obtained from the Indonesian Remote Sensing and Geographic Information Systems (RSGIS Forum) mailing list, United Nation-Health Information Center (UN-HIC) and other NGOs. Epimap was used to examine the disaster impact in terms of the condition of the health infrastructure, staffs and functions. Information of each health facility were published online using open-source MapServer software.*

Results: *About 20% of the health facilities were destroyed with different intensity. The most affected areas were the Banda Aceh municipality, the district of Aceh Besar, Aceh Jaya and Aceh Barat. Spatial analyses showed that the damaged area influenced the damaged severity of health facilities. A web-based GIS application was developed to provide this information accessible by the public.*

Conclusion: *It is possible to integrate GIS method for data collection, analysis, and online visualization of health facilities assessment. The use of free software and collaboration with multiple organization enhanced the implementation. Strengthening local capacity with low cost GIS method is important for future disaster preparedness especially for developing countries.b-based GIS application to make it accessible by public.*

1. Introduction

Geographic information systems (GIS) is a system composed by hardware and software to collect, process, analyze data (tabular and spatial) to produce geographic based information in order to improve decision making. In the public health domain, GIS methods were mostly used for outbreak investigation and epidemiologic studies. It has been used to define physical access to malaria treatment in Kenya[1], measurement tuberculosis catchments area in the South Africa[2], describing the epidemiological pattern of hepatitis C in Bangladesh[3] and many others[4]. The use of GIS is popular in the developed and developing countries as well, especially with the support of advanced information technologies

With the increasing use of GIS in several public health functions[5], however its utilization for humanitarian emergency is limited. Kaiser *et al* proposed several GIS potentials following the disaster i.e: rapid health assessment, estimation of mortality, resource allocation, planning and logistics as well as epidemiologic control[6]. On the other hand, Noji proposed the use GIS method also useful for estimating the disaster-affected population[7]

The tsunami disaster in December 2004 has caused more than 200.000 casualties, more than 500.000 people became homeless and a great deal of the infrastructure was destroyed including health facilities. Public health responses following the disaster can be categorized as emergency relief, rehabilitation and reconstruction of the health system. Information technology can facilitate an effective public health response through several methods. Arnold *et al*, especially reported the importance of information-sharing to enable rapid information collection, processing and distribution[8]. Mathew emphasized the use of information technology architecture (wireless network), hardware (personal digital assistant) and application systems (software) to facilitate this function in out of hospital condition[9].

However, until recently, lack of empirical evidence exists in describing the use of GIS for health facilities assessment following a disaster. Only fourteen papers could be found focusing on the simultaneously occurrence of the terms ‘geographical information systems’ and ‘natural disasters’ and only one of them is

related with the needs assessment. Existing publications of post disaster needs assessment mostly concerned with human needs to feed the emergency action, such as the work of Waring *et al*[10]. During the tropical storm Allison in Texas in 2001, Waring *et al* utilized GIS for indicating the survey cluster and analyzed the impact of the storm based on the cluster.

The importance of this research is justified because of while most of the published articles were about disaster-impact on human; our report is about its impact on health facilities. During the rehabilitative and reconstructive phase, public health authorities are often having difficulties whether to rebuild the existing or to develop new health facilities in the post disaster area. Detailed information of the disaster impact on health facilities including health facilities damaged level, population catchments area as well as its staffs and equipment, is hypothetically will help in this situation. Objective of this article is to report (1) the process of rapid assessment of health facilities following the tsunami disaster in Aceh, (2) the result of the field assessment analysis and (3) the lesson learnt of free GIS software utilisation on data collection, analysis and dissemination of the result. analysis and (3) the lesson learnt of free GIS software utilisation on data collection, analysis and dissemination of the result.

