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## Exploring The Role of Geospatial Technology in Disaster Management of Batu City: Qualitative Analysis using RQDA Method

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**Abstract.** Disaster management is important to reduce the risk casualties as well as the environment and economic impacts. One of the stakeholders in disaster management in Indonesia at the local level is the Regional Disaster Management Agency (*Badan Pengelolan Bencana Daerah – BPBD*). In the process of disaster management, there are several phases. Thi initial phase is known as the prevention phase, which is an attempt to eliminate or reduce the possibility of a threat. In this phase, the role of information technology is important to increase the efficiency in disaster management. One of the information technologies that is used widely in disaster management is the Geographic Information System (GIS). This study explores the role of GIS technology employed at BPBD of Batu City in disaster management. The Research Qualitative Data Analysis (RQDA) method is employed based on the questionnaire data. The results show that the role of GIS technology is very limited. The disaster management at the Batu City is mostly done by the traditional method with the manual approach. The role of technology is limited it needs to be improved. Suggestions for increasing the role of technology is to conduct training on the use of GIS for employees. It is expected to increase the role of technology in disaster management.

**Keyword :** BPBD, disaster, analysis results

### 1 Introduction

The role of information technology in disaster management is important. Information technology that is widely used is in this field is the Geographic Information System (GIS). GIS is a tool that can be used to manage and analyze geospatial data [1]. GIS is generally recognized as the main support tool for disaster management [2]. The GIS is not only used for spatial physical data processing but also social-economic data that is geographically referenced. Developments in GIS have the capability of inter-field collaboration more efficiently and effectively. The GIS technology can be used in all of the Comprehensive Emergency Management (CEM) of disaster that is divided into 4 phases: mitigation, preparedness, handling and recovery [3] [4].

At the mitigation phase, this technology can be used for evaluation of mitigation alternatives prioritization of efforts. At the preparedness phase, this technology can be used for environmental monitoring event mapping (detecting, monitoring, and modelling virtually all different types of individual hazards). At the response phase,

GIS is useful for the assessment of damage and coordination of responses and assistance, and at the recovery phase, it can be used for the allocation of resources. Esri, in 2008 [5] illustrate how Geographic Information System (GIS) technology effectively improves the workflow in all phases of disaster management and defines an effective architecture to implement a framework on the ground. Another study in disaster management [6] on web-based GIS development uses the Spatial Data Infrastructure framework for disaster response. Getting results can help disaster management agencies improve the quality of their decision making. Hamid et al, in 2010 [7] focuses on developing a GIS-based landslide monitoring and management system including the Central Repository System (CRS), Disaster Data Processing Module (DDPM), Command and Control System (CCS) and Portal Management System (PMS). The results showed that the system was able to be used to support the modelling, monitoring and management of landslide disasters.

Several studies explain used IT is useful to improve performance in all fields. Camilla et all, in 2017 [8] describes the issues about the usefulness of information technology for the process of radiology. From the qualitative analysis with usability heuristic testing produces 5 the highest result. The conclusion of this research is the lack of the use of information technology that is used for research on the radiology system. Siswahyudi in 2019 [9] have done previous research. The aim is to determine the quality of the proposed framework. Evaluation is carried out using a feature-based analysis that uses seven criteria. As a result, the framework is declared ready for use.

While Walji et al, in 2014 [10] explained that problems regarding the use of technology in electronic health records by data collection using 3 methods: (1) user testing, (2) semi-structured interviews and (3) surveys. From the results of his research get 54% results from user testing, 28% from semi-structured interviews and 18% from surveys. The conclusion from his research explains that the use of 3 methods of approach provides comprehensive results.

Furthermore, Gibbs et al in 2015 [11] discusses the use of information technology in teaching and learning and qualitative research to produce results superior. The result show exploration approach is strongly supported by the software. Use of software such as Correlation Explorer, coMentor, learning web sites, reusable learning objects, open educational resources, and videos. that the core of qualitative analysis involves data exploration. The new analytical tools offered by this software provide excellent support for exploratory analysis. These tools include text search, code hierarchy, code queries, and the use of charts and diagrams. On the other hand, the research of using RQDA method was done by Peter in 2016 [12]. His research focuses on the sale of drinking water to customers in urban areas. The research used the combination method of qualitative and quantitative to explore the attitude of the employees in the water utility and customer perception related to the quality of service. The result shows that the RQDA method is effective to explore the employees and customer-related water quality.

