

**DIFFERENCES IN DISASTER RESPONSE DUE TO VARYING DATA  
AVAILABILITY A SERIOUS GAME FOR FLOODING DISASTER  
RESEARCH IN SURAKARTA, INDONESIA**

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**ABSTRACT**

*This research aims to propose a method to study the effect of data availability in disaster-response study. This research focused on how to quantify the relation between data availability and actions taken by decision maker. The more specific topic is represented as disaster response due to varying data availability using Serious Game method in the Public Works Unit Surakarta. The serious game provide scenario to gather data about several issues. Digital elevation model, flood alert stage decision making, and damage prediction information were needed. This research also could promote as a complement the other method for collecting data and decision-making training program for flood manager. The result of analysis has shown that there are differences of responses based on the data availability. Better responses can be achieved by the improvement of data availability. It also proves that the number of correct decision was raised by the improvement of data availability.*

**Keywords :** disaster response, data availability, spatial information, serious game, flash.

## INTRODUCTION

Within the framework of flood risk management, several aspects need to be considered to mitigate the flood risk, most influential are the cycle of flood and the response against it. The response may vary and influenced by many factors, including the availability of the data. This relationship, the influence of varying degree of data availability toward response, requires a better understanding that could be achieved through the research.



Figure 1. Disaster management cycle  
(Committee on Planning for Catastrophe 2007)

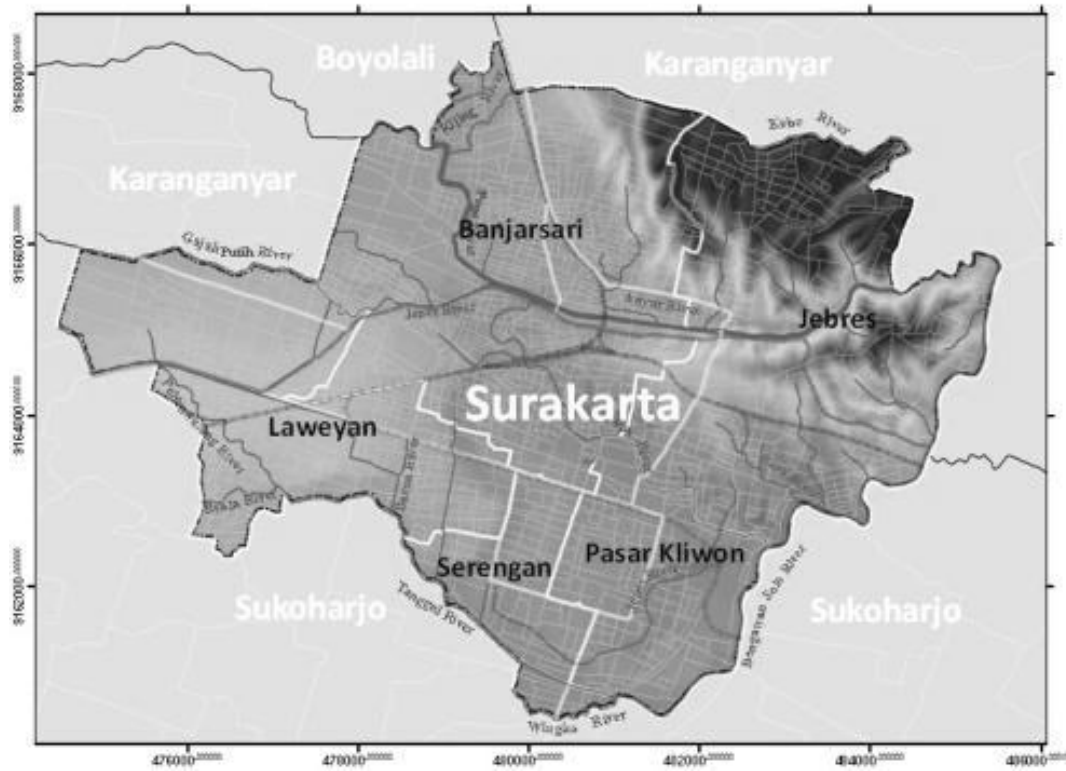
Fig. 1 illustrates the response phase in disaster management cycle, which covers all actions taken just before, during, or just after a disaster, the main activities are on providing basic needs of the affected people until comprehensive solutions can be provided [Warfield, 2010]. In this phase, information about disaster events, risk, vulnerability and risk indicators are essential to provide a better response.