2. Material and methods

A cross sectional study was conducted in Aceh province two months after the tsunami. Eight teams (each consisted of 1 public health surveyor, 1 civil engineer and 1 GIS surveyor) visited 20 out of 21 districts in two weeks period. The survey aimed to collect data and information to assess health facilities functioning, number, types and presence of human resources, types of medical equipments and supplies, physical infrastructure, photograph as well as geographic coordinate. This data is important to measure to what extent the impact of the disaster on existing health infrastructures. Health facilities which have been visited were public hospitals, district health office, primary health centers, district pharmacy warehouse and health laboratories. Each teams was equipped with paper based questionnaires, laptop, digital camera and a global positioning system receiver. GPS Garmin 72 S was used to capture geographic coordinate with 15 m accuracy in latitude/longitude. During the survey, each team member performed different task. The public health surveyor was responsible to interview the respondents (mostly head of the health facilities), the civil engineer surveyor measured physical infrastructure condition and GIS surveyor captured the coordinate.

Electronic data entry was facilitated by a web based electronic form. Application was developed with PHP (Personal Hypertext Processor) v 4.3.10 programming software combined with mysql database v 4.1.9 (both are free softwares). As in other developing countries, obtaining spatial data is very hard and even if available the cost is expensive. After the tsunami, several versions of Aceh spatial data existed, however, the most accurate spatial data were obtained from Indonesian Remote Sensing and GIS (RSGIS Forum) mailing list . This version contains the most complete and uptodate administrative boundaries, main road and river as well as topographic elevation. Shapefile of damaged area was obtained from United Nation Humanitarian Information Center (UN-HIC). Epimap, a GIS module in a public domain epidemioligical software of Epi Info 3.3.2, was used to create layers of health facilities types and to superimpose with other layers.

In spite of being analyzed descriptively, assessment result was visualized online. The aim was to make the result available immediately and accessible anytime, anywhere to the public and especially to the stakeholders who are involved in Aceh rehabilitation activities. We asked for permission from the Ministry of Health to install a web-based GIS into one of its servers. Previously, there was only one web server and one mail server at the MOH Data Center. We selected one server to be installed with RedHat 6.2 operating systems before installing UMN MapServer v 4.4.1, an open source web-based GIS application . Soon after installation, the webgis was accessible at http://map.depkes.go.id.

3. Results

Aceh province is located at the top of Sumatra island which is inhabitated by approximately 4.3 million population who are distributed 55.390 km2 area composed by 21 districts, 228 subdistricts and 5.928 villages. The gap of population density is very high, so that with average density of 77,7 people/km2, the most populated district is Banda Aceh municipality (density of 2.916/km2), while the lowest is Gayo Lues (with the density of 13/km2). People seems to live in the northern and eastern part of Aceh and capital province not elsewhere. Before the tsunami, median life expectancy of of Aceh people in general is about similar to other province in Indonesia. While the self morbidity was not differently significant to other area, however, proportion of the population more than 5 kilometres to health facilities were higher than average (38% vs 27,75%) than other part of Indonesia[14].

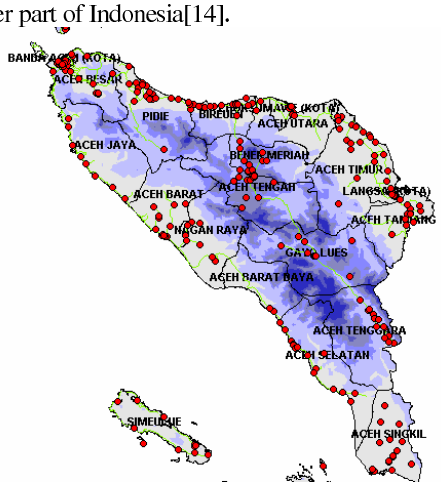

***Figure 1**. Health facilities distribution in Aceh Province*

According to the APHO database there were 259 public health centers in Aceh province. This survey then collected a provincial-wide data from nearly all of health facilities in Aceh based on the APHO database. We have visited 301 health facilities including 233 public health centers, 31 public and private hospitals, 20 district health offices, 16 district pharmacy warehouses and 1 provincial level tuberculosis treatment center. Most of them are primary health centers since which are dispersed usually in each subdistricts to provide primary health care program for 8.000-45.000 of population. Public health center ratio to population is tend to smaller in urban areas than in rural.

Damaged intensity of physical infrastructure was classified within two categories; I (mild to moderated damaged) and II (heavy damaged). We found 26 (8,6%). health facilities were within category I and 24(7,9%) in category II. Most of the health facility with category III was located in Banda Aceh municipality, Aceh Besar district, Aceh Jaya district, Aceh Barat district and Simeuleu district.

