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MAPPING UNDERMINED ROLE OF INFORMATION AND COMMUNICATION TECHNOLOGIES IN FLOODS

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This paper reports the undermined potential of broad range of (Information and communication technologies) ICTs that remained effective yet unnoticed in different flood-phases to exchange traffic, travel, and evacuation related information. The objective was to identify convenient ICTs that people found operational in life cycle of a flood. For the purpose, ICTs were tested in relation to 18 different variables based on personal capabilities, demographic, and vehicle-based information etc.

Samples of 105 and 102 subjects were recruited from flood-prone communities of developing and developed case-studies respectively, through random sampling and analyzed through Multinomial Logistic Regression. Those categories of independent variables that showed p-value ≥ 0.05 were considered to model the results. The main findings showed that in developed countries TV, mobile phone subscriptions and international news channels were prominent source of information whilst in developing countries multiple messengers, Facebook and contributory websites were impactful for information dissemination. The results are useful for academia, engineers, and policy makers and for future work same variables can be tested for different disaster affected communities.

Keywords: Multinomial Logistic Regression, Intelligent transport system technologies, Emerging Technologies, Transport-Disaster scenarios

1. Introduction

In recent decades, it has been witnessed that whenever any disaster occurs then two systems i.e. transport and information and communication flow (ICF) collapse quickly causing major life and other losses. Published literature on disaster coping strategies has been advocating to sustain these two systems together to provide smooth search, rescue operations and lifesaving activities. Practically, collapse of transport system is very much dependent on the collapse of ICF because in these instances, transport system requires an effective support of fluent ICF to endure critical system functions and to restore other levels of functionality which is not possible without an active transport and disaster related ICF.

Though floods are predictable, yet their dynamics change quickly and poses a new challenge every time (Gerhardinger *et al.*, 2005), especially with the change of phases (i.e. pre, during and post). The mechanism and related effects of each flood is different from the others, so even if there is a good planning well ahead of their occurrence, unpredictable problems originate that may undermine the success of planned strategies (Gerhardinger *et al.,* 2005). In every case, emergency and rescue logistics' operations are required to save lives, but while practicing, can run into difficulties due to incomplete and missing information links between flood affected and authorities/managers (Abbas *et al.,* 2016). The continuation of transport activities and services require an on-going supply of real-time information about the prevailing situation (infrastructure, injured people, flood water status, blocked roads, broken vehicles, death tolls, safe traffic evacuation and the demand related to emergency vehicles) concerning the flood. Many activities during this critical time, particularly transport system activities, are dependent on effective ICF. This in turn depends on Information and communication technologies (Al-Akkad *et al.,* 2012) that are operational under prevailed situations.

By acknowledging the advancements in technologies and its widespread use in crisis management by common public, international NGOs like Red Cross emphasized repeatedly that the three areas i.e. engagement of technologies in disaster response, public behaviours during disasters and motivation to use technology are required to be addressed (Societies, 2015). Also, Sendai framework of disaster management (2015-2030) has clearly pointed out the neglected role of ICTs in disasters. Therefore, this research has addressed the widespread use of technologies used by common public of society to see how they can play a key role in reducing the negative impacts of transport systems under disasters. The narrative desk-based literature review highlighted the need of in-depth investigation of linkages of ICF with transport systems under floods in both developed and developing countries. This research investigates the above-described challenges through strong information flow, by developing connections between transport-flood victims and managers (e.g. rescuers) through a variety of ICT deployment strategies and useful data generated through them to take in-time effective measures (Mohan and Mittal, 2020).

Adeel in (2018) emphasized the role of efficient ICF and that how critical it is to make intime decisions to save lives, for example, lower-income groups are discovered to have less access to communication technologies (Abel *et al.,* 2019). To-date, there is a lack of significant evidence of pre-planning of transport under disasters' management measures through deployment of ICTs (Authority, 2016; Mondal *et al.,* 2021). This shows that the role of ICTs for ICF among different sectors of flood prone community is under studied. Therefore, this paper considered a variety of variables and focused on getting benefit out of those technologies that are already in use and are very affordable but are excluded from mainstream disaster management policies and plans.