All the previous study the role of GIS technology in disaster management landslides is very important. The sophistication of GIS technology that can facilitate the performance of any disaster which has occur. based on the study of field observations with evidence of the use of GIS Technology on the BPBD is still very minimal, then

The objective of this study is to understand the role of GIS Technology and provide suggestions for improved employees used GIS technology at the BPBD of Batu City. This article is organized as follows: Section 2 explains the methodology used in the study, section 3 explains the results and analysis found in the study, and section 4 explains the conclusions from the results of the study.

## 2 Methodology

The methodology of this research is illustrated in Figure 1. In the first Step is based on the problem of minimum to determine the purpose of the research is to know the role of GIS Technology that has been used BPBD Batu. Then, perform data retrieval, the data test the validity of field data, process the data using the software RStudio, and the final step is to perform data analysis.

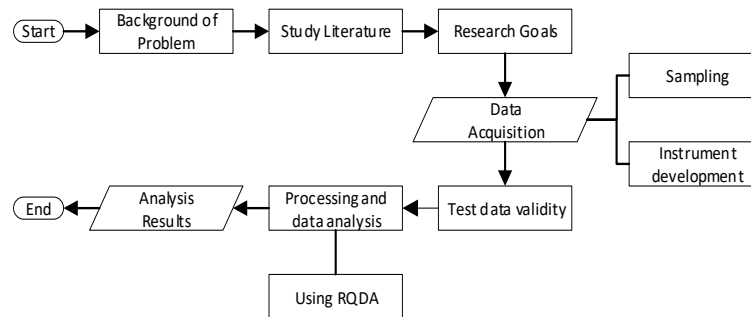


Fig. 1 research methodology

### 2.1 Study area

Batu city is situated at highland with slopy topography. Batu City is classified as a disaster-prone area by BPBD of Batu City. It is recorded that a lot of landslides occurred during the rainy season. According to the BPBD of Batu City, the number of disasters in Batu City increase every year. In 2018 there were 27 landslides, out of a total of 95 disasters. In 2019 there were a total of 109 disasters, with 20 events of landslides. In early 2020 alone, there have been five landslides occurring. landslides are natural disasters that often occur during the rainy season during 2018-2020.

There are three main phases of disaster management covered by BPBD. The first phase is the pre-disaster phase, where BPBD of Batu City conducts socialization to the community, carries out research and studies on the disaster and creates hazard maps, which can minimize the casualties and property losses. The second phase of disaster management is to deliver relief assistance, rescue, provision of temporary shelter, basic needs, and health services. The third phase is the phase where BPBD of Batu City helps for the recovery and reconstruction of the environment and the residents affected by the disaster [13].

### 2.2 Number of interview samples

The data acquisition was conducted at BPBD of Batu City. The determination of the number of samples os based on equation (1) [14]:

$$n = \frac{N}{(1+(Ne^2))} , (1)$$

Where :

$n$  = sample size

$N$  = population size of BPBD Batu City is (36 employees)

$e$  = per cent for inaccuracy that can still be tolerated. In this study, we used 20% [15]

in the slovin formula there are provisions:

10% value for a large population, A value of 20% for a small population [16]

BPBD only has 36 employees, a value of 20% is used.

Then we calculated the sample size as follow:

$$n = \frac{36}{(1 + (36 * 20\%^2))}$$

$$n = \frac{36}{2.44}$$

$$n = 14.7$$

The sample size is rounded to 15 employees.

### 2.3 Instrument development

Data was collected before the pandemic occurred so that the study could conduct interviews and give face-to-face questionnaire samples to BPBD Kota Batu. As obtained from the calculation in Section 2.2, the number of respondents is 15. The list of questions used in the study is shown in Table 1.

Table 1. Interview Question Items

No	Question	Answer
1	<i>What is the process for handling landslides during the preparedness phase in Batu City?</i>	
2	<i>How good is the handling of landslides during the preparedness phase using information technology?</i>	
3	<i>What was the stage of preparedness of the Batu City BPBD before the disaster occurred?</i>	
4	<i>What is the coordination of the parties involved in the preparedness phase for the management of a landslide?</i>	
5	<i>What is the education effort provided by the BPBD to the community?</i>	
6	<i>What is the role and responsibility BPBD of Batu City in a landslide disaster event?</i>	
7	<i>Is the SOP performs well in handling landslides?</i>	
8	<i>How is BPBD's service to local communities affected by landslides?</i>	
9	<i>How is the use of spatial technology in BPBD during the handling of landslides in Batu City?</i>	

