Development of Unified Framework for Innovative Information Technology Tools Diffusion towards Flood Risk Communication in Sri Lanka

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Abstract: Devastating floods have emerged as one of the mostly occurring and ruthless naturally happening disaster when consider the worldwide situation. Even though the impact of the flood cannot be alleviated completely, the severity of the disruptions could be meritoriously optimized through efficient monitoring systems and effective risk communication. In recent times, risk communication has gained incremental research attention to the more user friendly and more powerful tools for reducing the overwhelming damage for the innocent lives and property. Sri Lanka is treated as a "tropical country" and has an influence of two torrential monsoons is highly susceptible to flooding. However, the recent floods highlighted substantial anomalies in acceptance of flood risk communication tools by citizens which prompted the fundamental inception for this research. This study assesses the influential factors for adoption of innovative Information Technology (IT) tools used by the people faced for floods in Sri Lanka based on three prominent theories in terms of "Diffusion of Innovation Theory", "Protection Motivation Theory" and the "Theory of Planed Behavior". This is accomplished by testing the hypothesis of conceptual model that has created based on the theoretical models and specially the causes and results of affected people's intention about IT tools usage and its applications for flood risk communication. The empirical research deploys a data analysis method as a quantitative technique for checking the validity of the proposed model. Primary data collection was conducted by a questionnaire survey where flood affected community in Sri Lanka was the focus group. "Descriptive statistical analysis" was conducted to ensure the data normality with the help of SPSS 22 statistical software. "Structural Equation Modeling" (SEM) method is used in "Analysis of Moment Structures" (AMOS) software (AMOS 22) on the gathered data for "testing hypotheses". Interesting results were derived through the analysis which reveals usefulness, compatibility, motivation to use innovations and past experience and preparedness behavior are the mostly affected factors of intention to use flood risk communications tools by the flood affected people in the proposed model. Further, as a theoretical contribution, this study reformed some determinants to synchronize with risk communication theory. For instance, the term subjective norms were replaced with motivation capacity while threat and coping appraisal were replaced with direct experience to flood threat and preparedness behaviour. It was also observed that the investigation effect of social media, government website and mobile apps like "DEWN" for flood risk communication and its adoption by flood affected community is poor in Sri Lankan context. In addition, the study highlights that although the use of mobile phone and social media penetration is high in Sri Lanka, the use of such facilities for government administrative purposes especially in emergency management is very poor. One of the prominent observations is that the elderly population is highly reluctant to use new innovations for daily use due to lack of skills and perceived response cost than the young generation. Innovative framework presented in this study gives reliable information about influencing factors for flood risk communication to rearrange and increase the effectiveness of public and private institution services regarding the flood risk communication. In conclusion, this research extends primary contributions in the duality of theory and operationally to expand the knowledge horizons in the area of flood emergency incidents management, explicitly with regard to administrative perspective.

Keywords: Risk Communication, Flood, Diffusion of Innovation, Planned behaviour, protection motivation, IT

Introduction

Disaster is a "serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources" UN [1].Local and global influence of a disaster gives a serious damage to the vulnerable people Chhoun [2]. It is mentioned that the 218 million people were influenced by disaster incidents in worldwide only from 1994 to 2013 Chhoun [2].when consider about the situation in Asia , disasters occurred in the region 2,778 times within this same period, causing major damaging 3.8 billion number of people in the Asia having deaths of 841,000 peoples and therefore the impact of a disaster does not depend on the location, country and its damage chance from one incident to another Chhoun [2].

Floods are considered as the major type of disaster losses and damages compared to all other disasters in worldwide and the people's flood vulnerability facing rate is greater than the population growth in each year Miller et al. [3]. When considering the literature related to flood hazards, Negative impacts of floods have increased in recent years since the increase of population and mainly the climate change and clearing and filling of the lands for various development activities by the people.

Information and communication technology (ICT) and ICT based tools are widely used by the majority among developed countries for effectively manage of the natural hazards and further the ICT includes both traditional tools like radio, television and new emerging tools like internet-based devices like mobile applications, satellite-based GPS receivers, etc. Van Westen [4]. Past studies highlighted that the use of traditional methods are still popular among those floods affected communities than the new tools. When conducting the data gathering of this study in the western side of the country, it was observed that the flood affected people are still waiting and rely on traditional flood risk communication methods like mobile phone calls and passing the flood risk messages through speakers and alarming methods. In a disaster, Communication techniques specially ICT tools are important to reduce the danger or the risk and these techniques are used as a media for communicating the information about danger, thus making it possible to take the necessary precautions to mitigate the impact of these hazards Van Westen [4].it means that the use of those communication methods allows people to prepare for the flood incidents by early information detection and pass the messages more and more within the community and then they can minimize the damage to the people and property.

The proper application of modern information technology (IT) tools can improve the effective flood risk communication Domingo & Rovira [5] and it helps to strengthen the social capital by developing trust among the public Peters et al. [6], raise individual awareness, build positive concern and motivate to adopt preparedness action towards flood hazard Firdhous & Karuratane [7]. presently there is an "increasing trend of using (IT)" tools "for flood risk communication by" the affected communities and in Sri Lanka it was identified that the tools like RiverNet.lk web site and the mobile application of RiverNet usage is high among the people for sharing and receiving flood risk information based on the questionnaire survey. Due to the graphical representation of flood risk levels as minor, moderate and major flood near the river gauge measurement station the flood risk seeking people can estimate the flood level variation near to their surrounding area based on the past experiences as well. This tool is widely used in some areas in the "western province of Sri Lanka" like Kaduwela and Sedawatta where higher population density and building density exists. When consider about "flood risk communication", it includes all methods of communicating between various factors at different scales, which then allows for risk assessment and taking the appropriate measures Schel-faut et al. [8]. Traditionally the risk communication is conducted as a one-way process like the risk information is sent by the government organizations and peoples are only accept that information. When reviewing the literature, it reveals that the beginning of risk communication is one way process and it was slowly transferred to the two-way process where flood affected community also participate for the risk information communication. This study enhances the existing "risk communication" theoretical models by combining factors and testing with the ground data.

Literature Review

There are lots of studies on IT acceptability and adoption, with some focusing on the advantages of "information technology (IT)" use in the "emergency management" profession Jennings et al. [9]. Some scholars have focused on people's motivation and challenging factors influenced for intention to use IT tools for flood risk communication. Some have studied about the advantages of using IT tools for information sharing in government sector. Based on the information of center for Disaster Management (DMC) in Sri Lanka "(http://www.dmc.gov.lk)", it is clear that the number of floods affected population is dramatically increasing yearly and any how there is a problem in controlling the situation by the administrative authorities. The interpolated line shows that this number will reach more than 8 million in 20230 and it will be a serious problem and the government should take immediate actions to control this matter. Most of the researchers mentioned that the problems in management, technical and administration has affected for this matter.