In flooding situation, the data of flood extent, number of affected population, victims and damaged facilities are important for decision maker, but usually it takes too much time to get and the accuracy sometimes does not good enough. Research is needed to study the usability of spatial information to enhance the response action during disaster. Serious game in scientific and experimental approach developed from user need assessment to make an evaluation of what kind of information actually needed in the response activity.

Surakarta is a city in the province of Central Java, also known as Solo City. It is located in the northeast of Yogyakarta, and southeast of Semarang city.

The Eastern part of Surakarta meet by the longest river on Java Island, called as Bengawan Solo River. The geographic coordinates of Surakarta (Solo) is

110045'15" – 110045'35" E and 7036'00" - 7056'00" S.



Source: RBI Map

Figure 2. Central Java Province and Surakarta City

## THE METHODS

The approach to investigate the relation between disaster response and data availability consist of literature research, interview, user need assessment and serious game as the proposed innovation. Literature research of the supplemental documents and reports was used as a starting point. In general, research activities illustrated in Fig. 3.

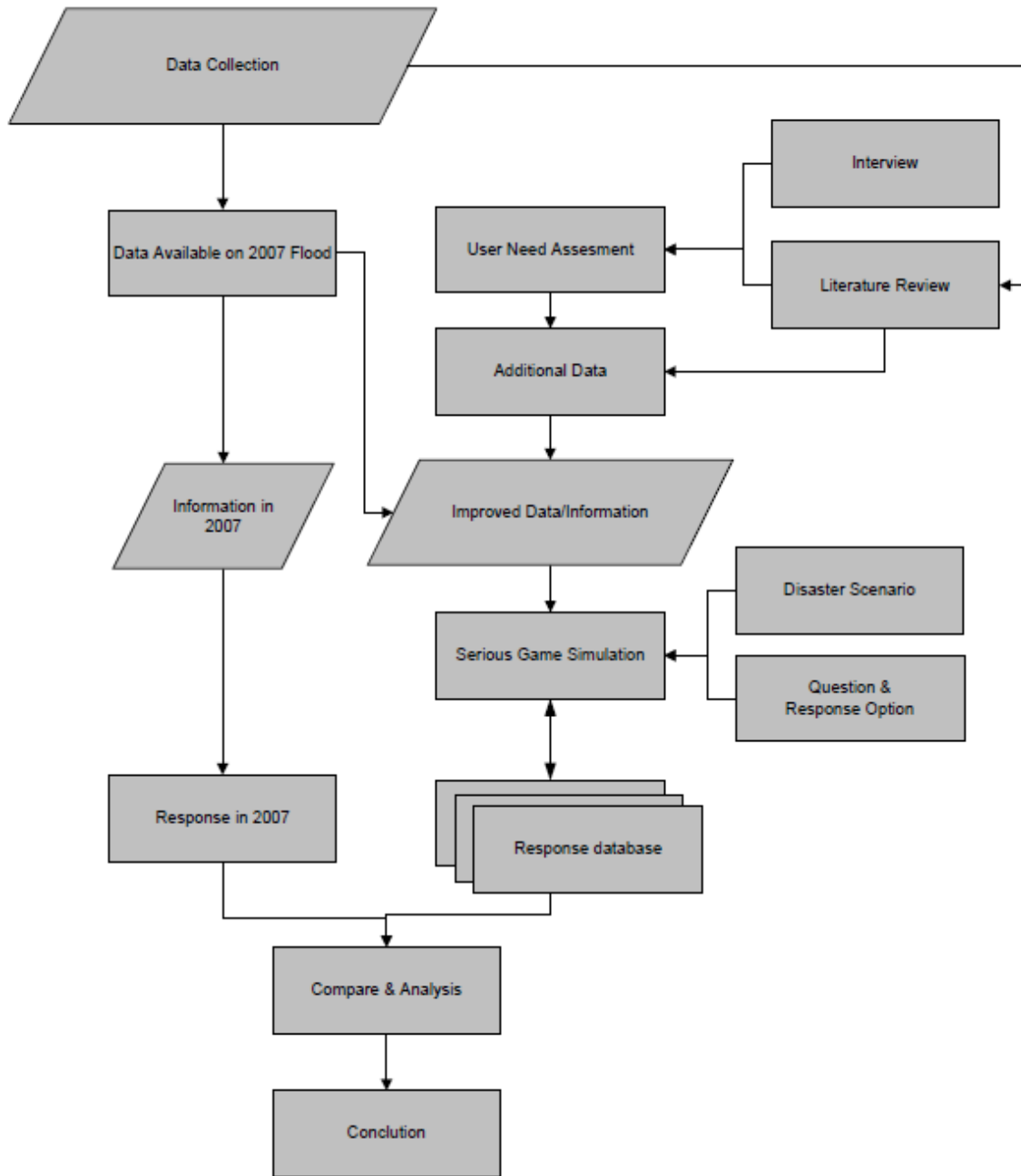


Figure 3. Simplified research framework

For local government especially flood defense unit in Public works, geographical information loses value if it adds nothing to the decision making or when there are barriers to accessing the right information, at the right time [Hayes-Roth, 2005; Langkamp, 2005; Vreugdenhil, 2009]. The participatory approach was used as a main method to measure differences of response. A serious game was developed and run by each of many participants. The game provides several scenarios, each scenario supplemented by options to be chooses by user. Various scenarios illustrate various degree of data availability: low, moderate and high (Fig. 4). Responses of each person were recorded and further analyzed to explore the difference of response due to varying data availability.

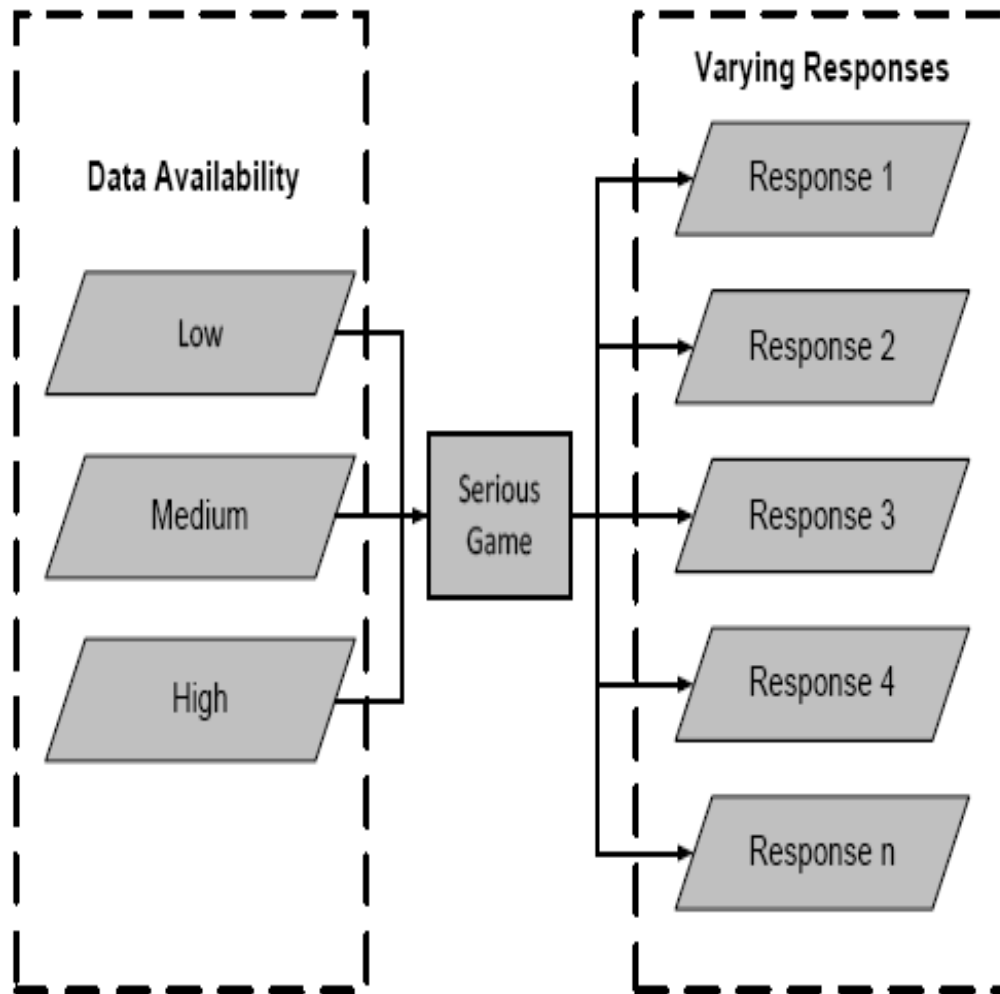


Figure 4. Serious Game Approach

The serious game was developed by combining ArcGIS shape file from many sources such as RBI map scale 1: 250.000 from BAKOSURTANAL, contour map (Scale 1:10.000) provided by Public Works of Surakarta in 1991, fieldwork data from Geographic FKIP Faculty UNS 2008 in [Setiyarso, 2009].