No	Question	Answer
10	<i>What is the process for determining the status of a disaster carried out by BPBD Kota Batu?</i>	

This study also uses a questionnaire that is aimed to determine the relationship between related variables (Internal BPBD, Human Resources, Communication, Responsibility and Technology) to disaster management. The questions used are shown in Table 2. We used the Likert scale for an answer [17]. The means of value 1 to 5 are as the following:

- 1 Strongly disagree
- 2 Disagree
- 3 Neither agree nor disagree
- 4 Agree
- 5 Strongly agree

Table 2. Question Questionnaire Items

No	Statements variable	Answer				
		1	2	3	4	5
<b>INTERNAL BPBD</b>						
1	<i>BPBD used a framework for disaster management of landslides</i>					
2	<i>BPBD used a framework for the preparedness phase</i>					
3	<i>BPBD used a framework that is integrated with information technology</i>					
4	<i>BPBD used an information technology-based framework</i>					
5	<i>BPBD has information technology related to landslides</i>					
6	<i>BPBD has a guidebook for landslide disaster management</i>					
<b>HUMAN RESOURCES</b>						
7	<i>The procedure of using a framework makes it easy for all employees</i>					
8	<i>There are clear written procedures about the framework</i>					
9	<i>All employees have received training on procedures for handling landslides during the preparedness phase</i>					
10	<i>Every work in handling landslides during the preparedness phase is carried out by capable people and by their expertise and education</i>					
<b>COMMUNICATION</b>						
11	<i>Implementation of landslide disaster management both internally and in the field has been by the intended application</i>					
12	<i>Communication that is established performs well</i>					
13	<i>The communication network support facilitates operational management of the landslide disaster preparedness phase</i>					

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14 *There is rarely a disruption in the communication network*

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**RESPONSIBILITY**

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15 *The authorizing employee is fully responsible for the implementation management of landslides*

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16 *There is a record of every activity for handling landslides*

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17 *There are often misunderstandings of coordination when handling landslides during the preparedness phase*

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**TECHNOLOGY**

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18 *Information technology has been used by BPBD*

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19 *Information technology can be accessed by all people. (e.g. Disaster Information Websites)*

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20 *Spatial technology has been utilized in the preparedness phase*

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## 2.4 RQDA method

RQDA is computer-assisted qualitative data analysis. RQDA's approach allows for tight integration of the constructivist approach of qualitative research with quantitative data analysis which can increase the rigour, transparency and validity of qualitative research [18] [19].

In this study, we used RQDA package within the RStudio environment to analyze the text derived from interview and questionnaire survey. The results of the recorded interviews are converted into CSV format the language that used is R, the statistical programming language. The special packages such as RQDA, text mining (tm), topic model, tidyverse, worlcloud, igraph are also used to extract the knowledge from the text datasets. The script used to run the RQDA method within the Rstudio is shown in Box 1.

Box 1. Script of RQDA

```
#Activating the library

library(RQDA)
library(tidyverse)
library(tm)
library(wordcloud)
library(igraph)
library(topicmodels)

#run the RQDA user interface

RQDA()

#Creating the wordcloud
set.seed(1969)
wordcloud(batu, min.freq = 10, max.words = 50, rot.per=0.35,
          colors = brewer.pal(8, "Reds")[-1:-5])
```

```

#Run the topic model using LDA

dtm <- DocumentTermMatrix(batu)
dtm <- removeSparseTerms(dtm, 0.99)
ldaOut <- LDA(dtm, k = 5)
terms(ldaOut,6)
#Run the RQDA Query

codings <- getCodingTable()[,4:5]
categories <- RQDAQuery("SELECT filecat.name AS category, source.name
AS filename
FROM treefile, filecat, source WHERE treefile.catid=filecat.catid AND
treefile.fid=source.id AND treefile.status=1")
codings <- merge(codings, categories, all.y = TRUE)head(codings)
#Show the network

reorder_size <- function(x) {
  factor(x, levels = names(sort(table(x))))
}
ggplot(codings, aes(reorder_size(codename), fill=category)) +
  geom_bar(stat="count") +
  facet_grid(~filename) + coord_flip() +
  theme(legend.position="bottom", legend.title=element_blank()) +
  ylab("Code frequency") + xlab("Code")

edges <- RQDAQuery("SELECT codecat.name, freecode.name FROM
codecat, freecode, treecode WHERE codecat.catid=treecode.catid AND
freecode.id=treecode.cid")
g <- graph_from_edgelist(as.matrix(edges), directed = TRUE) %>% simplify()
V(g)$name <- gsub(" ", "\n", V(g)$name)
c <- spinglass.community(g)
par(mar=rep(0,4))
set.seed(999)
plot(c, g,
      vertex.size = 10,
      vertex.color = NA,
      vertex.frame.color = NA,
      layout = layout.drl)

```

### 3 RESULTS AND ANALYSIS

#### 3.1 Quantitative Analysis of Respondents

The results of the questionnaire with 20 questions (Table 2) using a rating of 1 – 5 are shown in Table 3.