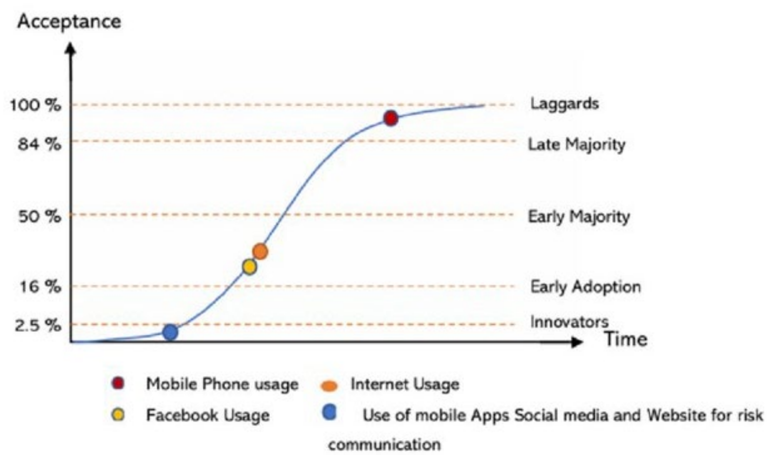

Figure 1: Differences between mobile phone usage and mobile app usage for "risk communication in Sri Lanka"
Source: Compiled by Author

Based on the literature study created "S Curve" by the author in figure 1, it is revealed that the use of SMS alerts in cell phones cell phones, web applications and social media like face book and WhatsApp for risk communication is very low comparative to the mobile phone usage in the "country" Geethalankara [10]. Based on the figure 1 prepared by author it is very clear that the mobile phone usage is majority level in Sri Lanka but the usage of cell phone-based applications for risk communication is very poor in the country. This was found in the literature review of this study and plotting the values with referenced to the S curve developed by Roger in 1962.

Therefore, this study mainly focusses on identifying the influencing factors for acceptance of IT tools used in flood risk communication as matter of social capital development, especially for government and citizen risk communication. This research will follow in a qualitative approach to identify the issues and derive the solutions. Hence the main idea of this descriptive study is to (1) identify "influencing factors" for acceptance or rejection of "IT tools" use in "risk communications" of floods in Sri Lanka (2) to develop a unified framework which will improve the level of acceptance of IT usage in flood risk communication with the support of selected variables in order to derive the administrative solution for mitigate future flood emergencies through effective flood risk communication mechanism.

Materials and Methods

In this part, the data collection technique and methods are described. The development of the conceptual framework has determined in one acceptance models (DOI), one behavioral model (TPB) and one motivation theory (PMT). Even though the DOI has been developed for the general population of technology users, in emergency management research rigorously validated the use of DOI, TPB empirical research. Constructs are selected from the above three theories and fitness of those factors with the data collected from the Sri Lankan "flood affected community" was conducted in this study. The selection of the appropriate factors from the above-mentioned theories and forming the conceptual model is explained as follows.

The following map shows the study area included three areas of interest in this study including Colombo Metropolitan Area (CMA), which comprise Four sub-catchments namely Kolonnawa, Kaduwela and Kotte Saparamadu [11] and Hanwella based on flood map prepared by the survey department of Sri Lanka 2018.

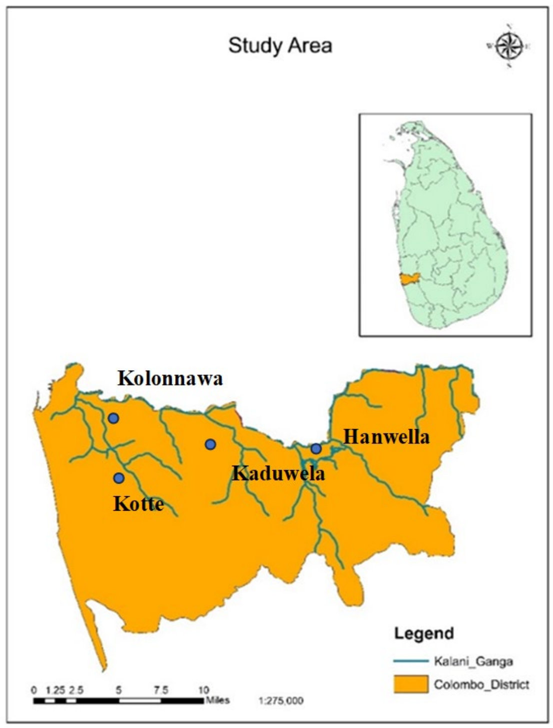

Figure 2 Study area map

When consider about sampling technique, most quantitative approach preferably uses probability sampling technique Adwok [12], because in probability sampling technique it gives equal chance for every member of a population Alvi [13]. This study intends to examine the relationships between selected variables with research objectives so, like many other qualitative studies, in this study, the probability sampling selection process determined by sample size in the study is applied with a small change of applying probability sampling this study used more suitable and organized method as stratified random sampling technique.

There were 42 GN divisions within the main flood affected regions selected as above in Kalani river floods in 2018 major flood incident. The total sample size selected as 400 based on the facts of previous studies in the literature survey where most of the scholars used more than 300 as the sample size for questionnaire survey. Based on the census data 2020, the population ratio is used for selecting the sample for each GN division for data collection.

Sheppard et al. [14] said the effective risk communication depend on a number of guiding theory or models, risk communication approaches demonstrate the complexity of the relationship between a risk message and its impact to preparedness motivation. When intergrade IT and risk communication the relationship will be more complicated. So, this research framework integrated three theoretical models to make simple this complex nature in two aspects (1) risk communication aspect and (2) e-government based technology usage. User acceptance depends on both internal factors and external factors, as Wood et al. [15] mentioned theoretical background like TPB and PMT discussed, individuals' behaviour and it mainly focuses on internal factors. And importantly PMT illustrated an individual's behaviour motivative based on threat or fear to some incident and TPB highlighted an individual's "perceived control" over performing a definite behaviour. Further Featonby [16] summarized TAM rather barriers and motivators, assuming duties as a decision maker, simply on usefulness and ease of use. Further study Venkatesh et al. [17] stated the determinant factors influencing "perceived usefulness", may affect both "perceived utility" and the willingness to use the technology.