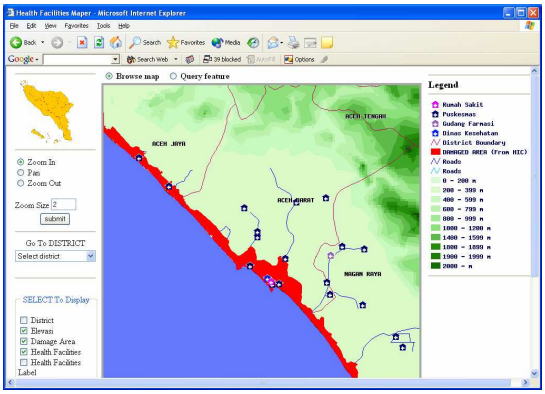

Figure 2. *Web based application of post tsunami health facility assessment (with zooming in Aceh Barat Daya district, superimposed with damaged area and elevation)*

4. Discussion

During the disaster, information about health facility is one of the most wanted information by many parties and NGOs. Therefore, providing this information is crucial during emergency and rehabilitative phase. We have explained the utility of geographic information systems to support health facilities assessment following the disaster. Geographic information systems was involved in this needs assessment from the collection of health facilities geographic location, more detailed analysis and data sharing.

However our method was not sterile from the limitation, for example the double burden of data entry from the manual and electronic. Even if each team has been prepared with the computer, in reality it was very hard to complete the electronic data entry within the field. In this concern, WHO has initiated Service Availability Mapping[15] project which intent to collect health facility information supported by a handheld gadget equipped with GPS. This PDA could serve as an electronic questionnaire and capture geographic location coordinate as well. This method is promised to perform more accurate and faster data collection than the conventional one. GIS team of WHO also has similar interest with health facilities mapping. activities in collecting health facilities database. Healthmapper software, (free, available under request to WHO), has been used as the main platform to store health facility database which then could be superimposed with other health indicators.

Actually, Indonesia conducts regularly, several national-wide surveys and census which in some part collects health facilities data including its coordinates (see, Indonesian Family Life Survey, Demographic Health Survey, National Social Economic Census). However, until present there is no initiative to integrate all of the health facility data. The only web-GIS application of those data was only the tematic map named as National Spatial Information Systems[16]. With this regards, our method to store online health facility database is relevant.

Another issue is the limited capacity of health sector in conducting health facility survey. Therefore emphasis on training is a must do agenda. Our personal experience showed that district health office staff were mostly not well informed about the use of GPS and the software to analyse the information. We underlined previous research which recommended the strengthening the capacity of district and provincial level on the use of GIS. In Indonesia, the use of GIS has been hampered with the limited human resources, unavailability of affordable GIS software, limited inter sectoral coordination and information sharing. Sipe and Dale recommended the importance of using ArcView (a GIS commercial software) and special training for public health staff[16]. However to implement a web-based GIS software with ArcView platform is still too expensive for some provincial health office

At the central level, MOH should also be encouraged to improve their capacity for managing a web-based GIS of health facilities in collaboration with the Central Bureau of Statistics. Before that, development standard of identifier for each health facilities should be put in place. For a big countries as Indonesia, until present no health facilities standard identifer exist for approximately 1200 hospitals, 7000 public health centers and others.

One of the important key success of this implementation is a good collaboration with multiple organizations. Even if, this survey could not be carried out immediately after the disaster, because of some administrative procedures and preparation of the teams, however good coordination with provincial level and district level, informal groups (mailing list) as well as the role of World Health Organization and the UN-HIC was very important. It emphasized the Malilay experience that coordination is the most important factor for the post disaster public health program[17].

In general, GIS methodology could provide more detailed analysis of in a post disaster situation beyond administrative boundaries. Our experience shows that the use of free GIS software is sufficient to present better insight on the tsunami impact to health facilities. This experience showed that limited budget is not the obstacle to implement GIS application in the public health domain, especially in the post disaster situation.

5. Conclusion

Health facilities assessment following the disaster can be enhanced with the GIS methodology. The use of free GIS software and collaboration with multiple organizations are the key success of the implementation. Capacity building of public health offices concerning the use of free GIS application remains important issue for the developing countries.

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