Table 3. Results of Respondents Questionnaires

Respondents 1 from 20 answer give a value of 3 as much as 5 and a value of 5 as much as 15.
Respondents 2 from 20 answer give 4 as many as 11 and 5 as many as 9.
Respondents 3 from 20 answer give a value of 4 as much as 7, a value of 5 as much as 13
Respondents 4 from 20 answer give a value of 2 as much as 3, value 3 as much as 4, value 4 as much as 11 and value 5 as much as 2.
Respondents 5 from 20 answer give a value of 2 as much as 2, value 3 as much as 4, value 4 as much as 12 and value 5 as much as 2.
Respondents 6 from 20 answer give a value of 1 as many as 12, value of 2 was 5, value of 3 was 2 and value of 5 was 1.
Respondents 7 from 20 answer give a value of 4 as many as 20
Respondents 8 from 20 answer give a value of 2 as much as 1 and value 4 of 19
Respondents 9 from 20 answer give a value of 1 for 1, value 2 for 1, value 3 for 2, value 4 for 4 and value 5 for 12.
Respondents 10 from 20 answer give a value of 3 as much as 2, 4 as many as 16 and a value of 5 as much as 2
Respondents 11 from 20 answer give a score of 2 of 2 and a score of 3 of 18
Respondents 12 from 20 answer give a value of 1 as much as 2, value 2 as much as 1, value 3 as much as 6, value 4 as much as 3 and value 5 as much as 8.
Respondents 13 from 20 answer give a value of 3 as many as 5, a value of 4 was 13 and a value of 5 was 2
Respondents 14 from 20 answer give a value of 3 as many as 4, a value of 4 was 5 and a value of 5 was 11
Respondents 15 from 20 answer give a value of 1 as many as 3, a value of 3 as much as 14 and a value of 4 as much as 3

The distribution of the questionnaire result is described in the histogram graphic in Figure 3. Answers from respondent no. 7 (r7) is not included because the distribution of answers is not normal.

Descriptive analysis is used to describe the characteristics of the sample data [20]. Which describe the minimum, maximum, mean and standard deviation of the respondent's answers. Descriptive statistics are presented in Tables 4.