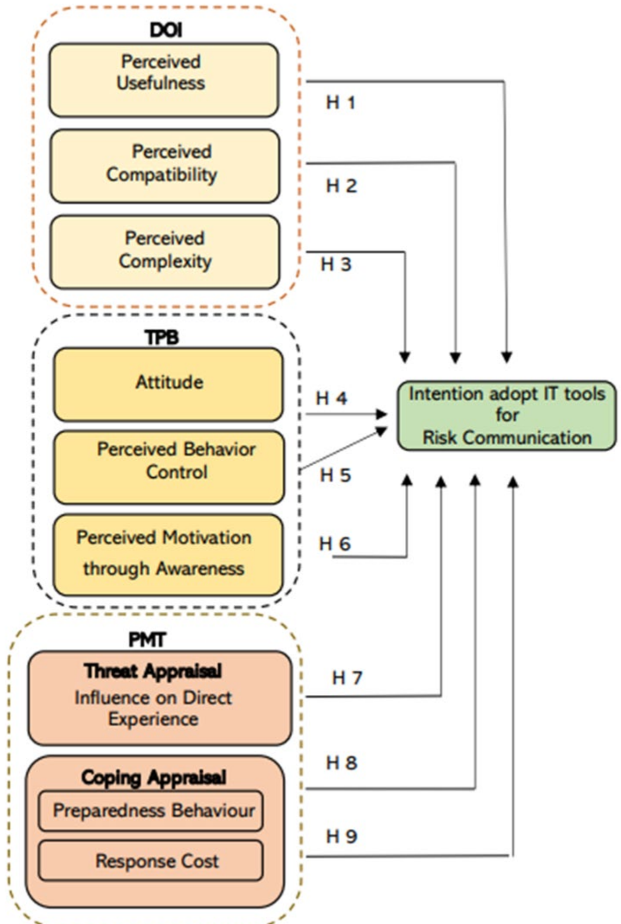

Figure 3 Research Framework

Nine "hypotheses" were tested for getting the influential factors for the acceptance of innovative information technology tools by flood affected people in Sri Lanka. Above figure 3 shows the "hypothesis" which are going to tested and the relationships between the variables as well.

The "quantitative data" collected from a questionnaire survey have loaded to the SPSS software based on the "Likert scale" and the defining of variables. SPSS software is extensively checked and considered by scholars in different research fields "including social sciences". So, SPSS has been used in this study to get the data in order to coding of data, treatment of any incomplete data etc. Apart from that, SPSS also apply to "perform descriptive statistics" like "frequencies, percentages, mean values, and standard deviations". Those analyses were conducted for "each variable" distinctly, to "summarize the demographic details" of the people who answered for the "questionnaire survey" to obtain basic details. Also, prior to applying "SEM (Structural Equation Modeling)", SPSS used to perform "exploratory factor analysis (EFA)" in the first part of data analysis in order to get the main idea from different variables according to research model to the minimum number of items, which is called as “factor/ dimension reduction”. EFA was to outline the connection among the variables and the constructs in the analysis. As mention by Joseph F. Hair et al. [18] EFA considered as “highly useful and powerful multivariate statistical technique for effectively extracting information from large bodies of interrelated data”. To simplify and clarify the relations among those constructs and to determine the data which really measure and what intended to measure is also included in this method.

Then the “Confirmatory Factor Analysis (CFA)” is used to carry out the estimation for the validity of each proposed “measurement model” for the latent construct Karaca et al. [19]. This technique is used to approve the early designed relationships between the items in each sub models and it facilitate to confirm that how well these variables are measuring the relevant factor. CFA is a precursor of “SEM” that specifically combined with “measurement models” and showcase the connection between “observed measures” or indicators and factors or “latent variables”. Based on the above-mentioned methods, the new “model” was developed.

Results and Discussion

Following test is used for calculating the “Sampling Adequacy (MSA)”. The method is a standardized method where the values can range between 0 to 1. It explains about the amount that each variable in a model is predicted without error from other variables in that model.

Table 1: KMO and Bartlett's Test

KMO and Bartlett's Test	Values
Kaiser-Meyer-Olkin Measure of Sampling Adequacy	.826
Bartlett's Test of Sphericity Approx. Chi-Square	9441.853
df	1326
Sig.	.000

Values near to 0 explains that the addition of all partial correlations is greater than the sum correlations and it says that the factor analysis is not satisfactory. If the value is closer to 1 saying that the factor analysis can be conducted based on reliable factors.

The construct perceived usefulness was tested based on four items which were validated in previous studies. Then CFA conducted for checking the appropriateness of these items applied to measure the above construct’s method results shows that these items are good to measure perceived usefulness construct since their standardized regression weights was .790, .763, .780, .632 it was greater than 0.50 and also “squared multiple correlations” was .624, .583, .608, .399 and greater than threshold value (0.30) that verified the “model fit”. The data mentioned above and as shown in figure 8 that the items are selected for measuring the perceived usefulness were identified as more suitable and it was within the limits. For single “construct”, this situation was enough to “confirm” a “satisfactory model fit” as items “loaded satisfactorily” on their relevant “variable or construct”.

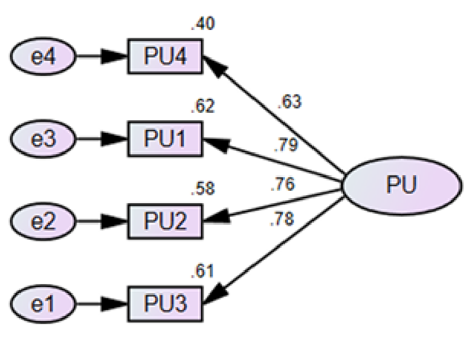

Figure 4 CFA for perceived usefulness

According to the following table 2 it is clear that the all requirements with “factor loadings” and “squared multiple correlations (R^2)” that has a proper fitting and particularly “GFI” (.997), “AGFI” (.983), “RMR” (.008), “CFI” (.999), and “TLI” (.996) and RMSEA (.029) were found within satisfactory range. Hence, this considered as model fit. By concerning the data here no need to run another round of CFA because this is well associate with the model fit.

