



# International Journal of Disaster Management

ISSN: 2527-4341

## Modeling the Factors Influencing the Adoption of a Map-Based Disaster Application in Indonesia: A Case of SIKK Magelang

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**Abstract**— Indonesia has high exposure to natural hazards and frequent disaster events, which make its population highly vulnerable. Therefore, risk communication and dissemination of disaster information are critical to reducing disaster risks. Various disaster mobile apps (applications) with location-based maps or services are available to facilitate risk communication to the wider community; however, availability does not automatically translate into use or adoption. Therefore, to understand the factors influencing the adoption of a map-based disaster app, this study, through the theoretical lenses of a combined information system (IS) success model, examined factors influencing the adoption of a local government-initiated map-based disaster app in Indonesia. The app was *Sistem Informasi Kebencanaan Kabupaten Magelang* or Disaster Information System of Magelang Regency (SIKK Magelang). Partial Least Squared – Structural Equation Modelling (PLS-SEM), with the help of Smart-PLS, was used to examine the hypothesized relationships among the proposed constructs (latent variables). Nine exogenous latent variables were proposed as the antecedents of intention to use a map-based disaster application (the endogenous latent variable), including information quality, system quality, familiarity with online maps, perceived usefulness, user satisfaction, facilitating conditions, risk perceptions, information-seeking behavior, and perceived quality of the Internet connection. Information-seeking behavior was also predicted to be influenced by risk perception. A questionnaire survey with an app trial was conducted in Magelang Regency for data collection. The study results confirmed the applicability of the combined IS success model frameworks in predicting the public's adoption of this map-based disaster app. Although new constructs representing disaster-related online maps and familiarity with those maps were initially proposed in the contextual model, the model validation results showed that intention to use SIKK Magelang was significantly influenced by perceived usefulness and user satisfaction. Practically, this study's results offer guidance to the local emergency managers in Indonesia, especially Magelang Regency, regarding developing strategies to increase the app's adoption.

**Keywords**— *factors, adoption, SIKK Magelang, map-based disaster application, Indonesia*

### INTRODUCTION

In recent years, the apps (applications) built for disaster purposes have become increasingly available in the market. These apps completed with various features were made to facilitate risk communication to the public and enrich situation awareness (Tan et al., 2017). Disaster apps with place-based capabilities and map-based disaster apps developed for information dissemination, emergency preparedness, and disaster response are becoming popular among the general public (Meechang, Leelawat, Tang, & Kodaka, 2020; Tan et al., 2017; Thomas, 2018). A disaster app's spatial features, or location-based services, are crucial because disasters have strong spatial and temporal elements (Dransch et al., 2010). The location-based services embedded in various apps have made it possible for a mobile device (i.e., a smartphone or a tablet) to perform a variety of place-based disaster management and disaster-support functions, such as assisting a person's routing for evacuation based on traffic flow or conveying place-specific weather warnings (Thomas, 2018).

The availability of technology does not automatically translate to sustainable use. When the government launches a new application to disseminate disaster information, its success depends on citizens' acceptance of the new tool and intended use. Lack of adoption and limited use can render the apps become useless (Hoehle & Venkatesh, 2015). As proven in many prior studies (e.g., W. DeLone & McLean, 2003; N. Rana et al., 2019; N. P. Rana et al., 2013), system-related variables (e.g., information quality and system quality) are not the only factors that motivate the adoption of technology; driving forces for adoption also include user-related variables (e.g., awareness, perceived usefulness, technological competence, risk perceptions, self-efficacy, and trust in the government) (e.g., H. Park & Lee, 2018; N. Rana, Dwivedi, Percy, & Williams, 2014; Shareef, Dwivedi, Stamati, & Williams, 2014; Shareef, Kumar, Kumar, & Dwivedi, 2011; Susanto & Goodwin, 2010). Specifically, for the case of disaster apps, risk perception may also influence usage intention (e.g., Fischer, Putzke-Hattori, & Fischbach (2019)).

Furthermore, in the context of disaster apps, user behavior towards the apps may also be different compared to behavior with regular apps for daily use (e.g., social media apps). Disaster apps may be used less regularly (Reuter et al., 2017). Moreover, when used, the users may be in high-risk situations. These apps may be used only for critical situations; hence, the impression of usability at initial use may impact users' decision to keep or abandon the app (Tan et al., 2018).

The adoption of disaster-related apps and technology has been a focus of several previous studies (e.g., Appleby-Arnold, Brockdorff, Fallou, & Bossu, 2019; Cheng & Mitomo, 2017; Liu et al., 2017; Sarshar, Nunavath, & Radianti, 2015; Tan et al., 2018). Remarkably, although most disaster apps available (e.g., InaRisk Personal, Magma Indonesia, and SIKK Magelang [Indonesia], VicEmergency [Australia], or Cmap, Nerv, and HazardOn [Japan]) have been equipped or were built based on location-based services or maps, map-use related factors have been largely ignored in existing studies on disaster applications. Thus, due to the scant literature on the adoption of map-based disaster apps, the aim was to provide comprehensive insights into citizens' acceptance and use intention of a map-based e-government app by addressing the following research questions. (1) What factors influence the adoption of a map-based disaster app? (2) Do factors related to map-use affect intention to use a map-based disaster app?