Developed and developing countries have different preferences in setting policies for transport systems and disasters depending on the available resources, political will, and authoritative power. Individual members of community use ICTs of their own choice and on their own to get information related to certain transport mode, travel and traffic plans and trip generation (Acar and Muraki, 2011; Stute *et al.,* 2020). Problem arises when information and emergency service providers make authoritative decisions concerning transport-flood updates and alerts services, on-call emergency vehicle facilities, location sharing etc. by neglecting the first responders' perspectives regarding ICTs for information dissemination which dilutes the impact of life saving efforts (Stute *et al.,* 2020).

An extensive published literature (Bingqing *et al.,* 2020) is available on ICTs, disasters and transport systems exclusively, yet these three fully developed research areas are not placed in a perspective together to understand their inter-linkages and combined effect to find a defined solution for transport and floods situation through ICTs. Also, there remains many unattended variables that significantly impact the choice of ICTs in floods, such as dependency status of a person, installed ICT in a vehicle, trust on flood managing authorities etc (Yamano *et al.,* 2020). These two massively important yet neglected aspects are taken up in this research for life-cycle of a flood rather than just focusing on only during or post flood-phases, which also adds a value to this work. Based on the facts, it is emphasized to understand the use of ICTs by flood and transport systems' affected people "the first responders". The research question is "what types of available ICTs are preferred by the flood affected communities to sustain transport related ICF?". The research question has two main facets: (i) the choice of specific technology by community members from those available, (ii) the influences of variables on the choice of ICTs supporting the transport systems under floods. Therefore, the addressed objective is to investigate the use of diverse ICTs in three phases of floods for the exchange of transport system related information among different community members.

2. Methodology

An extensive published literature and talks with experts lead to device the methodology of the study such as identification of existing gap in research to devise the research question, setting up of objective and focused variables, selection of case-studies, data collection and analysis technique. To understand the behavioural choice in using ICTs, two case-studies from developed (York, UK) and developing (Head-Marala, Pakistan) countries were employed, for the whole life cycle of a flood (pre, during and post phases). ICTs considered here were all those technologies including gadgets, applications, WEB2/3.0 technologies etc. that are used to facilitate transport system activities such as journey planning, vehicle sharing, information exchange and evacuations etc. by users, under normal or disastrous situations.

Transport and flood affected communities from the two case-studies i.e., river Ouse in the city of York, UK and river Chenab at Head-Marala location, near Sialkot city, Pakistan, were chosen for study. The cause of floods is similar in both case-studies i.e., over spilling of river water due to precipitation and both communities are facing floods for over more than a decade. York is a developed area, a well-integrated transport system exists, and residents are fluent in using ICTs. Whilst Head-Marala is a developing area, residents use private vehicles and paratransit and are also familiar with ICTs.

The primary data was collected face-to-face through carefully designed, self-reported, ethically approved, piloted questionnaires by a trained team over four months in 2019 through random sampling technique. 102 participants were recruited from York (whose urban and rural population was 204,439 by mid-2014) who were residing alongside the river Ouse and were directly and severely affected by floods. The limited sample size indicated that there has been a high turnover on house selling and purchasing in the affected area and those who were directly affected by floods were very fewer in number.

Similarly, residences alongside the river Chenab at Head-Marala were visited to collect data directly from individuals who were affected by severe flooding. This region faces floods of different severity (i.e. from light to strong severity) nearly every year. The population largely consists of middle to middle-higher class households. 105 participants were recruited which was a good representation of the whole Head-Marala population as it is a minute community. Even small fluctuations in the water level affects the lives, transport, and travel activities of both case-study areas. The collected data was further refined and validated to analyse and interpret result. Descriptive statistics and Multinomial logistic regression (MNLR) technique was used to analyse the data and is presented in next sections.

3. Data Analysis and Results

Table 1 from shows 18 variables that were used in study to understand the effect of transport-flood ICF in relation to ICTs that were operational in three phases of flood and had unalike users. The categorical variables involved gender, age with least representation of 65+ individuals from Head-Marala because in household surveys they were less likely to attend the strangers on the door compared to their young family members. Also, vehicle ownership, in-built vehicle technology along with its types in which residents of York leads that of Head-Marala, in-vehicle built technology in which York dominates Head-Marala. Individuals of York rely more on emergency services such as police, rescue, and government authorities and follow-up previous flood events compared to York. York's residents used private vehicles for evacuation whilst Head-Maralas' residents were to be rescued by air-borne vehicles. Majority of respondents were alone, independent and were from severely transport-flood affected area. compared to the residents of Head-Marala, the residents of York were ahead in owning vehicles especially cars and the use of in-built technologies especially GPS system whilst the residents of Head-Marala owned motorcycles that were not observed in York.