Table 2 Fit measure values for perceived usefulness

Model Fit (No of round)	“CMIN / DF” (χ 2/df)	“GFI”	“AGFI”	“RMSEA”	“RMR”	“CFI”	“TLI”
1 Round	1.329	0.997	0.983	0.029	0.008	0.999	0.996

“1 round model fit: Chi-square” =2.658 “Degrees of freedom” = 2 p=.265

“CFA” was conducted for all other variables including perceived compatibility, perceived complexity, Perceived Attitude, Perceived Behaviour Control, Perceived Motivation Capacity, Preparedness Behaviour, Direct Flood Experience, Perceived Response Cost and Perceived Intention and they were within the standard levels and fit with the reference values. Similar to the above “variable” other nines were also checked for “CFA” and they were within the required limits.

Here appropriateness of the “measurement model” was tested based on the below mentioned indicators. In order to evaluate the “measurement model”, following techniques were utilized. (1) “Goodness-of- fit (GOF) criteria indices” and (2) Assessing “validity” and “reliability” of the “measurement model”. Many numbers of “fit measures” can be sued to verify and identify at what how far the “hypothetical model” match with the data.

As early illustrated the fundamental aim of “model fit” is to evaluate the “GOF” measurement among the hypothesized “model” and the collected information from the flood affected people. Here, at first, the hypothesized model was prepared and secondly, the collected data was used to evaluate the framework. The “maximum likelihood” (ML) “estimation technique” was used to estimate the “measurement model”. In order to measure the “overall goodness of model fit in CFA”, commonly used eight model-fit parameters taken to the work. Hariri & Roberts [20]; Khater [21] used “CMIND/DF”, “GFI”, “AGFI”, “CFI”, “RMSEA” as measuring parameters. Bodur et al. [22] used these “statistical fit indices” CDMIN/DF, RMSEA, CFI, and GIF to measure model fit. And Hubona & Geitz [23] conceded CDMIN/DF, p-value, GFI, RMR, AGFI as least requirement to assess the model fit. Whereas, Zaidi [24] apart from all measure’s incremental fit measures “TLI” used to “measure the “GOF” of his designed framework. Hence, this study introduced the “absolute fit measures” such as the chi-square test (X^2), the “relative chi-square (CMIN/DF)”, p-value, “Goodness of Fit Index” (GFI), “Root Mean Square of Error Approximation (RMSEA)”, “Root Mean Square Residual (RMR)”. “Incremental fit measures” like “Tucker-Lewis Index (TLI)”, “Comparative Fit Index (CFI)”, and Parsimony fit measures like “Adjusted Goodness of Fit Index (AGFI)” were used to measure “GOI”.

When considering about the “Goodness-of-Fit (GOF) indices” of “proposed framework” of IT innovation adoption for flood risk communication. Figure 5 shows the “proposed measurement model with all constructs” were created with the help of “AMOS” 22 software.