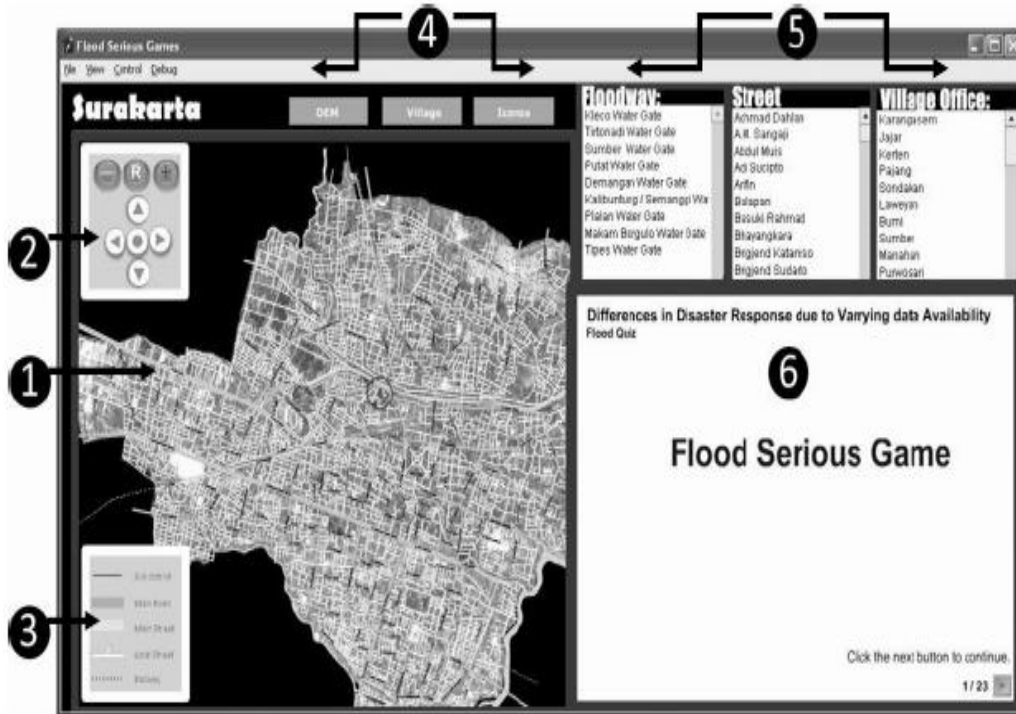


Figure 5. User Interface of Serious Game

Interaction toolbox provided Adobe/Macromedia <http://www.adobe.com> in [Gowin, 2002] combined with idea and technique developed in <http://om4gus.blogspot.com>. Within the serious game, there were six scenarios with three level data availability provided for user:

- a. Difference in disaster response from early warning data.
- b. Difference in disaster response from information during flooding.
- c. Difference in disaster response in quick response to find a location.
- d. Difference in Disaster Response in Flood Alert Stage Decision Making.
- e. Difference in Disaster Response from Digital Elevation Model usability.
- f. Difference in Disaster Response from Damage Prediction information.

The serious game was successfully implemented and record responses from participants from several governmental agencies responsible for flood response. Profile of participants are presented at Table 1.

Table 1. Profile of participants of serious game

Work	Familiar with Surakarta area		Familiar on using Map	
	Yes	No	Yes	No
Public Works				
Bapermas	15	2	10	7
Kesbang Linmas	6	1	3	4
Kesbang Linmas	7	3	4	6
Sub Total	28	6	17	17
Total	34		34	

The recorded responses were then analyzed in statistical approach to draw conclusion. Several aspects being studied were:

- a. Maximum response selected for detemining the biggest number of selected response from the player.
- b. Minimum response selected for detemining the smallest number of selected response fro the player.
- c. Stay the same response is the non changing response for different data availability.
- d. Changing response is the changing response for different data availability
- e. Cross tabulation : is a joint frequency distribution of cases based on two or more categorical variables.
- f. Chi Square analysis : test is used to determine whether there is a significant difference between the expected frequencies and the observed frequencies in one or more categories.

The public works response could be influenced by other factor besides data availability. The level of development, the local capacity of flood defense unit and structural organization arrangement can also affecting the effectiveness of flood response. It is important to determine the effect of spatial information especially in disaster management information among others causes. Due to this issue, this research aims to determine the correlation of varying of data and information to disaster response activity. More specifically, the main objectives of this research are: (i) to determine what, when, and where information is useful for the Public Works Unit of Surakarta to assist in the response phase of the flood risk-management cycle and, (ii) to identify the key elements in decision making for a given task through the implementation of a serious game to test the disaster response decision.