Table 1. A comparison of transport characteristics of York and Head-Marala's communities

Variables	**York %**	**Head-Marala %**	**Variables**	**York %**	**Head-Marala %**
Gender			Type (in-built) technology		
Male	60	59	Do not know / None of the above	16	65
Female	40	41	Radio / GPS (Navigation system) or both	84	35
Age			Vehicle used on daily basis		
18 – 25	19	34	Cycle / Motorcycle / Car	83	80
26 – 40	45	50	Public or paratransit	5	7
41 – 65	19	14	All above	12	13
65+	18	2	Vehicles used for evacuation		
Vehicle ownership			Do not know/Not required or used	18	30
Yes	88	52	Cycle / Motorcycle / Car	41	17
No	12	48	Boat / Helicopter or Airplane	18	43
Technology (in-built) in vehicle			More than one from above	23	10
Yes	85	37	Education		
No	12	63	School / College	30	5
Contacted Emergency services			University / Professional qualification	70	95
Yes	30	9	Experience of being in disaster		
No	70	91	Yes	87	88
Occupation			No	13	12
Full time / part time employed	61	47	Volunteering		
Student / Home maker	12	41	Yes	85	50
Unemployed / Retired	26	12	No	15	50
Followed-up previous disaster			Severity		
Yes	57	20	No flood to light flood	6	3
No	43	80	Moderate to strong / major flood	94	97
Preferred authority to contact in emergency			Awareness about alerts/updates/ information sources		
Police	43	33	Yes	50	26
Rescue/emergency authorities	37	27	No	50	74
Government authority	41	25			
Dependency Status			Location		
Alone and independent	76	78	Not affected to least-affected area	12	3
Not alone but either dependent on others or other people were dependent on you such as family or friends	24	22	Moderate to highly affected area (river)	88	97

Figure 1 shows comfort level of the residents of York and Head-Marala in using ICTs in seeking and dissemination of transport and flood related information under normal circumstances. The overall impression was that residents of York were more comfortable to use ICTs for exchange of transport-flood information compared to Head-Marala.

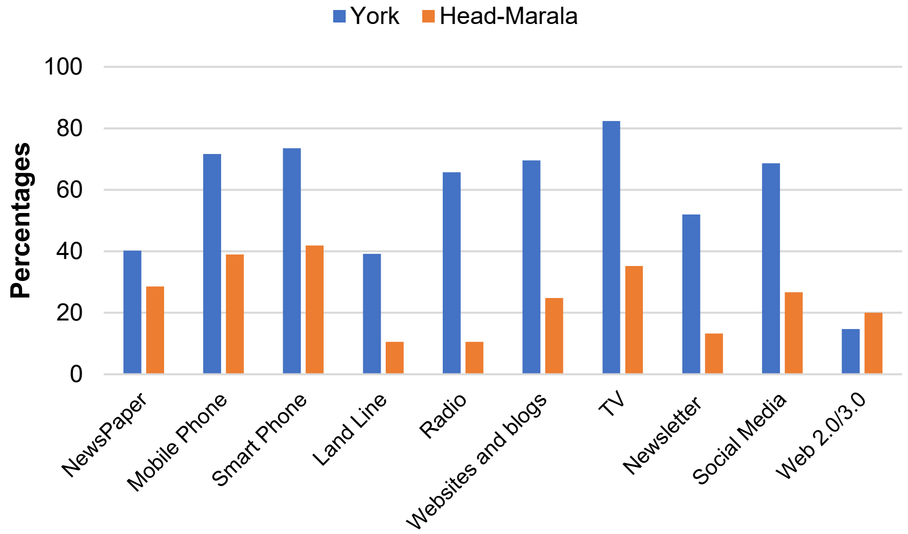

Figure 1. Comfort in using ICTs; A comparison of residents of York and Head-Marala

Table 2. Information and communication technologies used in flood for the exchange of transport related information