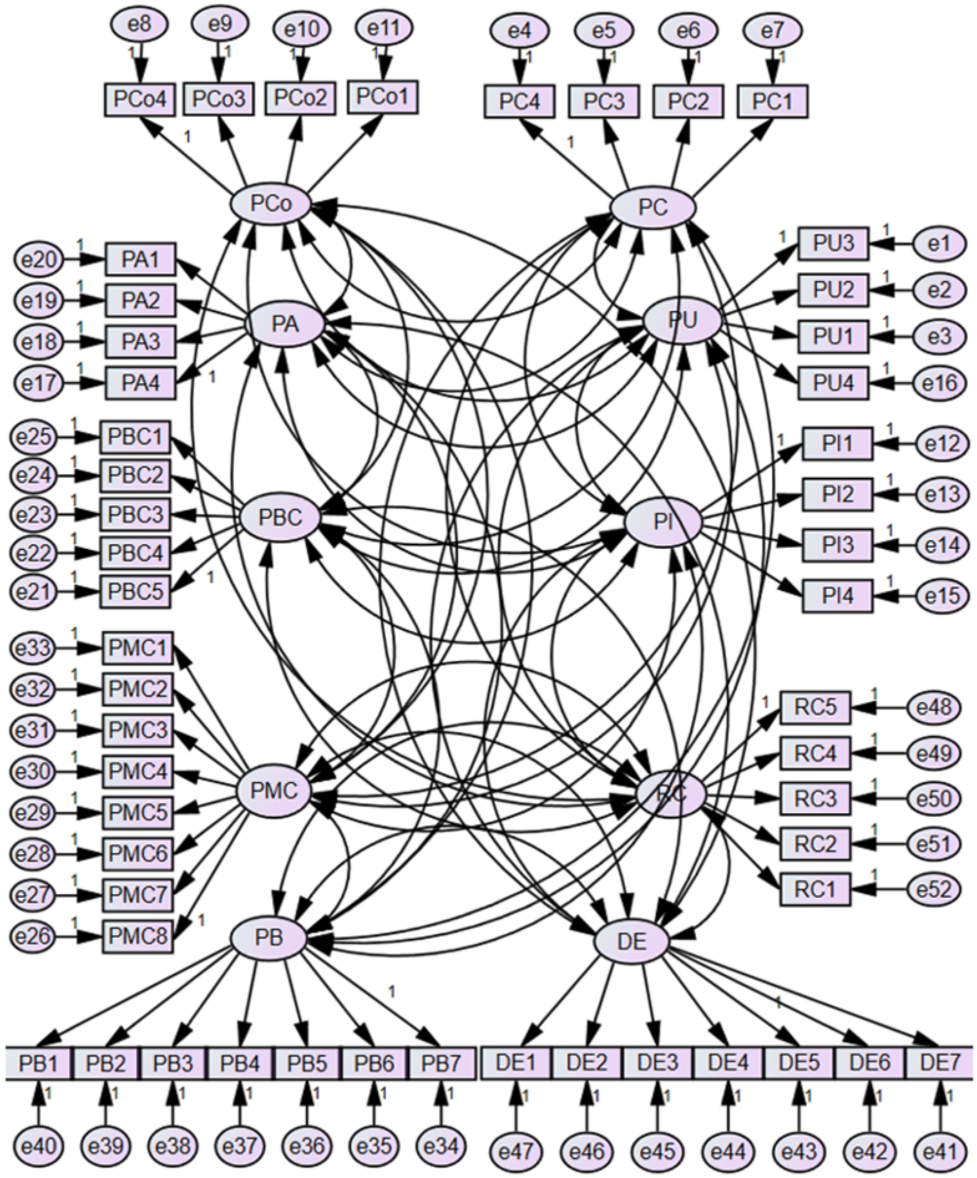

Figure 5. Designed “Measurement model with all constructs in AMOS” 22

The first round of “CFA” was carryout with total of “constructs” shown in (figure 5); “after running” the “first-round simulation, the proposed model” did not satisfactorily “fit the data”. It can see that few “values” which were found moderately low than threshold values. The values that achieved the “overall fit of the model particularly”, “Chi-square” (2152.889), “degree of freedom” (df) (1229), “p” (0.000), “CMIN/DF” (1.752), “RMSEA” (.044), “RMR” (.036), “CFI” (.911), and “TLI” (.904) were able to get within satisfactory range and the values of GFI (.825) 49 and AGFI (.803) 50 showed comparatively “poor model fit”. However, the examination of “maximum likelihood estimates” was identified as within the tolerance limits. The item's value for “standardized regression weights” were observed “more than 0.50” and “squared multiple correlations” found “more than 0.30”. In order to perfect model fit for the next round of simulation was carried out to identify the cause of “poor model fitting”, so, “modification indices” were determined. According to “modification indices” it was found that “some error terms values” were considerably high “(e17, e18), (e19, e20), (e32, e33), (e34, e35), (e38, e39), (e39, e40), (e48, e49),” and “(e51, e52)”. To overcome this problem, “covariance” between “high error terms” were used and the item PMC1 was dropped and second round “simulation” for “model fit” was carried out. The summary of the first stage of “model fit statistics” and “indices” for the “proposed measurement model” are listed in following table 3.

Table 3 Model fit Indices in first round simulation

Model Fit	"CMIN / DF (χ 2/df)"	"GFI"	"AGFI"	"RMSEA"	"RMR"	"CFI"	"TLI"
Values	1.752	0.825	0.803	0.044	0.036	0.911	0.904

Chi-square =2152.889 Degrees of freedom = 1229 p=.000

Description given from the software

"Chi-square (χ2), degree of freedom (df), Normed chi-square or ratio of likelihood (χ2) to df (χ 2/df) < 3 good fit, Goodness of fit index (GFI) ≥ 0.90, Adjusted goodness of fit index AGFI ≥ 0.80 acceptable but ≥ 0.90 considered good fit, Root mean square error of approximation RMSEA <.06, Good model fit, <.08 reasonable fit <.10 Poor fit, Root Means Square Residual RMR < 0.05, Comparative fit index (CFI) ≥ .90 and Tucker–Lewis Index TLI ≥.90"

The measurement model was simulated for second time, third time and lastly for the fourth time and some constructs were removed for the better fit and final fit model is shown in the figure 10. All most all the "criteria that determine the overall model fit" in "fourth round simulation" particularly "Chi-square" (1387.214), "degree of freedom" (1071), p=.000, "CMIN/DF" (1.295), "GFI" (.886), "AGFI" (868), "RMR" (.032), "RMSEA" (.027), "CLI" (.969), and "TLI" (.966) were received within accepted level. Especially "GFI" value can be identified closer to 0.9.

But it was observed that many studies have not given specific margin for GIF value for an example, Khater [21] used 0.836 is good it, Hubona & Geitz [23] considered 0.85 is good fit, Bodur et al. [22] considered 0.871 is good fit and Hariri & Roberts [20] considered 0.88 is good fit likewise it is ranging long spectrum. On the other hand, AGFI (.867) was above the required level (0.8) as many scholars were pointed out (Hariri & Roberts [20]; Zaidi [24]).

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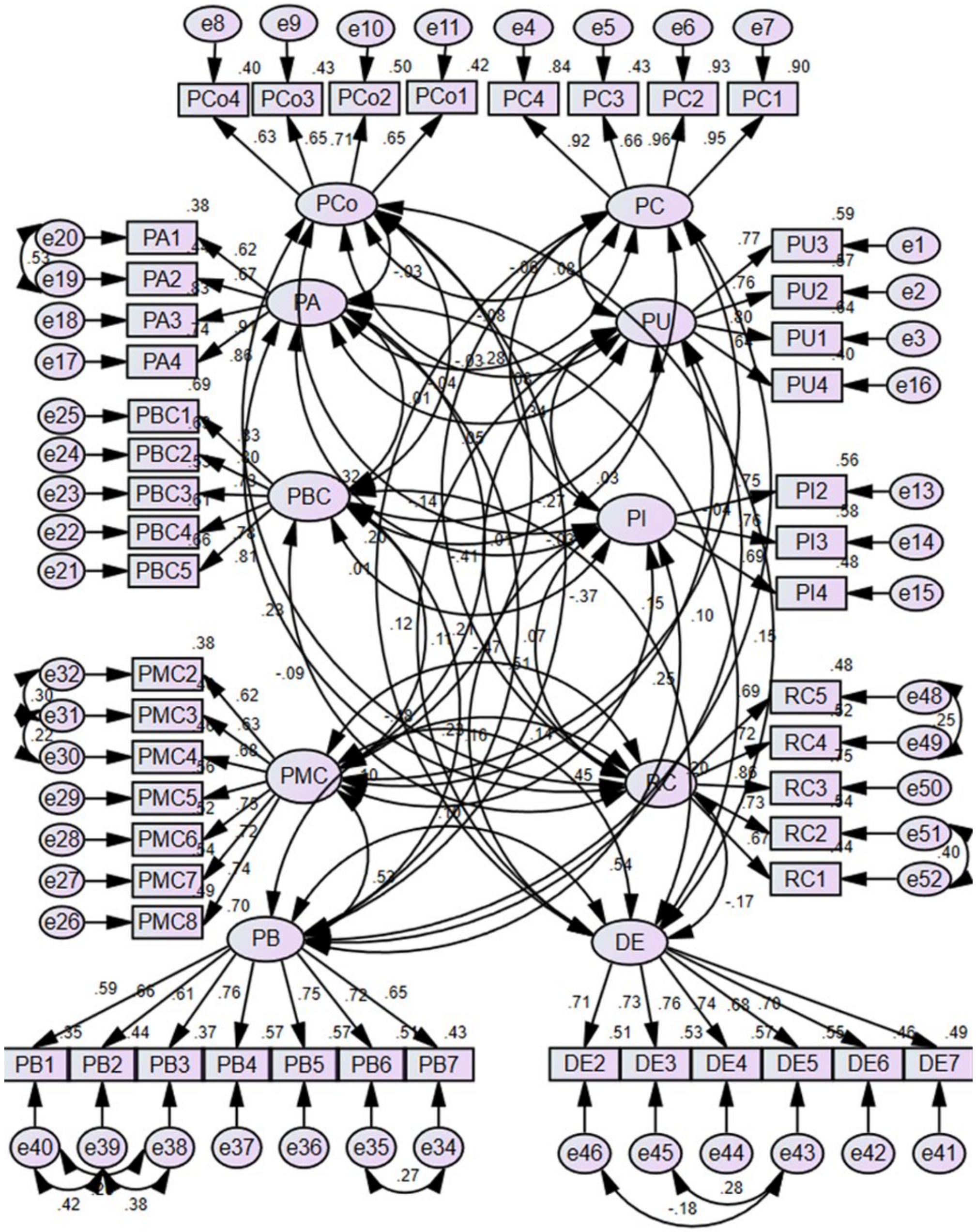