To answer the questions, factors were examined that affect the adoption of a local government-initiated map-based disaster app in Indonesia, namely *Sistem Informasi Kebencanaan Kabupaten Magelang*, or Disaster Information System of Magelang Regency (SIKK Magelang), through the theoretical lenses of a combined information system (IS) success model with a Partial Least Squared – Structural Equation Modelling (PLS-SEM) approach. Theoretically, this exploratory study extends the model used in a study done by Rana et al. (2014) to the domain of map-mediated disaster risk communication by considering predisposing factors, risk-related perceptions, and map-related self-efficacy. Rana et al.'s study was developed from Seddon's (1997) version of DeLone and McLean's (1992, 2003) Information System (IS) Success Model.

## LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

The government's role is critical in communicating the risks of hazards and disasters. Risk and hazard communication aim to inform people of potential dangers, predictions of future events, and technical information

regarding how dangerous risks could be and what to do if they occur (Rogers, 2020). Social media and other new communication technologies, along with location-based services, now facilitate the rapid delivery of information, real-time interaction, and place-based knowledge generation (H. Park & Lee, 2018; Thomas, 2018). Accordingly, governments (including governments at the local level) are working towards developing apps specifically for disaster-management purposes or dissemination of information of disasters to the public. The greater availability and affordability of geographic information systems and technology, including digital and interactive maps, have enhanced apps with place-based capabilities. Namely, such apps allow users to increase their hazard risk awareness in a spatial context; to explore and query complex hazard and risk databases efficiently; to read and interact with maps easily, even during disasters and emergencies; and to pinpoint disaster-related locations to make more accurate decisions (Kawasaki et al., 2013; Thomas, 2018). The map-based disaster app that is the focus of this study offers these advantages.

A government-initiated map-based disaster app is a blend of e-government services, a built-for-disaster-purpose app, and a map service. Thus, this study assumed that factors influencing the adoption of this type of app are composed of the determinants of adopting e-government services (especially mobile e-government), disaster apps, and factors influencing map usability.

Among the prominent technology adoption models used in the context of e-government and mobile apps, the IS success model (W. H. DeLone & McLean, 1992; W. DeLone & McLean, 2003) was used, particularly its extended version developed by Rana et al. (2014), as the main base theory. The IS success model, which allows for the modification of constructs, was built exclusively for understanding the use of information technology (Urbach & Müller, 2012). It was selected for the following reasons. First, the model applies “intention to use” instead of “use” as the dependent variable, which suits the context of this study, which focused on examining a service or an information system from the perspective of potential adopters (not actual users) who have been exposed to how the system works and its benefits. Second, the model excludes the service quality construct, which also suits this study’s focus on a specific app. Service quality is concerned with measuring the quality of a service obtained by an IT department rather than the service of specific IT applications. Finally, the model includes perceived usefulness. The inclusion of perceived usefulness in this extended IS success model was based on Seddon and Kiew’s (1996), and Seddon’s (1997) criticism of the original IS success model of DeLone and McLean, which included perceived usefulness as an IS measure that influences user satisfaction. They conjectured that the underlying information system success construct is usefulness, not use. This notion is equivalent to the construct called perceived usefulness from the Technology Acceptance Model (TAM) (Davis, 1989). This construct posits that the user’s behavioral intention is the single best predictor of actual system use determined by two particular beliefs: perceived usefulness and ease of use.

The extended version of the IS success model was developed from three constructs (perceived usefulness, information quality, and system quality) to examine two dependent variables (intention to use and user satisfaction) with eight hypotheses. These variables and hypotheses were first adapted to the context. Intention to use is defined as the degree to which people are likely to use SIKK Magelang. User satisfaction represents the feelings and attitudes that emerge after aggregating all the benefits that a person expects to receive from the app. User satisfaction is the citizens’ ability to use the app to get the information they require and to address their

concerns (Wirtz & Kurtz, 2016). System quality is concerned with whether there are “bugs” in SIKK Magelang, the user interface’s consistency, ease of use, and sometimes the program code’s quality and maintainability. In contrast, information quality is concerned with users’ expectations regarding information relevance, timeliness, completeness, trustworthiness, accuracy, understanding, and significance.

Following TAM (Davis, 1989), perceived usefulness is a perceptual indicator of the degree to which one believes that using a particular system or service has enhanced their job performance. In this study, perceived usefulness is defined as the degree to which users believe that SIKK Magelang would enhance their knowledge of hazards and evacuation plans and inform about disaster events in the Magelang Regency. A great deal of prior research on e-government has supported the positive relationship between perceived usefulness and behavioral intention to use. For the context of mobile map services adoption, perceived usefulness was also found significant as a driver of intention to use (E. Park & Ohm, 2014). Based on this primary foundation model, the following is hypothesized:

- H1: System quality will have a significant and positive relationship with the perceived usefulness of SIKK Magelang.*
- H2: System quality will have a significant and positive relationship with the intention to use SIKK Magelang.*
- H3: System quality will have a significant and positive relationship with user satisfaction with SIKK Magelang.*
- H4: Information quality will have a significant and positive relationship with the perceived usefulness of SIKK Magelang.*
- H5: Information quality will have a significant and positive relationship with the intention to use SIKK Magelang.*
- H6: Information quality will have a significant and positive relationship with user satisfaction with SIKK Magelang.*
- H7: Perceived usefulness will have a significant and positive relationship with the intention to use SIKK Magelang.*
- H8: Perceived usefulness will have a significant and positive relationship with user satisfaction with SIKK Magelang.*

Several prior studies have reported a generally positive relationship between users’ perceived satisfaction and usability of e-government services, information systems, and mobile technologies (e.g., Alawneh, Al-Refai, & Batiha, 2013; E. Park & Ohm, 2014; Wirtz & Kurtz, 2016). Therefore, a ninth hypothesis was added:

- H9: User satisfaction will have a significant and positive relationship with the intention to use SIKK Magelang.*