Information and communication technologies (ICTs)	**York**			**Head-Marala**		
	Pre	**During**	**Post**	**Pre**	**During**	**Post**
Simple ICT						
Do not know/None (RC)	**2**	13	3	16	**24**	**24**
Landline/Mobile phone	**7**	15	8	**45**	41	35
Radio	9	**14**	10	**3**	7	8
TV	**63**	40	62	**11**	**11**	**11**
All above	20	19	**18**	**25**	17	23
Subscriptions						
Do not know/None (RC)	55	**75**	62	37	59	**35**
Email subscriptions	12	**10**	12	19	17	**27**
Mobile phone subscriptions	24	**10**	16	**29**	10	20
All above	10	**6**	11	15	14	**18**
Applications						
Do not know/None (RC)	63	**74**	64	**51**	53	57
Contributory Applications	10	4	**2**	**25**	17	14
GPS trackers	18	21	**27**	10	**9**	11
All above	10	**2**	8	14	**21**	17
Messengers						
Do not know/None (RC)	38	**58**	**32**	43	51	36
WhatsApp/Skype/Viber/Line	62	**42**	**68**	57	49	64
Social media public forums						
Do not know / None (RC)	35	43	**27**	34	**49**	40
Facebook	36	28	**48**	24	**20**	21
Twitter	3	**10**	**1**	2	2	**1**
All above	26	**19**	25	**40**	30	38
Social media websites						
Do not know/None (RC)	50	**67**	52	44	52	**43**
YouTube	**16**	12	**5**	**16**	13	11
Information websites and blogs	30	19	**34**	16	**11**	16
All above	4	**3**	9	24	24	**31**
News Channels						
Do not know/None (RC)	**2**	33	3	18	**38**	32
Local	**43**	37	30	**43**	30	**24**
International	**1**	5	**16**	5	8	11
All above	**54**	**25**	51	34	**25**	33
RC = Reference category in Multinomial Logistic Regression (MNLR)						

The least and most used ICTs are highlighted in bold. The variables mentioned in table 1 and ICTs' in table 2 were analysed with respect to each other by employing Multinomial Logistic Regression and is presented in next section.

3.1. Multinomial Logistic Regression Analysis (MNLR)

The Multinomial Logistic Regression (MNLR) technique was chosen as it is multinomial in nature, making it suitable for the type of data collected in this research. The use of MNLR is not new to Intelligent transport systems, ICTs, behaviours and disasters (Aderamo, 2012), however, little has been published concerning the application of MNLR in the context of emerging transport system technologies in disasters. This research presents the use of MNLR at a personal choice level to identify the extent, use, availability, and choice of technologies in floods. Also, it is attempted to consider multiple categories of dependent variables (DVs) which is rarely used in the published literature.

The sufficiency of the sample i.e. minimum number of cases per Independent variables (IDV) 1:10, was satisfied in the analysis for each case-study as following the guidelines mentioned by (Acar and Muraki, 2011). While analysing data it was noted that the distribution of responses was such that some response categories had very high numbers of responses whilst others did not receive any. Also, some categories received very similar levels of responses. This does not offer much variation in the data and results in poor model formation (standard error > 2 is not acceptable due to multi-collinearity). Therefore, some of the DVs categories were merged to obtain best fit model(s) Table 3 and the model fit was determined by the statistically significant p-value. The model fit information that shows the strength of the model was considered as a key guideline in selecting a 'best fitting' model, including the strength of each individual DV and IDV's categories. The proportional by chance accuracy was satisfied for each case-study which is necessary particularly where small number of predictors are involved in analysis (Aida *et al.,* 2013). The standard criteria used to characterize a MNLR model as useful is a 25% improvement over the rate of accuracy achieved by chance alone to measures the strength of MNLR model by comparing the predicted group membership based on logistic model to the actual known group membership that is the value for dependent variable.

A maximum of four IDVs were computed together to maintain the ideal ratio of cases to IDVs (at least 10:1). Coefficients were computed through an iterative maximum likelihood method. The goodness of fit criteria (likelihood ratio) was based on statistical significance of the (X2) statistics of the model fit. The model fitting information criteria (-2log likelihood) provides information about the improvement of the model with every added variable at every step and its statistical significance via likelihood ratio test. Parameter estimates such as the intercept, standard error, Wald statistics, P-values and odds ratio were also calculated. Tables 3 and 4 show that ICT technology as a category of DV with respect to reference category (RC) as mentioned in table 2 is statistically significant with a particular category of IDVs which is evaluated with respect to RC of IDV, shown in table 2. The β-values shows the strength of coefficient and +ve or -ve sign shows the increasing or decreasing likelihood with respect to reference categories. The results from the analysis gave outlooks regarding ICTs with respect to variables that influenced their potential to use in lifecycle of a flood. In total 18 different IDVs were tested out of which 10 showed relationship with DVs for both case-studies. Results from table 3 and table 4 are compared and discussed below.