Figure 6. Fourth "round simulation" for the "proposed measurements model"

After forming and "measurement model" was checked for the "model fit" and then it is needed to calculate "construct reliability", "convergent validity" and "discriminant validity" before calculating the "structural model" fit. As Zaidi [24] mentioned "reliability" and "construct validity" are "mandatory validities" for "measurement model fit assessment" process. Consequently, "reliability" and "validity" should be examined for each measure of assessment model and the "measurement model" needs indicate good quality of reliability and validity including "convergent validity" and "discriminant validity".

Generally, "reliability of the construct" is used to measure the "internal consistency" of the "constructs" by utilizing the "Cronbach's Alpha (α)" techniques. The "reliability" belongs to individual "constructs" calculated based on "Cronbach's Alpha (α)" and the "constructs to measure the internal consistency" as well. After measuring the "measurement model" once again "Cronbach's Alpha" test will be conducted by keeping all "items" of "constructs". Table 4 illustrated the results of "Cronbach's alpha values" for each contract after deleting some "items".

“Composite reliability” (C.R) and “Average Variance Extractions (AVE)” were additively used to confirm the “constructs reliability”. As many studies suggested that “conducting the reliability test of constructs” should carry out earlier to the “construct’s validity test” Zaidi [24]. C.R and calculation of AVE are considered as the most common process in “SEM” for examining the reliability. Thus, “Cronbach’s alpha”, the C. R and the AVE were used to calculate the “reliability of the constructs”. C.R should be ≥ 0.70 and the AVE should be ≥ 0.50 Zaidi [24]. According to table 4, it clearly illustrated that all criteria above the threshold values so, it clearly explains high “reliability” and high “internal consistency” in calculating “relationships” within in the framework.

Table 4 Constructs’ reliability data

Constructs	“Average Variance Extracted (AVE)”	“Composite Reliability (C.R)”	Deleted items	“Cronbach’s alpha (α) after deleting of items”
PU	0.662	0.886		0.825
PC	0.819	0.947		0.926
PCo	0.574	0.844		0.795
PA	0.721	0.912		0.871
PBC	0.696	0.919		0.891
PMC	0.529	0.887	PMC1	0.870
PB	0.562	0.899		0.868
DE	0.596	0.899	DE1	0.866
RC	0.622	0.891		0.865
PI	0.659	0.852	PI1	0.776

The formula used for calculating the C.R and AVE are as follows:

$AVE = \sum \lambda^2 / (n)$ ……………………………. Eq. 1

$C.R = (\sum \lambda)^2 / (\sum \lambda)^2 + (\sum \varepsilon)$ ..……………… Eq. 2

Where:

λ - Standardized factor loadings

n - Number of factors loading

ε - Standardized error

In order to test the above mentioned “hypothesis”, “structural model” was examined based on ten “constructs”, which was adopted in “measurement model”. However, during “CFA”, PMC1, DE1 and PI1 were dropped due to weak fitness. During “CFA”, “measurement model constructs” were linked with double headed arrows “covariance”, whereas, in “structural model constructs” were linked with a single headed arrow and it shows the “path relationship” among the “constructs”. In SEM, “structural model” estimated with path coefficient or “regression weights”, “critical ratio (CR) or t-values”, standard errors, and “p-values”. The “Hypothesis testing” was then conducted with the use of analysis software and results were shown in table 5.

Table 5 "Hypotheses testing results of the structural model" from AMOS Software

Hypothesized Path / Relationship			Path Coefficient (β)	Critical Ratio (CR)	P	Hypothesis Supported
PI	<--	PU	0.18	3.047	0.002	Accepted /+
PI	<--	PC	0.21	3.813	***	Accepted /+
PI	<--	PCo	-0.16	-2.531	0.011	Accepted /-
PI	<--	PA	0.16	2.881	0.004	Accepted /+
PI	<--	PBC	0.14	2.484	0.013	Accepted /+
PI	<--	PMC	0.17	2.974	0.003	Accepted /+
PI	<--	PB	0.30	4.793	***	Accepted /+
PI	<--	DE	0.15	2.507	0.012	Accepted /+
PI	<--	RC	-0.24	-3.952	***	Accepted /-

Note

"If $p \leq 0.05$ is significant and *** $p \leq 0.001$, ** $p \leq 0.01$, * $p \leq 0.05$, $CR \geq 1.96$"

Table 5 explains that the tested nine "hypothesis" were accepted and three were "significant" where "P value" is less than 0.001. "Critical Ratio" is also greater than 1.96 for all relationships as well.

Above Figure 3 represents "nine hypothesized paths" and an importantly all were "rightly predicted" and found "statistically significant". It was observed "significant negative correlations" among "perceived complexity" and "perceived intention to adoption innovation" (PCo →PI) and "perceived response cost" and "perceived intention to adoption innovation" (RC→ PI). According to figure 7 with the "factor values", it shows that "perceived usefulness", "perceived compatibility", "perceived complexity", "perceived attitude", "perceived behaviour control", "perceived motivation capacity", "preparedness behaviour", "direct experience to flood threat" and "response cost" has "significant effect" on "innovation adoption for flood risk communication". Significant "hypothesized relationships" were found between all constructs and their "critical ratios" were found >1.96 also "p-values" (***) were found within the accepted level. Hence, the "hypothesized relationships" were significant and confirmed the "proposed hypotheses" H1, H2, H3, H4, H5, H6, H7, H8 and H9. Then the comparison of each "factor" was done since the "factor loadings" are "standardized measures".

With the results, it was confirmed that "perceived usefulness", "perceived compatibility", "perceived complexity", "perceived attitude", "perceived behaviour control", "perceived motivation capacity", "preparedness behaviour", "direct experience to flood threat" and "response cost" has stronger impact on "innovation adoption for flood risk communication" with the "variance" of 0.338, 0.573, 0754, 0.403, 0.358, 0.398, 0.363, 0.379 and 0.373 respectively. This was indicated that above "constructs" have strong antecedents for "innovation adoption for flood risk communication". From the "structural equation model and hypotheses analysis", it is observed that all "hypothesized relationships" are supported by the "empirical data" and confirmed the findings of the proposed study.