Many studies have empirically suggested the influence of Internet connection on the acceptance of e-services (e.g., Pikkariainen, Pikkariainen, Karjaluoto, & Pahnla; 2004; Rallis, Chatzoudes, Symeonidis, Aggelidis, & Chatzoglou, 2019; Sathye, 1999; Shareef, Kumar, Kumar, & Dwivedi, 2011). In the case of geographic information, poor Internet connection limits the import and uploading of the data and hinders geo-informatic training via distance learning (Teeuw et al., 2013). Thus, the Internet connection quality is also a vital driving force for the adoption of online maps. Accordingly, the following hypothesis is also added:

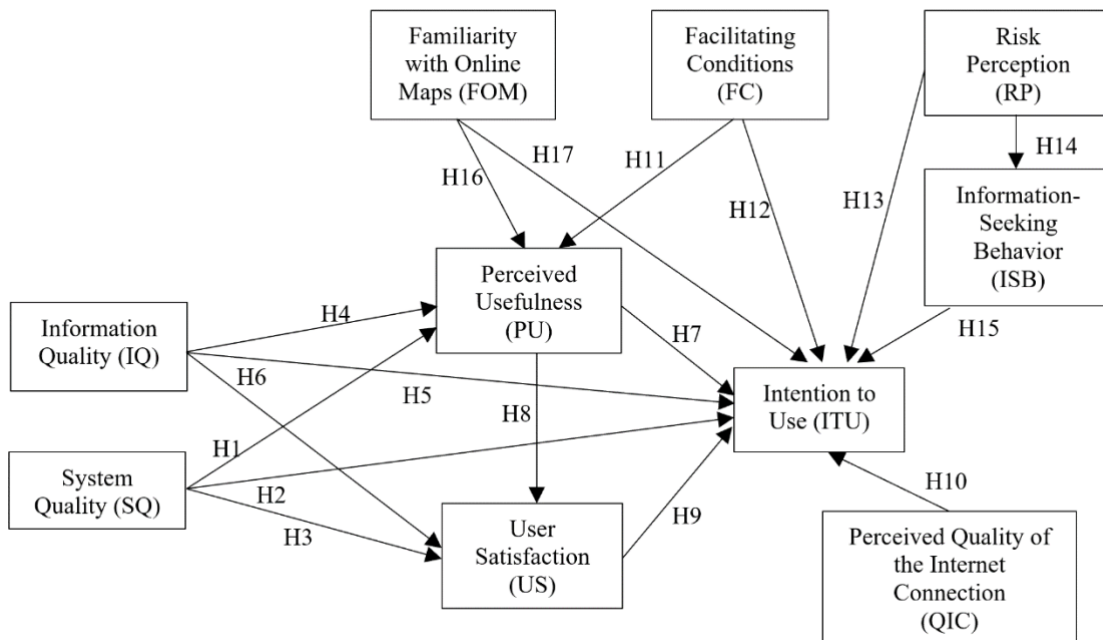
- H10: Quality of the internet connection will have a significant effect on the intention to use SIKK Magelang.*

Among the pronounced challenges that e-government faces are its lower suitability for poor, illiterate, and rural people due to this population's lack of resources and technological literacy (Murenzi & Olivier, 2017; Shareef et al., 2011). Such challenges are evident in developing countries, where resources such as electricity, computers, the Internet, and government support (e.g., via call-centers, resource-centers, or cyber-café) are scarce (Shareef et al., 2011). Hence, facilitating conditions are considered important and crucial. Facilitating conditions are defined as users' perceptions of the resources and support available to help them perform a behavior (Venkatesh et al., 2012). Facilitating conditions are measured by the perception of access to the required resources and knowledge and the necessary support needed to use a service (Al-Shafi & Weerakkody, 2010). The effect of facilitating conditions on the acceptance of e-services in prior literature has been mixed. Several studies have shown that facilitating conditions are insignificant as drivers of usage intention (e.g., Venkatesh, Morris, Davis, & Davis, 2003); however, other studies have shown the opposite (e.g., Dwivedi et al., 2017; Lallmahomed, Lallmahomed, & Lallmahomed, 2017; Verkijika & De Wet, 2018).

Facilitating conditions may also have an impact on perceived usefulness. In the e-learning system context, the information technology infrastructure significantly impacts perceived usefulness (Alsabawy et al., 2016). Thus, assuming the infrastructure is part of facilitating conditions, it can be predicted that facilitating conditions may correlate with perceived usefulness. Thus, the following is hypothesized:

*H11: Facilitating conditions will have a positive and significant effect on the perceived usefulness of SIKK Magelang.*

*H12: Facilitating conditions will have a positive and significant effect on the intention to use SIKK Magelang.*



**Figure 1.** Proposed research model

Risk perception may also be significant as a predictor of usage intention (Fischer et al., 2019). This finding is supported by prior research done by H. Park and Lee (2018), which showed that risk perception, directly and indirectly, influenced one's intention to use an application for risk communication purposes and that risk-related perceptions (including perceived severity, perceived susceptibility, and response efficacy) are antecedents of risk-related information-seeking behavior and subsequently influence whether an individual accepts a new app for risk management developed by the government. Hence:

*H13: Risk perception will have a significant influence on the intention to use SIKK Magelang.*

*H14: Risk perception will have a significant influence on information-seeking behavior.*

*H15: Information-seeking behavior will have a significant effect on the intention to use SIKK Magelang.*

Users' familiarity with similar technology is also crucial when proposing a new technology for disaster-related purposes. Cheng and Mitomo (2017) found that the perceived usefulness of using smart wearable devices for disaster apps was influenced by the perceived usefulness of smart wearable devices (similar technology). In the context of map usability in an e-government app, Bishop, Haggerty, and Richardson (2015) found that although the app was well-understood (practical) and satisfying in its completion of various tasks, users had some issues regarding the efficiency of the app, including users' unfamiliarity with its functionality and features. Therefore:

*H16: Familiarity with online maps will positively and significantly affect the perceived usefulness of SIKK Magelang.*

*H17: Familiarity with online maps will positively and significantly affect the intention to use SIKK Magelang.*

Based on the literature review, a model was proposed to explain the adoption of the app (Figure 1).