Simple ICTs: Irrespective of the stage of flood cycle, the common IDV that effected their use was socially active behaviour of people. Other than this, York's transport-flood affected were aware of emergency/authorities whilst Head-Marala's community was not aware of any authority to contact and were deprived of the services (such as information in relation to transport-flood problems) that might have offered by the authorities which led them to use unified technology that perhaps avoided the loss of information.

The transport-flood affected of York showed diversified use of ICTs compared to the transport-flood affected of Head-Marala. The behavioural trend observed in the community of Head-Marala and was also shared by transport-flood affected people was that some individuals managed on a personal basis to receive information about evacuation and rescue plans from (local) government officials, such as the weather forecasting department. The remainder of the community then followed those people who had received the early information and who effectively became 'information-leaders'. This pattern of behaviour was therefore typified by a few individuals taking a lead in information sharing and acting as communicators between members of the public and authority personnel (sometimes by using their influential positions and personal relations). These information leaders then started taking responsibility for the community and managed facilities for others. These included arranging resources, like vehicles, for those who did not have a vehicle, e.g., by influencing and persuading others with a formal evacuation role in the area to help, and by approaching resources such as hospitals. Some members of Head-Marala community shared that when people were uninformed of how to get access to sources of information, then an extra burden was exerted on front line "emergency/rescue authorities". People approached them repeatedly, even for very general information, causing delays in the emergency and rescue activities. The efficiency of rescue and recovery activities was compromised. Contrary to this, the residents of York showed individual behaviour towards obtaining information through ICTs, therefore, used diversified ICTs whilst the source of information was same (i.e. emergency/rescue authorities). In both case-studies, Infra-structure was not operational from the time when the initial threats were established i.e. pre-flood, especially, contrary to York Head-Marala took a considerable length of time spanning over many months to make infrastructure operational. Throughout the flood cycle transport-flood plans, specifically emergency based, were not made clear to people. A lot of ambiguity existed concerning the information available and resources, largely due to a lack of formal communication channels between the public and authorities.

Email and mobile phone Subscriptions: In York different IDVs played a role whilst in Head-Marala the influencing IDV is mainly related to the role of authorities and affected community's awareness about them that encourages people to take their own decisions which may be well organized at personal level but may be very fuzzy when impact collectively.

The overall impression regarding the use of ICTs showed that mobile phone subscriptions survived the most critical phase of flood i.e. during a flood. It indicates that mobile phones as operated from a distant infrastructure is relatively sustainable compared to email subscriptions which is dependent on the local infrastructure. Transport-flood affected of both case-studies, however, used both types of subscriptions throughout the flood life cycle.

Subscriptions were not the first preference from other ICTs because of the nature of information required in flood instance. Some departments shared general non-event specific information on websites which were not visited frequently by flood affected people because either people were unaware of such subscription services, or the infrastructure was not functional to allow the affected to access the informational benefits.

Smart phone messengers: In York, two IDVs i.e. dependency status of family on the transport-flood affected individual of community and his own dependency on government authorities made him to choose ICT technology to communicate with outer world which is very interesting because it depicts the prevailed circumstances through which an individual member of a community has to go through. The behaviour of each member of community contributes towards the overall behaviour of community. In Head-Marala, gender, evacuation vehicle and inbuilt technologies that evacuation vehicle held played a key role in using ICTs.

Both communities used messengers of various types. Messengers might not be very effective in bridging the gap between authorities and vulnerable individuals but promoted community strength because they facilitated peer-to-peer communication. The lack of attention from authorities pushed people to develop stronger bonds among themselves.