Next page

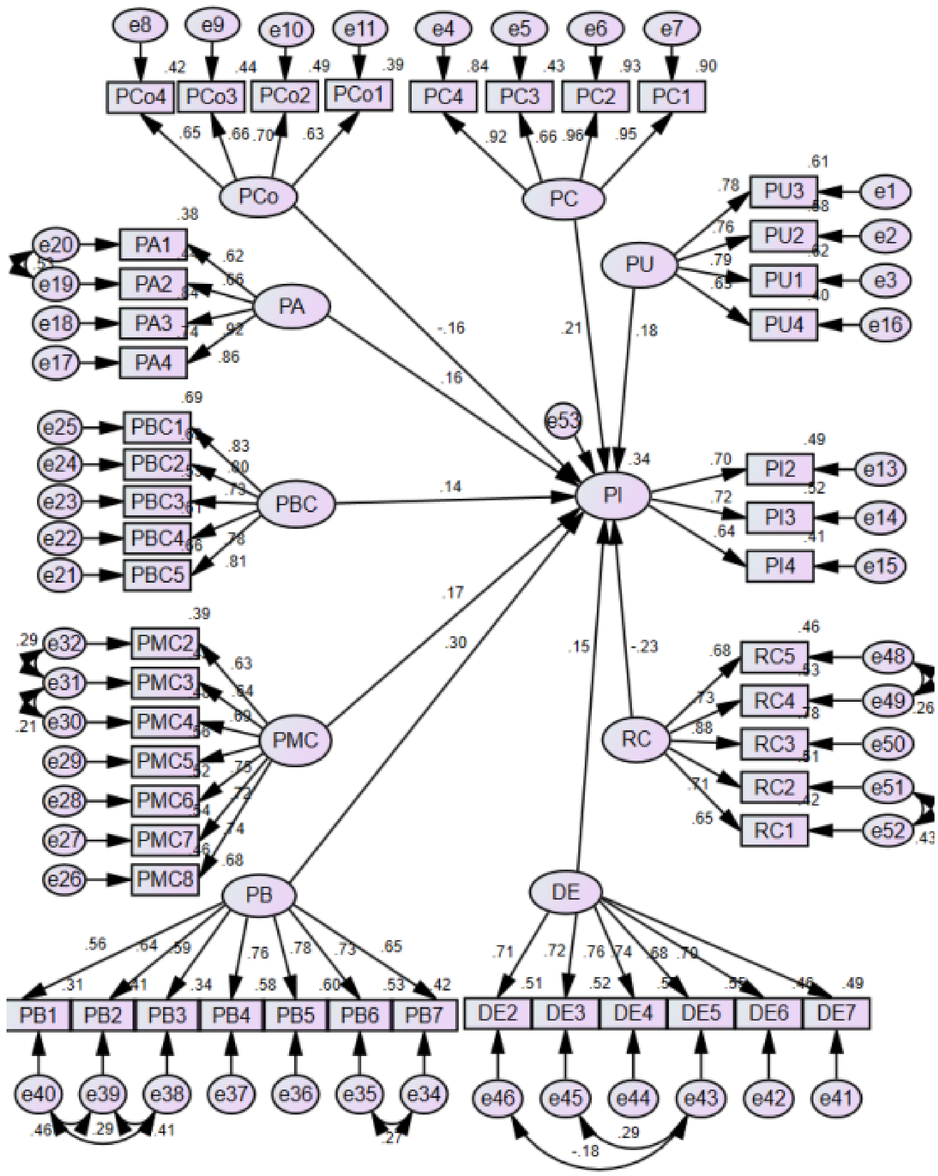

Figure 7. Structural Model with all Constructs

In order to perform the “advanced data analysis”, “SPSS 22 and AMOS 22” software were used. “Descriptive analysis” was carried out using “SPSS 22”. This software was used to check the “data normality”. After testing the “data normality”, the further examination process proceeded towards “advance statistical analysis SEM” using the above stated software.

Within the “Proposed framework’s” and its “constructs” and its “items” were tested using “CFA”. “CFA” was applied to each “individual construct”. Then, the analysis proceeded towards the “assessment of the measurement model fit”. Four times of “simulations” were conducted to “confirm the measurement model” as the “model fit”. Next “discriminant validity” and “convergent validity” test was conducted to identify “constructs reliability” and validity. At last, “path analysis” was conducted using “structural model fit criteria”. According to the above results, all “hypothesized relationships” which were proposed in the study were significant.

Based on the findings, it was suggested that the use of new “IT tools for flood risk communication” is an easy and fast method of “risk communication” in terms of time concern. Importantly most of the young age groups believed that the “cost of internet” and “SMS alerts” and their “IT literacy” in not an issue to “adopt innovation for flood risk communication” but elderly crowd response were vice versa.

With the results can be concluded that “perceived response cost” has greater bearing to “adopt innovation” for “flood risk communication”. So, this finding was in-line to the previous studies. figure 8 depicts the overall “research model” as follows. The following frame work was the main finding of this study.