## **DATA COLLECTION AND RESEARCH METHOD**

### **Research method**

This research was conducted from December 2019 to January 2020 in Magelang Regency, an area with frequent disaster events, especially volcanic activities and landslides, located in Central Java in Indonesia province (BPBD of Magelang Regency, 2019). The 220 respondents of this study were all citizens of the Magelang Regency who lived in both at-risk and safe areas.

The collected data were compiled and analyzed by using SPSS 27.0 for univariate first-generation analysis. Next, Smart PLS 3.3.0 (Ringle et al., 2015) was used to conduct a second-generation multivariate analysis by applying the PLS-SEM. The PLS-SEM was used because it is a promising methodology of statistical data analysis that integrates regression models with structural equation modeling. PLS-SEM is widely used in information systems, strategic management, and marketing research (Leguina, 2015). PLS-SEM makes practically no assumptions about the underlying data and works proficiently with complex models and small sample sizes (Hair et al., 2017). PLS-SEM was applied to test the proposed research hypotheses, perform path analytic modeling with latent variables, and determine the variables' predictive power. The structural model assessment tested the path coefficients, i.e., direct and indirect effects between latent variables.

## Research setting

SIKK Magelang is a map-based disaster app that comprises various disaster-related maps (risk, hazard, and capacity maps, evacuation plan maps), non-geographical and geographical disaster-related databases, and a list of disaster occurrences in Magelang, including several graphics and photographs (BPBD of Magelang Regency, 2019). SIKK Magelang was initially developed as an internal disaster database intended to help emergency managers, especially those working in the field, to report disasters immediately; however, perceiving its potential to disseminate disaster information and risks, SIKK Magelang was recently made publicly accessible (M. Roychani, personal communication, May 06, 2019). The public can now access it via a desktop version (<https://sikk.bpbdmagelang.id>, previously <http://sikk-bpbdmagelang.info/>) or a mobile phone app (available since 2019).

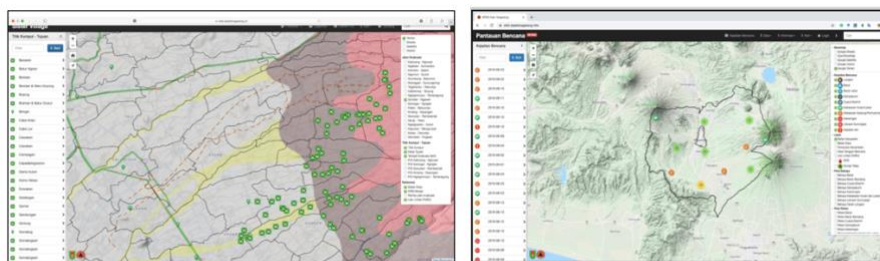
Despite its useful features, as with many e-government services in Indonesia, SIKK Magelang shows a low adoption rate, as indicated by the low and stagnant usage statistics for the desktop version and the small number of downloads of the mobile app. Based on the records obtained from Google Web Analytics, from July 2018 to July 2020, the average number of users per month was 631 with 2,160 sessions. These numbers indicate that on average, each user only accesses it around three times per month. Usage statistics before conducting this study were even lower (247 users/month). With only around 600 users per month, if compared to the population of Magelang Regency itself, including the primarily targeted users, the number of monthly users is less than 0.1% of the population, not including non-resident users. Interestingly, two peaks of users were found in October 2019 and June 2020. During these months, many eruptions of Merapi were recorded. Therefore, SIKK Magelang may have more usage only when a significant disaster event happens.

Figure 2 shows the interfaces of both the desktop and mobile versions of SIKK Magelang. The left picture of Figure 2a, to the left, displays the Sister Village menu, which visualizes an evacuation plan for Mount Merapi's severe future eruptions. This plan includes a visualization of evacuation routes, assembly points, evacuation sites, and evacuation signage. To the right is the *Pantauhan Bencana* (disaster monitoring) interface, which provides users with various hazard and risk maps. It also provides a geographical distribution and other detailed information on disasters in the last 30 days (previously, it showed the last 90 days' disaster events). Two additional features have recently been added: GeoServer allows users to download disaster maps/layers and other attributes, and "Info Corona" shows the geographical distribution of suspected COVID-19 cases in Magelang. Figure 2b shows some interfaces from the mobile version of SIKK Magelang. The mobile version, currently available only on Android, has just around 1,000 downloads. As of October 31, 2020, it has a rating of 4.7/5 with positive reviews from its active users.