## RESULT AND DISCUSSION

Analysis of the recorded responses of participants has shown some result as highlighted below.

### Content of information (When, Where, Why) the flooding happening

Hierarchy of preferred content of information from the most important to the least important are time content (when), spatial content (where) and causal content (why), as shown at Fig. 6.

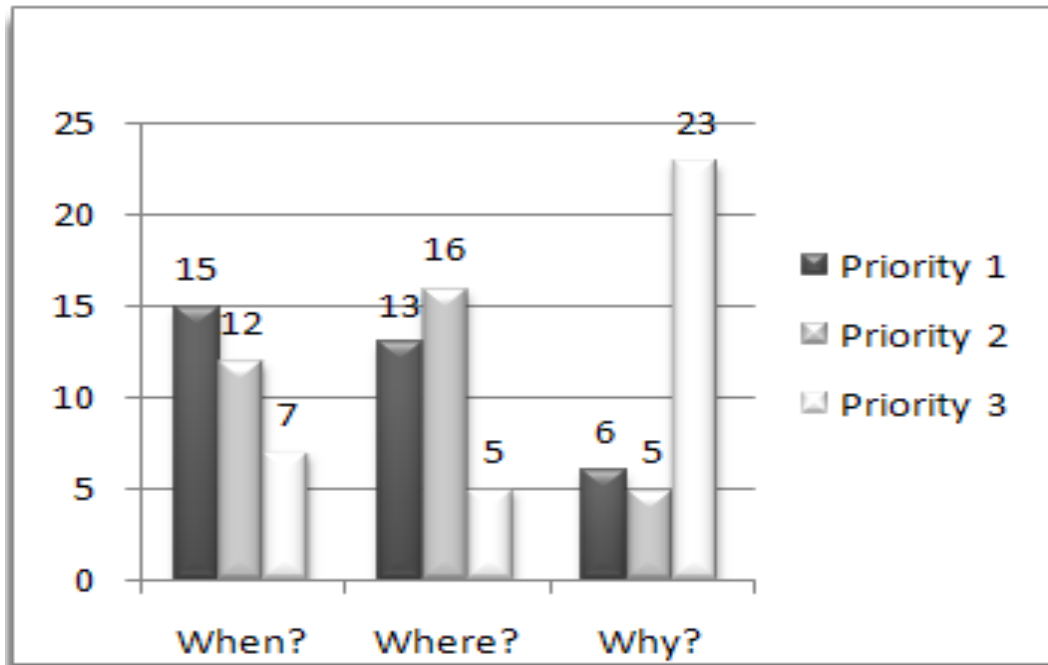


Figure 6. Priority content of flood information

### Method for Locating Incidents and address (Street Name, Map, Village)

Order of preferred method for locating incidents and addresses, arranged from the most preferred to the least preferred are (i) using village name and prominent building, (ii) using map, and (iii) using street name and number, as shown at Fig. 7.