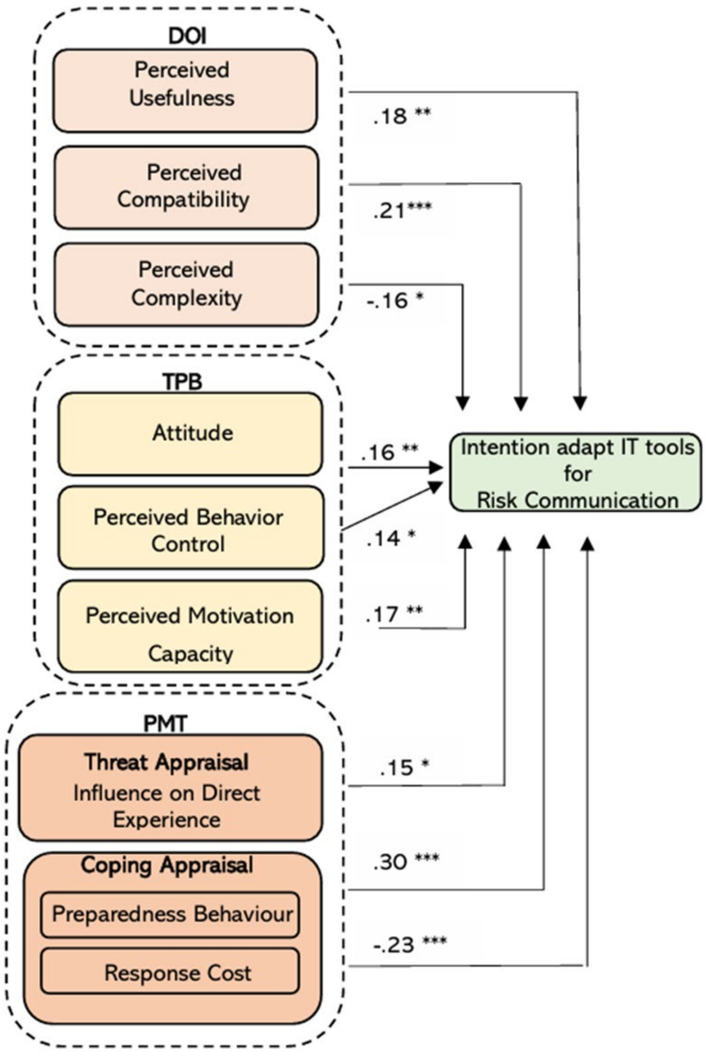

Figure 8 The research model (If $p \leq 0.05$ is significant & ***$p \leq 0.001$, **$p \leq 0.01$, *$p \leq 0.05$)

This study names this developed “model” as “Diffusion of Protective Innovation and Motivation model” (DPIM). Importantly this developed “model” describes three basic factors (1) “innovation diffusion factors” (2) “behavioural factors” and (3) “motivation factors” combinedly.

This study shows that the combination of “technical and behavioral” and “motivational factors” is providing new insight and contributing to “innovation diffusion” and its adoption for “flood risk communication” in relation to administrative purposes.

The further above statement can be illustrated as follows, out of some inherent qualities of “innovation” like “usefulness”, “compatibility” and “less complexity”, “citizen perceived” that “compatibility of IT tools” has greater influence “adopt IT tools for flood risk communication” than “perceived usefulness and complexity of IT tools”. As well as individual “behavioural” aspect concern, “citizen perceived” that the individual’s “motivation capacity” due “risk information” has greater influence to “adopt IT tools for flood risk communication” than “perceived attitude and perceived behaviour control”. And when concern about “fear and protection motivation”, the generated “preparedness behavior” due to “risk information has a greater influence on adoption IT tools for flood risk communication” than “direct experience to flood threat” and “response cost”.

Additionally, this proposed model highlighted that "fear and protection motivation" have a greater influence on the "adoption of innovative tools for flood risk communication" than other two theoretical environments. So, according to result the information seeking behaviour will generate within the community due to "past experience" to "threat" and their "cooping capabilities" through the "risk" information.

Even though floods are so devastated it is not frequent (once a year). Hence, people reluctant to download "mobile applications" which do not use frequently unless which is so important. So, "mobile applications" in this nature need to have multifunctional and more attractive. When its multi-functional people could use the different function at once so, the application became part of daily life and get use it more frequently. This will automatically generate the "perceived usefulness" and "compatibility" of the tool.

According to the study, people perceived that "direct experience to flood" has positive motivation to seek information for coming hazard event. So, fear of threat generated due to early experiences catalysis to adopt "new technology tools" as a mode of "risk communication". As chapter two stated the acceptance rate is higher when discussed the negative effect than the positive effect of something. It means this study suggest authority need to make aware of the public with bad consequences "flood hazard" than the advantage of "risk communication tools". Further, the study highlighted the "positive attitude toward technology" and "perceived behavioural control" is an important aspect for the "adoption of innovation". As literature suggested the young generation "adopt innovations" based on the attitude but the elder generation depends on both attitude and "behavioural control". Hence, awareness mechanism to approach needs to be changed based on social states.

Conclusions and Recommendation

Flood "disaster" considered as the most "brutal natural disaster" all over the world and it is same even in Sri Lanka. The situation is such that very few scholars have conducted a study on issues in "flood risk communication" all over the world and this study did not find more than two to three in Sri Lanka. Out of that none of the discussed "innovation adoption for flood risk communication" in Sri Lanka. So, this study provides a good contribution to the field to identify states of current "flood risk communication" mechanism.

According to data, it was found in Sri Lanka, the very low effect of social media, government website and "mobile apps" like DEWN and RiverNet for "flood risk communication" due to less adoption rate by flood affected community. So, it is considered this as the first study in Sri Lanka which conducted in the field of flood risk communication. And these open eyes of authority to improve the risk communication mechanism.

According to the available statistic in Sri Lanka, it was observed that very few numbers of face book users who follow the DMC face book site and use DEWN apps to receive "risk information". So, in order to save life and property through the effective "risk communication" study suggested developing two avenues (1) technical perspective (2) "behavioural and motivation perspective". Hence, the development of those two avenues will contribute to saving innocent life and property from future "flood disasters".

As study highlighted motivation to use technology and awareness of technology are the most "critical factor" to "adopt innovation in flood risk communication". Government and responsible authority need to motivate specially "flood affected community" to use innovation as a tool to get future flood warnings. And make aware of the community about new "IT tools" and how to use it and also what is the benefit of those "IT tools". So, the use of printed and digital media to give awareness to the general public at following "risk warning" through social media, government information system and mobile applications. Further, the study identified continuing education of negative impacts of has a greater effect on information seeking, hence, the study recommended informed the public about the negative effects of "flood hazards" as much as possible. Hence, the current structure and policy need to be revised.

According to citizen perception, some (especially elderly community) perceived that cost of services (internet and SMS) and technology skill is an issue for them to use technology. So, the government need to consider more about free SMS warning network from native languages which is common to all telecommunication networks (Dialog, Mobitel, Airtel) or introduced cell broadcast (CB) facilities. Further, it was seen during survey questioner authority used to educate people on how to deal with a flood during an emergency, but they are not giving awareness of how to use "IT tools" received "risk information". So, this awareness mechanism needs to be revised.

According to IT diffusion pattern in Sri Lanka the mobile phone penetration almost achieved late majority level diffusion curve but technology usage (social media, mobile apps etc) still runs in early adoption stage in "diffusion curve". In order to push this value at least early adoption stage, by improving positive attitude about the system within the community and improve the further usefulness of system, compatibility and less complexity of the system. It needs to be rather strategical decision not the operational decision. According to the review of the present situation in Sri Lanka, the online platform which uses as DMC Disaster reporting platform (figure 12) and it seems not attractive and user friendly further, it was observed that there was no continues update of risk information in government websites and DMC Facebook pages. So, this study recommended having the development of ICT leadership in different level of the institution who take part in emergency management duties.

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