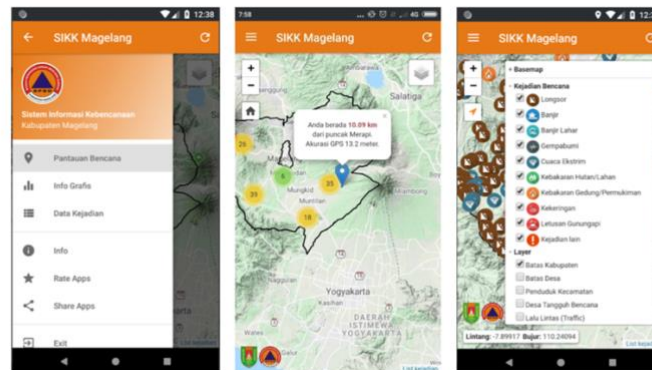
## Measurement

To test the research model, a questionnaire survey was conducted. The constructs were adapted from previous literature to ensure survey content validity. A pretest was used to validate and evaluate the interpretability and clarity of the instrument. The measurement of the constructs involved using multi-item reflective scales, which enhanced confidence that the measurements were consistent.

The key factors related to intention to use SIKK Magelang were captured by information quality, system quality, facilitating conditions, familiarity with online maps, perceived quality of the Internet connection, perceived usefulness, user satisfaction, risk perception, and information-seeking behavior. Each construct was comprised of several items to measure a scale. All measures except the risk perception and information-seeking behavior constructs were assessed via a five-point Likert scale ranging from “1 = strongly disagree” to “5 = strongly agree.” Risk perception items were assessed by a five-point scale from “1,” representing “not probable,” to “5,” representing “very probable.” Information-seeking behavior items were assessed by a five-point Likert scale ranging from “1 = never” to “5 = every time.” Thirty-five items measured ten latent variables in addition to several items to gather background information for the data analysis and model validation (see Appendix). Nine independent variables were proposed as the antecedents of intention to use a map-based disaster application, including information quality, system quality, familiarity with online maps, perceived usefulness, user satisfaction, facilitating conditions, risk perceptions, information-seeking behavior, and perceived quality of the Internet connection. Information-seeking behavior was also predicted to be influenced by risk perception.



2a. Displays of the desktop version of SIKK Magelang



2b. Interfaces of the mobile version of SIKK Magelang

**Figure 2.** Examples of interfaces of SIKK Magelang in both versions

## RESULTS

### Demography of the respondents

There were 220 samples used in this study, which is adequate to perform PLS-SEM because this method works efficiently with small sample sizes (Hair et al., 2017). The average respondent age was 34 years old (the youngest was 13 years old, while the oldest was 65 years old), with men accounting for 52.7% of the sample and women for 47.3%. Over half of the respondents had finished senior high school (51.8%), and 40.9% had monthly incomes of around 2.1 to 5 million rupiahs (equivalent to around 140 to 333 USD). All respondents had experienced disasters, and 90.9% had been victims of disasters, including evacuations during the 2010 Merapi eruption.



Concerning the Merapi volcano risk areas, while 24.5% of the respondents lived in non-volcano risk areas, the rest (75.5%) lived in volcano-risk areas. The vast majority of the respondents owned smartphones (92.3%). Only 7.27% (16 people) had used SIKK Magelang before the survey, which means that almost all respondents were potential adopters, not actual users of SIKK Magelang; however, the model validation included both who had and had not used the app.

### The results of the measurement model

Both convergent and discriminant validities were assessed to test the measurement model. Convergent validity was supported after examining item loadings, Cronbach's alpha, composite reliabilities, and average variance extracted (AVE). Table 1 summarizes the results of the convergent validity and discriminant validity test of the variables used in this study. First, each measurement item should significantly load on its latent construct (Gefen et al., 2000). The resulting factor loadings ranged from 0.774 to 0.975, all of which exceeded the cut-off value of 0.5 recommended by Straub (1989).

**Table 1.** Results of convergent and discriminant validity

Constructs (Latent Variables)	#items	Loadings	$\alpha$	CR	AVE
Facilitating Conditions (FC)	4	0.833 – 0.901	0.898	0.929	0.765
Familiarity with Online Maps (FOM)	2	0.944 – 0.962	0.900	0.952	0.908
Information Quality (IQ)	4	0.909 – 0.935	0.943	0.959	0.855
Information-Seeking Behavior (ISB)	2	0.890 – 0.956	0.836	0.921	0.854
Intention to Use (ITU)	2	0.963 – 0.965	0.925	0.964	0.930
Perceived Usefulness (PU)	5	0.877 – 0.923	0.946	0.959	0.823
Perceived Quality of the Internet Connection (QIC)	2	0.962 – 0.975	0.934	0.968	0.938
Risk Perception (RP)	3	0.774 – 0.899	0.796	0.858	0.669
System Quality (SQ)	5	0.863 – 0.928	0.939	0.953	0.803
User Satisfaction (US)	3	0.928 – 0.953	0.936	0.959	0.887

$\alpha$ : Cronbach's Alpha, CR: Composite Reliability, AVE: Average Variance Extracted, N=220

The measurement model's internal reliability was tested using Cronbach's alpha (Fornell & Larcker, 1981). Cronbach's alpha should be greater than 0.70 to indicate strong reliability of questionnaire content (Nunnally & Bernstein, 1994). The Cronbach's alpha values of all nine variables were found to be higher than 0.70. The smallest was 0.796 for risk perception, indicating the strong reliability of the questionnaire content.