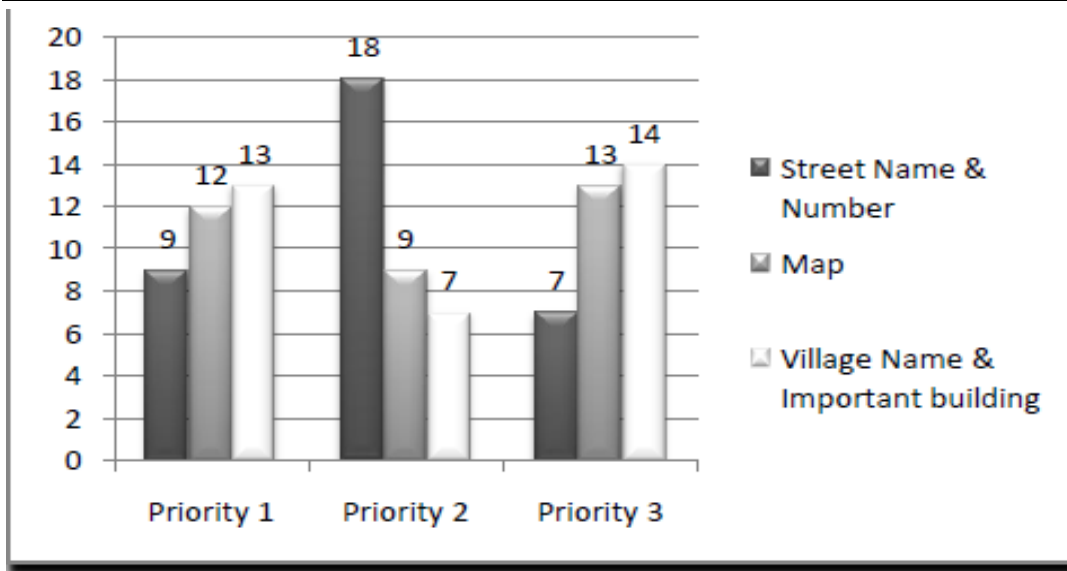


Figure 7. Response on preferred method for locating incidents and address

#### Difference in disaster response from early warning data

As shown by Table 2, at low availability, most participants ask for more information (28 of 66 ~ 42,42%); at medium availability, response is directed to go to flood post (23 of 78 ~ 29,49 %); while at high availability, most participants (27 of 89 ~ 30,34%) confidently taking action: prepare sand bag and water pump.

Table 2. Difference in disaster response from early warning data

		Data Availability		
		Low	Medium	High
Ask for more information	Response 1	28	19	14
Go to flood post	Response 2	22	23	12
Prepare sand bag and water pump	Response 3	6	16	27
Repair flood infrastructure	Response 4	6	2	19
Issue a flood warning	Response 5	4	18	17
Total Response	66	78	89	

#### Difference in disaster response from information during flooding “Flood Extent and Magnitude”

As shown at Table 3, the response is change as data availability vary. Most respondents ask for more information at low data availability; at medium level, most respondents opt to begin evacuation; at high level, option for evacuation were selected by most respondent with larger constituent than those at medium level.

Table 3. Summary of response taken during flooding

		Low	Medium	High
Ask for more information	Response 1	28	19	14
Go to flood post	Response 2	22	23	12
Prepare sand bag and water pump	Response 3	6	16	27
Repair flood infrastructure	Response 4	6	2	19
Issue a flood warning	Response 5	4	18	17
Total Response	66	78	89	

**Difference in disaster response in quick response to find a location**

As shown at Fig. 8, the influence of data availability is clear, more data improve the accuracy of response to find a location. At low level, less than half respondent found a location correctly, at medium level, approximately 90% found correct location; at high data availability, all respondent found the site correctly.

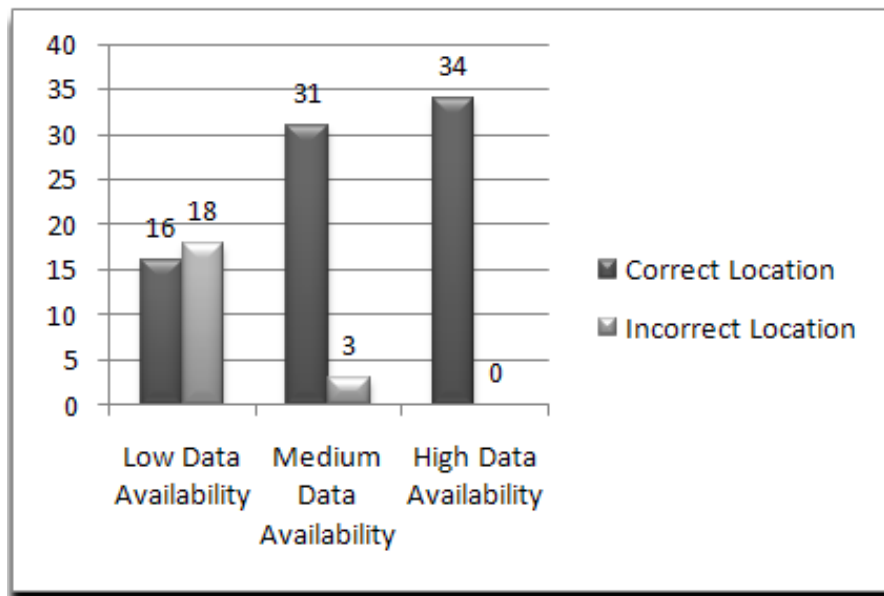


Figure 8. Summary of responses to find a location

**Difference in Disaster Response in Flood Alert Stage Decision Making**

As shown at Table 4, at minimal data level, only with information of water height, only 35% respondent took correct decision. With additional data, number of correct response increase to 88%. When supply with damage report showing condition of levee, the correct response are 62%.