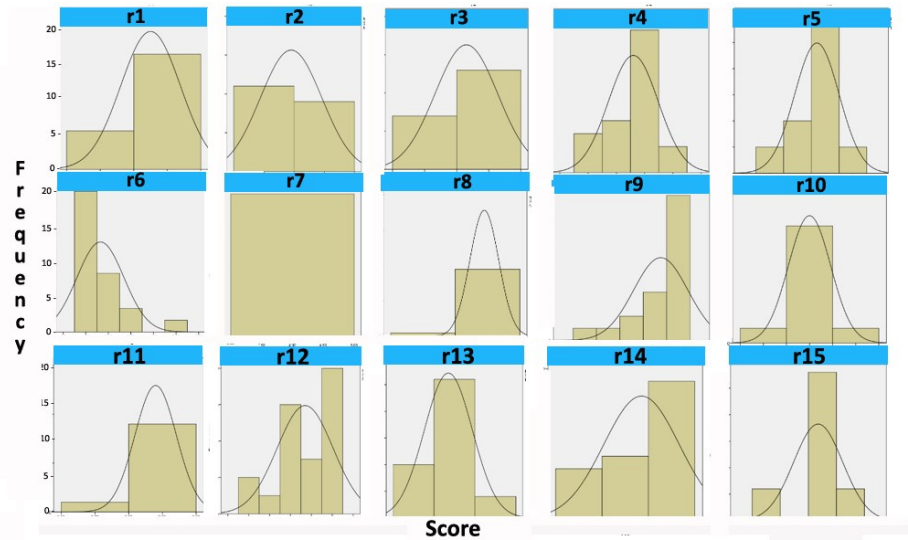


Fig. 3 Histogram questionnaire of respondents

Table 4. Statistics descriptive of questionnaire result

	N	Minimum	Maximum	Mean	Std. Deviation (SD)
r1	20	3.00	4.00	3.7500	.44426
r2	20	4.00	5.00	4.4500	.51042
r3	20	4.00	5.00	4.6500	.48936
r4	20	2.00	5.00	3.6000	.88258
r5	20	2.00	5.00	3.7000	.80131
r6	20	1.00	5.00	1.6500	1.03999
r7	20	4.00	4.00	4.0000	.00000
r8	20	2.00	4.00	3.9000	.44721
r9	20	1.00	5.00	4.2500	1.16416
r10	20	3.00	5.00	4.0000	.45883
r11	20	2.00	3.00	2.9000	.30779
r12	20	1.00	5.00	3.7000	1.34164
r13	20	3.00	5.00	3.8500	.58714
r14	20	3.00	5.00	4.3500	.81273
r15	20	1.00	4.00	2.8500	.87509
Valid N (listwise)	20				

From the statistic descriptive data we found that SD of respondent no. 7 is 0.00, which is not valid. Therefore the respondent no. 7 are excluded from the analysis.

### 3.2 Item analysis questionnaire and interview

The results of the analysis of interview items and questionnaires then calculated using equation (2) to produce the percentage of questionnaire and interview answers [21].

$$p = \frac{f}{n} \times 100\% \quad , (2)$$

Where :

- $p$  : percentage questionnaire and interview answers
- $f$  : frequency of each interview answer
- $n$  : number of respondents

The results obtained from the item analysis show that the answer to question number 9 has a low value. Question number 9 related to the use of spatial technology in BPBD during the handling of landslides in Batu City, with a value of 70.66%. It is shown that the value of the role of geospatial technology in BPBD of Batu City is in a low category (Figure 4). For assessment, the used criteria are shown in Table 7 [22].

Table 5. Assessment criteria

Category	Criteria
>90%	High
75% - 90%	Medium
<75 %	Low

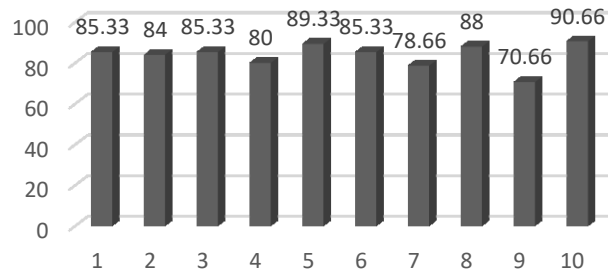


Fig. 4 Result of interview question items

Results of the questionnaire question of the respondent about the relationship between five variables (Internal BPBD, Human Resources, Communication, Responsibility and Technology) on Disaster management show that the role of information technology is low compared to other factors. The highest factor is “assign responsibility” (Figure 5). According to the interview result, we also found the role of GIS as the technology for disaster management is still very limited.

### 3.3 Research Qualitative Data Analysis (RQDA)

The result of RQDA analysis in this study was divided into three-part; Numerical Text Analysis, Topic Models, and Network Diagram Analysis [23].

(1) Numerical Text Analysis. One form of Numerical Text Analysis is Wordcloud. Wordcloud is a popular method for text exploratory analysis. Wordcloud is made with a text mining (tm) package. Wordcloud is a collection of words that have been used in the results of interviews and have the most frequencies appearing. Word frequencies that often appear are ‘disaster’ followed by ‘city’, ‘research’, ‘soil’, ‘landslide’, ‘Preparedness’, ‘stage’, ‘handling’, ‘bpbdd’, ‘information’. But the word ‘GIS’ and “technology” does not appear in the Wordcloud due to its’ low frequency (Figure 6).

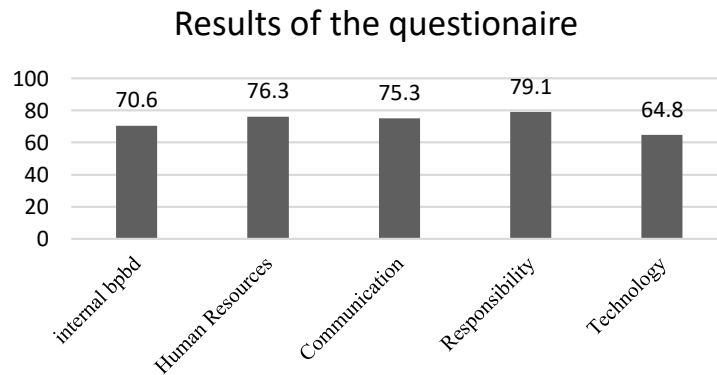


Fig. 5 Percentage of questionnaire question items



Fig. 6 Wordcloud

Topic Model is a more advanced method for extracting information from the text to assess the proximity of words to each other. By modelling the topic we could know the words that the emergence of frequent and close together. The result of the topic model also shows that information technology such as GIS as part of geospatial technology does not play an important role in disaster management at BPBD of Batu City. Meaning that the involvement of GIS is very minimal or not available (Table 8)