**Table 2.** Correlation Matrix

	FC	FOM	IQ	ISB	ITU	PU	QIC	RP	SQ	US
FC	<b>0.875</b>									
FOM	0.705	<b>0.953</b>								
IQ	0.602	0.622	<b>0.924</b>							
ISB	0.03	0.077	0.059	<b>0.924</b>						
ITU	0.573	0.588	0.827	0.07	<b>0.964</b>					
PU	0.649	0.629	0.873	0.046	0.844	<b>0.907</b>				
QIC	0.502	0.492	0.514	0.164	0.504	0.456	<b>0.968</b>			

<b>RP</b>	0.329	0.194	0.247	0.159	0.191	0.296	0.16	<b>0.818</b>		
<b>SQ</b>	0.691	0.718	0.841	0.076	0.77	0.799	0.618	0.245	<b>0.896</b>	
<b>US</b>	0.586	0.588	0.891	0.042	0.836	0.847	0.503	0.232	0.784	<b>0.942</b>

Notes: The bold values on the diagonal represent the square root of the AVE. Other entries represent intercorrelations of the constructs.

Afterward, the convergent validity of the proposed model was assessed by examining the AVE and the composites' reliability. For composite reliability, 0.6 is the recommended cut-off value (Bagozzi & Yi, 1988). In this study, all composite reliability values exceeded this threshold, ranging from 0.858 (risk perception) to 0.968 (perceived quality of the internet connection) and demonstrating composite reliability. According to several scholars (e.g., Hair Jr., Black, Babin, & Anderson, 2010), AVE values should be greater than 0.5 to validate convergent validity. As shown in Table 1, all AVE values exceeded the recommended threshold value of 0.5, ranging from 0.669 (risk perception) to 0.938 (perceived quality of the internet connection), again demonstrating convergent validity, which means the measures of latent variables are valid. Fornell and Larcker (1981) stated that AVE's square root needs to be higher for this construct than its correlation with other constructs to establish the construct discriminant validity. Table 2 shows the square root of the variance shared between the construct. Its items were greater than the correlations between the construct and any other construct in the model, satisfying the discriminant validity criteria. All diagonal values exceeded the inter-construct correlations, and the results confirmed that the instrument had satisfactory construct validity.

### The results of hypotheses testing

Table 3 summarizes the parameter estimates, significance levels, and hypotheses test results, while Figure 3 illustrates the relationships between the hypothesized variables. Six of the 17 constructs were significantly supported by the results. Perceived information quality positively influenced perceived usefulness (H4) and user satisfaction (H6). Facilitating conditions positively influenced perceived usefulness (H11). In turn, perceived usefulness positively influenced intention to use (H7) and user satisfaction (H8). Finally, user satisfaction positively influenced intention to use (H9). This study failed to significantly support the new proposed constructs (i.e., risk perception and familiarity with maps) as drivers of intention to use. While H8 was found significant at  $p < 0.01$ , the other five hypotheses were found significant at levels of  $p < 0.001$ . Overall, a substantial amount of variance is explained in the dependent variable, i.e., the intention to use SIKK Magelang. Its  $R^2$  value of 0.779 indicates that the nine independent factors predicted a substantial proportion of variance as the larger the  $R^2$ , the more the framework's predictive power (Hair Jr. et al., 2010).

**Table 3.** Hypothesis testing results

H#	Hypothesis	Path coefficient	t-value	p-value	Hypothesis status
H1	SQ → PU	0.112	1.648	0.100	Not supported
H2	SQ → ITU	0.101	1.501	0.134	Not supported
H3	SQ → US	0.060	0.816	0.415	Not supported
<b>H4</b>	<b>IQ → PU</b>	<b>0.675</b>	<b>11.207</b>	<b>0.000</b>	<b>Supported</b>
H5	IQ → ITU	0.081	0.800	0.424	Not supported

Hypothesis	Path	β	t	p	Result
H6	IQ → US	0.602	7.692	0.000	Supported
H7	PU → ITU	0.421	4.244	0.000	Supported
H8	PU → US	0.273	3.369	0.001	Supported
H9	US → ITU	0.319	3.751	0.000	Supported
H10	QIC → ITU	0.061	1.447	0.149	Not supported
H11	FC → PU	0.147	3.663	0.000	Supported
H12	FC → ITU	-0.023	0.549	0.583	Not supported
H13	RP → ITU	-0.059	1.476	0.140	Not supported
H14	RP → ISB	0.159	1.660	0.098	Not supported
H15	ISB → ITU	0.024	0.653	0.514	Not supported
H16	FOM → PU	0.025	0.545	0.586	Not supported
H17	FOM → ITU	0.009	0.186	0.852	Not supported