Table 4. Alert stage responses

	Additional Data & Scenario		
	Water Height Level	Flood Alert Procedure	Demage Report
Correct Decision	12	30	21
Incorect Decision	22	4	13
Total	34	34	34

### Difference in Disaster Response from Digital Elevation Model usability

As shown at Fig. 9, the usability of DEM is justified. More data availability increase the correctness of response, from 76% at Low to 97% at high.

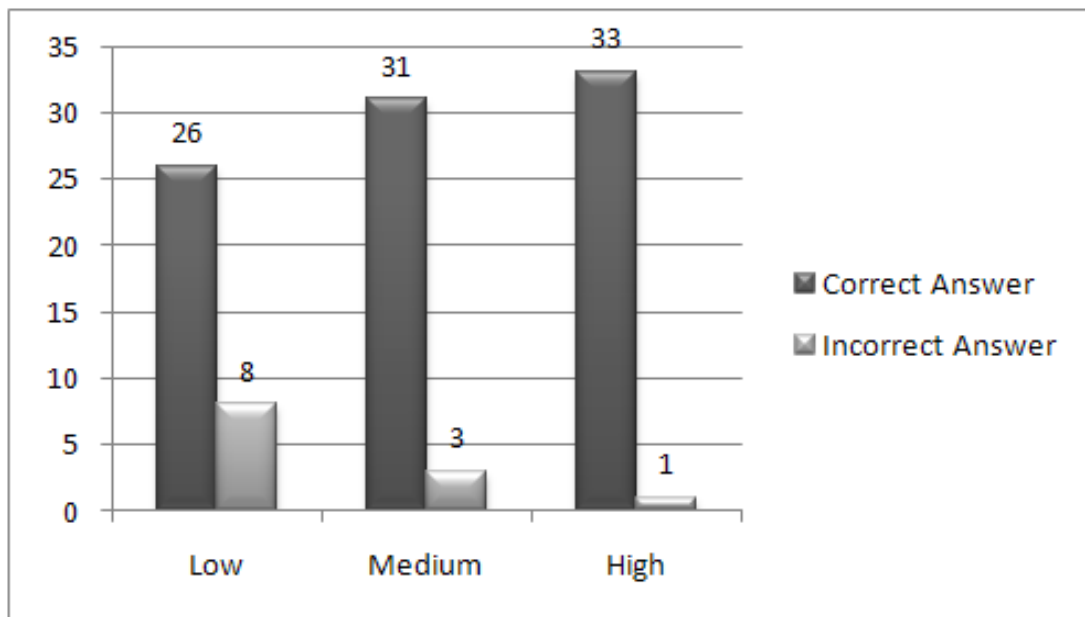


Figure 9. Summary responses of DEM Usability

### Difference in Disaster Response from Damage Prediction information

As shown at Fig.10, increased on data availability resulted on increased accuracy of responses, from 26% at low to 71% at high data availability.