Table 6. Topic models

Topic 1	Topic 2	Topic 3	Topic 4	Topic 5
disaster	disaster	disaster	disaster	disaster
information	status	countermeasures	status	soil
soil	countermeasures	landslide	handling	handling
prevention	preparedness	phase	soil	prevention
landslide	soil	preparedness	data	information
status	landslide	bpbd	landslide	community

Part (2) the RQDA is analyzing each text and assigning codes (topics) manually to parts of the text. Text coding is an iterative process that aims to extract the meaning of a text [24][25]. The open coding phase successfully identifies 63 codes (Figure 7). The code produces three core categories: Human Resources, Technology dan Communication. The Human Resources category is the parties that are involved in disaster management (e.g. *BPBD, Volunteer and Community*). The Technology category is the tools used for disaster management (e.g. *SIG, GPS and Drone*). The Communication category is the method used for disaster management (e.g. *Rapid Review, Coordination, and Training*). The results of the analysis of respondents did not raise the issue of "SIG" in the Technology category. The codes that appear a lot are *Rapid review, Prevention and Community*. This result means that the traditional method still plays the main role in disaster management at the BPBD of Batu City.



Fig. 7 Distribution of the code from the interview

Part (3) is a network diagram analysis. A network diagram is a good tool for visualizing this structure. Selective coding is done by identifying the class using the Walktrap and Spinglass algorithm [26][27] . The results of the topic analysis from coding produce three classes (Table 9).

Variable Human Resources and Variable Responsibility become class D because the topic lies in the overlap between the two classes. Thus, it produces four discourse classes that can be used to determine important aspects of Disaster Management: BPBD Strategy, Role of Technology, Communication Services and Role of Related Parties, each of which is discussed in detail below.

Table 7. Class coding results

Class	Topics
A	Preparedness, infrastructure, prevention, mapping, strategy, personnel training, implementation, acceleration, disaster, assessment.
B	Information, Not yet using IT, GPS, Drones, Erosion, Manuals, Coordinates, Soil Structure, GIS, Information Systems, Vegetation, Heavy equipment, Rainfall.
C	Education, Rapid Review, Communication, Miscoordination, counselling, formation, structuring, socialization.
D	Human Resources, Quick Response Team, Accessibility, Department of transportation, City government, National Disaster Management Authority, Provincial government, PMI, Education, Training, Public works service, BPBD Prevention and Preparedness, Volunteers, BPBD City.

### 3.3.1 BPBD Strategy

Topics that are in the BPBD strategy are Preparedness, disaster assessment, acceleration, strategy, personnel training is for conducting the organization of disaster assessment, personnel training and preparation of infrastructure to support the acceleration of disaster prevention.

### 3.3.2 The Role of Technology

The results of the network visualization show the BPBD of Batu City has not been using the advance information technology to disaster management and still use the traditional method, such as the GPS to determine the coordinates of the disaster, while the use of GIS can be used to provide information about vegetation, land cover, soil structure, and rainfall. To enhance the role of technology in BPBD of Batu City need to be held GIS training for each Employee.

### 3.3.3 Communication Services

In class C there is a topic on how to communicate with BPBD of Batu City, related parties and the community. Communication about disaster awareness is the process of disaster management by providing socialization and education to the community to reduce the impact of disasters. Coordination is conducted by BPBD of Batu City by coordinating rapid assessments of disasters.

### 3.3.4 Relationship to related parties

In class D there are topics about parties involved in disaster management such as BPBD of Batu City, Prevention and Preparedness Department of BPBD of Batu City, Department of Transportation, Public health officials, Public works service, Provincial government, village government, National Disaster Management Authority, volunteers and quick reaction teams (Figure 8).

Class A is the result of collecting the topic of Disaster Prevention, Class B is the result of collecting topics on the role of technology use, Class C is the result of collecting the topic of Disaster Management Action, and Class D is the result of collecting topics of responsible stakeholder. As shown in table 7



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