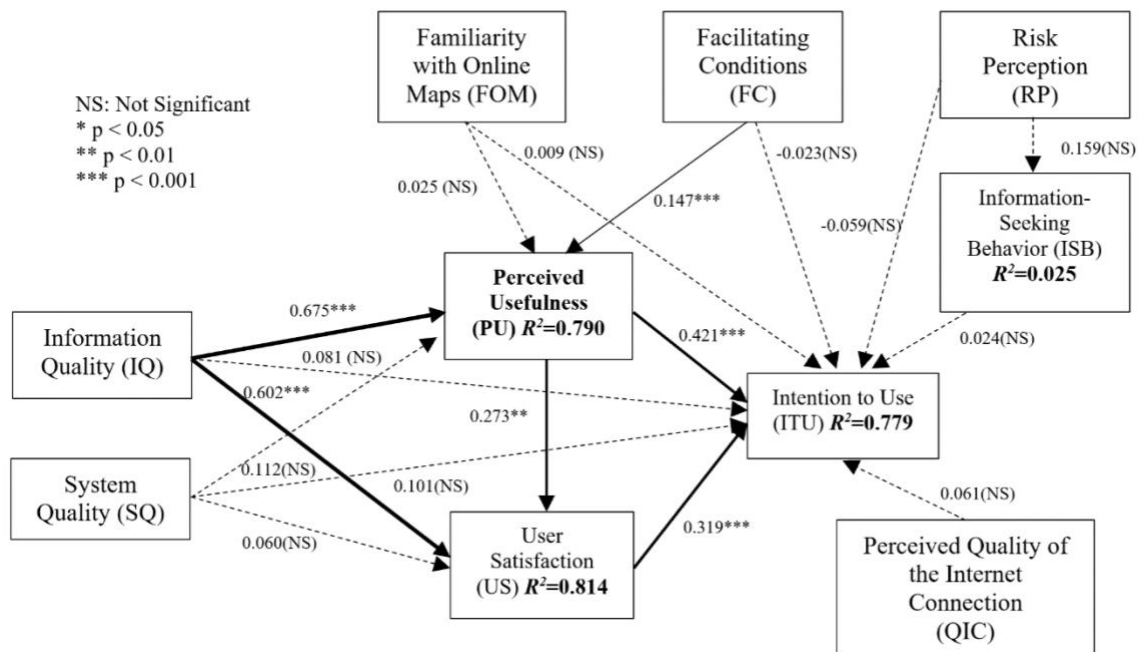


Figure 3. The Validated Model

## DISCUSSION

The extended IS success model (Rana et al., 2014) that was adopted as the main foundation of this study hypothesizes that intention to use is directly influenced by information quality, perceived usefulness, and system quality. However, this study could only significantly prove the direct influence of perceived usefulness on usage intention. While system quality had no significant effect, direct or indirect, on the intention to use, information quality indirectly influenced intention to use via perceived usefulness, user satisfaction, and both (IQ → PU →

ITU was significant at  $p < 0.001$ ,  $IQ \rightarrow US \rightarrow ITU$  was significant at  $p < 0.01$ , and  $IQ \rightarrow PU \rightarrow US \rightarrow ITU$  was significant at  $p < 0.001$ ).

The correlation between perceived usefulness and intention to use was relatively strong, as indicated by the path coefficient value (0.421). It is also evident from the analysis that the app's perceived usefulness led respondents more toward their intention to use it rather than toward being satisfied (as shown by the path coefficients). This finding supports perhaps the most basic notion of technology acceptance; namely, perceived usefulness is the main determinant of technology adoption. This finding also aligns with the many articles that have discussed perceived usefulness as a dimension of disaster risk management technology (e.g., Aloudat et al., 2014; Meechang et al., 2020). When technology makes a task easier for an individual, dependency on the technology will likely take place, and thus usage will be prolonged. This important aspect of perceived usefulness suggests emergency managers should emphasize the usefulness of a disaster app, such as by allowing citizens, especially those who live in high-risk areas, to participate in the app's development and share ideas regarding what information should be included.

When comparing respondents' demography (i.e., gender, age, level of education, and experiences as disaster victims) by performing a multi-group analysis (PLS-MGA), it was found that the relationship between perceived usefulness and intention to use was not sensitive to respondents' characteristics. First, regarding the sex of the respondents, the path coefficient value for females is 0.423, while for males, it is 0.359, indicating the more substantial relationship of PU to ITU for female respondents. Nevertheless, the result of the PLS-MGA showed that these differences were insignificant ( $p = 0.735$ ). Regarding the respondents' educational background, the path coefficient for those who finished elementary school and no formal education cannot be generated. The path coefficient value for those with a degree is 0.503, while for those who only finished junior and senior high school is 0.374 and 0.328, respectively. These figures indicate that those who have higher education than only finishing high school tend to have a more decisive influence of intention to use from perceived usefulness; however, the results of the PLS-MGA showed that these differences were insignificant ( $p$  values  $> 0.10$ ). For age, respondents were regrouped into three groups:  $< 20$  years old, 20-50 years old, and  $> 50$  years old. The path coefficient value for the youngest group is 0.470, for those aged 20-50 years old it is 0.292, and for the oldest group it is 0.368, indicating that the influence of perceived usefulness on the intention to use is biggest for teenagers; however, after performing the PLS-MGA, these differences were not significant. Finally, regarding their experience as victims of disasters, disaster victims' path coefficient is higher than those who were not (0.451 and 0.318, respectively); however, these different coefficients are not significant.

In addition to perceived usefulness, the model also indicates that user satisfaction enhances the intention to use SIKK Magelang. This finding is relevant to the study of E. Park and Ohm (2014), which showed that satisfaction and perceived usefulness are the most significant antecedents of users' intention to use mobile map services. A significant correlation between satisfaction and usage intention has been identified in numerous prior studies on e-government (e.g., Alawneh et al., 2013; Wirtz & Kurtz, 2016) and has been a focus in the improvement of public administrations. User satisfaction is crucial for an e-service developed by governments; to guarantee the adoption and continued usage of e-government, governments must ensure citizens have higher satisfaction levels.

User satisfaction and perceived usefulness were found to be significantly correlated with information quality, a finding that has also been supported by prior literature (e.g., E. Park & Ohm, 2014; Petter, DeLone, & McLean, 2008; Rana et al., 2014; Rana, Dwivedi, & Williams, 2013). Thus, an improvement in the information quality of SIKK Magelang is likely to increase user satisfaction and perceptions of the app's usefulness. The user satisfaction of SIKK Magelang was also influenced by perceived usefulness. This finding is consistent with the base theories and models (Rana et al., 2013, 2014; P. B. Seddon, 1997) and much other literature (e.g., Almarashdeh, 2016; Xu & Du, 2018).