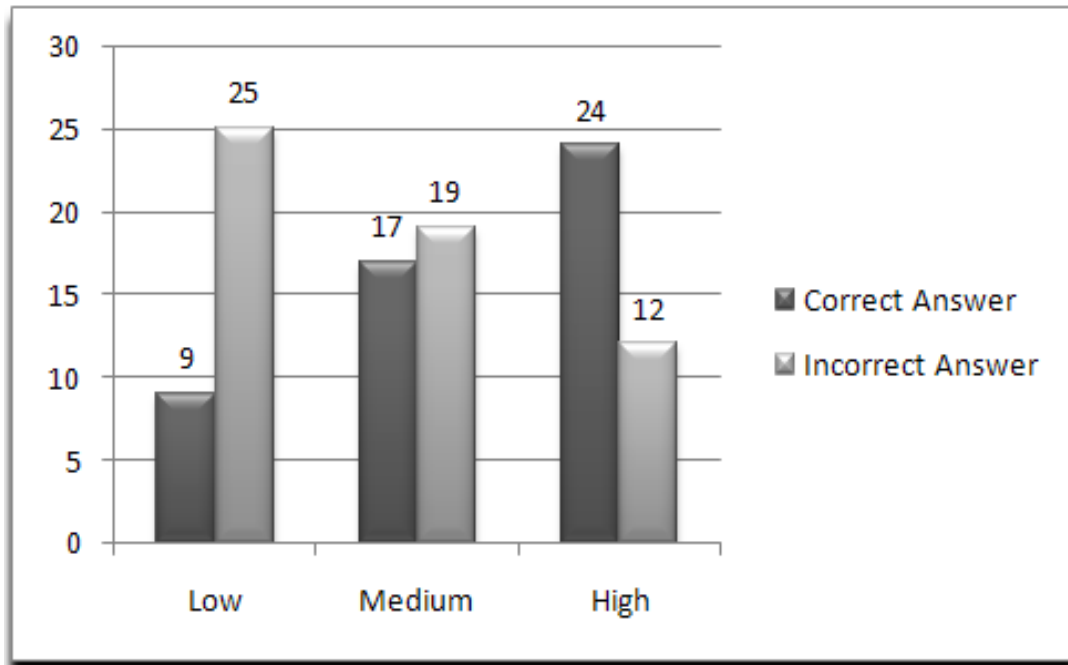


Figure 10. Summary responses from damage prediction information

## CONCLUSION

Several conclusions can be drawn from the experimental flood serious game:

- a. The more accurate data and its completeness can help decision maker produce more accurate decision and confident action.
- b. To address specific issues during disaster, it is important to adopt one procedure and common term to avoid miss interpretation about data and disaster situation.
- c. Specific information can lead to specific decisions, which produce effective and efficient response.
- d. Geographical information could give benefit if it provided in time when it needed and used by the capable decision maker.
- e. Some data continuously needed during disaster and some data only needed once.
- f. Several data need to simplify before it delivered to the decision maker.
- g. Type of information can influence decision maker although it contain the same information.

The result of analysis has shown that there are differences of responses based on the data availability:

- a. For early information (see table 2), at low availability, the decision makers ask for more information (28 of 66 ~ 42,42%); at medium availability, response is directed to go to flood post (23 of 78 ~ 29,49 %); while at high availability, most decision makers (27 of 89 ~ 30,34%) confidently taking action: prepare sand bag and water pump
- b. For Flood extent and magnitude, better responses can be achieved by the improvement of data availability. Number of correct decision raised significantly by the improvement of data availability: 47,06% at low availability, 91,17% at medium availability, 100% at high data availability (see Table 3). Results presented at table 34 and table 37 provide similar conclusion.

### RECOMMENDATION

To provide effective flood information for response action the recommendations to the Public Works of Surakarta are:

- a. To make a standard protocol and format for flood information inside of each institution and among institution.
- b. The procedure should provide standard minimal information in timely manner.
- c. When using spatial data, there should be only one base data used in the common operation.
- d. Combination of radio communication, printed document and spatial data needed to enhance response action

For serious game development, researcher suggests several points to consider:

To make a serious gaming could be done in various platforms. The realistic scenario and good preparation of visualization data would determine its performance. The other factor is how the player interact with the game environment is also important.

Multi disciplinary approaches are needed to make a good serious game for simulating the real world phenomena. GIS professional, computer programmer, disaster manager and information analyst experts are needed in a team to make a good serious game. GIS professional is responsible for providing a good spatial data with adequate accuracy, Disaster manager and information analysts needed to determine what information needed and creating scenario for the serious game while the Computer programmer implement the data and the scenario in a chosen platform e.g. Flash, Java, Ajax, C and others.

## REFERENCE

- Committee on Planning for Catastrophe (2007), *A Blueprint for Improving Geospatial Data, Tools, and Infrastructure*, National Research Council, *Successful Response Starts with a Map: Improving Geospatial Support for Disaster Management*. Washington, D.C., The National Academy of Sciences.
- Gowin, S. (2002), Using a Macromedia Flash MX quiz template.
- Hayes-Roth, F. (2005), *Model-based Communication Networks and VIRT: Filtering Information by Value to Improve Collaborative Decision-Making*. 10th International Command and Control Research and Technology Symposium: The Future of C2. McLean, VA.
- Langkamp, E. J., L.R. Wentholt., B.E. Pengel., C. Gooijer and J.J. de, Flikweert (2005), *NOAH, the right in-formation at the right time at the right place*. Third International Flood Defence Symposium, Nijmegen, The Netherlands.
- Setiyarso, B. (2009), *Studi Reaksi Manusia Terhadap Bahaya Banjir Kota Surakarta*. Surakarta, Education Science Faculty, Sebelas Maret University.(in bahasa)
- Vreugdenhil, H. (2009), *FLIWAS, the right information at the right place at the right time for the right persons to take the right decision*. Utrech, The Netherlands.
- Warfield, C. (2010), *The Disaster Management Cycle*. Retrieved 28 May 2010, from [http://www.gdrc.org/uem/disasters/1-dm\\_cycle.html](http://www.gdrc.org/uem/disasters/1-dm_cycle.html).