While facilitating conditions are believed to be a direct determinant of the user behavior of adopting new technology (Venkatesh et al., 2012), this study showed that facilitating conditions did not directly contribute to intention to use SIKK Magelang. This finding is nonetheless consistent with Venkatesh et al. (2003). Facilitating conditions had a significant and positive correlation with perceived usefulness. An indirect effect of facilitating conditions on intention was also found. Facilitating conditions affected perceived usefulness before influencing intention to use ( $FC \rightarrow PU \rightarrow ITU$  was significant at  $p < 0.05$ ). Thus, if a country lacks the skills and resources to make e-government available to all citizens equally, the government should not expect the same aptitude from all citizens in adopting the system. In other words, if the digital divide is not reduced first, the adoption of e-government is unlikely to be successful.

While prior literature has suggested a positive correlation between the quality of the Internet connection and intention to use (Pikkarainen et al., 2004; Rallis et al., 2019), an insignificant relationship between these constructs was found. In addition, users' experience with using online maps, such as Google Maps, or their ability to use online maps in general (e.g., to locate themselves) was not significantly correlated with intention to use SIKK Magelang.

## CONCLUSIONS

The adoption of e-government services, including those aimed at disseminating disaster information to the public, is essential. Such technologies help to increase the public's knowledge and awareness of surrounding hazards with up-to-date information. Using the PLS-SEM approach, this research has identified several factors that influence the intention to use SIKK Magelang, a map-based disaster app initiated by a local government agency in Magelang Regency, Indonesia. These factors answered the first research question. Almost all participants were potential adopters because they had never tried the app before the survey. A theoretical model that expands an already extended version of the DeLone and McLean IS success model by incorporating nine variables was validated. This study's findings indicated that intention to use was significantly affected by perceived usefulness and user satisfaction. Perceived information quality was the only factor that significantly influenced perceived usefulness and user satisfaction.

Regarding the second research question, this study could not significantly prove factors related to map use as a determinant of intention to use SIKK Magelang. Although the model cannot significantly prove a more specific disaster- and map-related constructs as determinants of intention to use a map-based disaster app, this study may

contribute to the literature on adopting e-government services to disseminate information about disasters to the public. Thus far, there is a lack of study on the adoption of disaster apps that include map-related constructs.

Future studies could include other variables (e.g., trust in the government or social influence), other theories (e.g., UTAUT or DTPB), or comparisons of different types of apps. It is also expected that future research could compare different groups by user demography (e.g., by age, sex, or education background) or by disaster experiences, because this study failed to confirm the effect of respondents' demographics on the influencing factors of intention to use a map-based disaster app. Understanding the demographic issues will help obtain more specific characteristics of targets for risk communication using this technology.

## ACKNOWLEDGMENT

The authors would like to thank the Disaster Management Agency of Magelang Regency and those who have supported the implementation of this research. The corresponding author would like to acknowledge Pusbindiklatren Bappenas for the opportunity granted as a PHRD IV doctoral program scholarship awardee and the Kokusaiteki Research Fund from Ritsumeikan University for financial support.

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## APPENDIX – Items used in this study

### Intention to Use

ITU2 I am willing to use SIKK Magelang for decision making.

ITU3 I recommend using SIKK Magelang as a source of disaster information to my family members and my friends.

**User Satisfaction**

- US1 I am satisfied with the information and records about disaster occurrences on SIKK Magelang.
- US3 I am satisfied with the assembly points visualization on SIKK Magelang.
- US4 I am satisfied with the information about evacuation routes visualization on SIKK Magelang.

**Perceived Usefulness**

- PU1 I now understand which areas in Magelang Regency frequently see natural disasters.
- PU3 I am now aware of what hazards may threaten the place where I work.
- PU4 I am now aware of what hazards may threaten other places in Magelang Regency.
- PU5 I now understand which nearby assembly points to go to during an emergency.
- PU7 I understand what actions to take during an emergency.

**Information Quality**

- IQ1 The disaster information and maps on SIKK Magelang are useful.
- IQ3 The disaster information and maps on SIKK Magelang are interesting.
- IQ4 The disaster information and maps on SIKK Magelang are complete/comprehensive.
- IQ5 The disaster information and maps on SIKK Magelang are trustworthy.

**System Quality**

- SQ1 SIKK Magelang is easy to access anywhere.
- SQ3 SIKK Magelang is easy to access via any device, including a cellphone or laptop.
- SQ5 SIKK Magelang is reliable as a source of disaster maps.
- SQ8 SIKK Magelang is reliable as a source of evacuation sites.
- SQ9 SIKK Magelang makes it is easier for me to access the necessary disaster information.

**Perceived Quality of the Internet Connection**

- QIC1 The Internet connection and network in this area are good.
- QIC2 Internet connection quality on my devices is good.

**Facilitating Conditions**

- FC1 My devices (cellphone/laptop) are compatible with SIKK Magelang.
- FC2 I use the Internet often.
- FC3 I often look up information via the Internet.
- FC4 I am able to and often communicate using SNSs like WhatsApp/Facebook/Instagram.

**Familiarity with Online Maps**

- FOM2 It is effortless for me to find locations using online maps (e.g., Google Maps).
- FOM3 I use online maps (e.g., Google Maps) often.

**Risk Perception**

- RP2 It is likely that I will die or be injured by natural disasters (either volcanic eruptions, landslides, or any others).
- RP3 It is likely that my family members will die or be injured by natural disasters (either volcanic eruptions, landslides, or any others).
- RP4 It is probable that my house or properties will be damaged because of natural disasters (volcanic eruptions, landslides, or others).

**Information-Seeking Behavior**

- ISB1 I frequently discuss natural disasters and their impacts with my family.
- ISB2 I often discuss natural disasters and their impacts with others (e.g., neighbors).