Smart phone applications: In York, available evacuation vehicle and dependency status compelled people to use GPS trackers that are used to find path along with other travelling details. The combination of these two IDVs is very interesting because it shows complicated situation in which individual is responsible for the safety, rescue, and/or evacuation of the loved ones whilst taking right travel decision at that time. In Head-Marala, mostly a person's personal characteristics influenced the choice of ICTs. Socially active individual, holding a good level of education and lack of attention from police (as authority) promoted self-realization of individuals to approach for information sources that are more appropriate.

In York, GPS trackers were the only ICT technology used from other Applications whilst in Head-Marala most types of Applications were used throughout the life cycle of flood. The noticeable aspect is that GPS trackers were used in the most dynamic phase of flood i.e. during phase.

The usual practice observed was that prior to floods, Yorks' residents were prepared to cope with the challenges because they were well-informed in advance by the authorities, well-supported and followed previous floods. This in comparison to Head-Marala's residents who were also warned, prepared to some extent to cope with a flood but were not as well-organized and supported as the residents of York. In both case-studies, various smart phone applications were used in the pre-flood phase, implying the importance of gathering as much information as possible before flood occurs. In the during-flood phase, as the flood approaches, the nature of the information required becomes more specific and so does the choice of "smart phone applications". This choice narrowed down to GPS trackers for guidance while travelling in floods.

Table 3. Results from MNLR analysis: ICTs used by flood affected people of York UK to access transport related information, communication, and services

DV	Pre-Flood			During-Flood			Post-Flood		
	DV's category (P<0.05)	IDV categories (p-value <0.05)	β	DV's category (P<0.05)	IDV categories (p-value <0.05)	B	DV's category (P<0.05)	IDV categories (p-value <0.05)	β
Simple ICTs	All above	Socially active (yes)	2.94	All above	Occupation (Full/time/part time employed)	-3.05	TV	Socially active (yes)	2.6
Subscription	Email Subscriptions	Evacuation vehicles (cycle/motorcycle/car)	-1.2	Mobile phone subscriptions	Socially active (yes)	-3.53	Mobile phone subscriptions	Police (Not to mildly prefer)	-2.8
Messengers	Skype/Line/Viber /WhatsApp	Govt. authorities (Not to mildly prefer)	5.46	No Model			Skype/Line/Viber /WhatsApp	Dependency status (Alone)	1.4
Applications	All above	Evacuation vehicle (cycle/motorcycle/car)	-2.9	GPS trackers	Dependency status (Alone)	2.2	No Model		
Social media public forums	Both	Evacuation vehicle (cycle/motorcycle/car)	-2.9	Twitter	Follow-up flood	-1.7	Facebook	Location (Not affected to least-affected area	-2.3
Social media websites	No Model			Contributory/information websites/blogs	Emergency rescue authorities (not to mildly prefer)	2.93	Contributory/information websites/blogs	Govt. Authorities (not to mildly prefer)	2.1
News Channels	Both	Socially active (yes)	3.45	Both	Occupation (full/part time employed	0.93	International News channels	Flood experience (Yes)	3.48

Table 4. Results from MNLR analysis: ICTs used by flood affected people of Head-Marala Pakistan to access transport related information, communication, and services.

DV	Pre-Flood			During-Flood			Post-Flood		
	DV's category (P<0.05)	IDV categories (p-value <0.05)	β	DV's category (P<0.05)	IDV categories (p-value <0.05)	β	DV's category (P<0.05)	IDV categories (p-value <0.05)	β
Simple ICTs	No Model			TV	Authorities' awareness (Yes)	-1.4	All above	Emergency/ rescue auth. (not to mildly prefer)	-2.1
Subscription	No Model			Mobile phone subscriptions	Police (Not to mildly prefer)	4.1	Mobile phone subscriptions	Authorities' awareness (Yes)	-3.1
Messengers	Skype/Line/Viber /WhatsApp	Evacuation Vehicles (Boat/helicopter/airplane)	1.9	Skype/Line/Viber /WhatsApp	Type of vehicle tech. (Radio and GPS)	-1.2	Skype/Line/Viber /WhatsApp	Gender (Male)	-1.1
Applications	All above	Socially active (yes)	2.0	GPS trackers	Education (School/College graduates)	2.6	GPS trackers	Police (Not to mildly prefer)	2.6
Social media public forums	Facebook	Police (Not to mildly prefer)	3.1	Facebook	Emergency/ rescue auth. (not to mildly prefer)	-1.7	Both	Socially active (yes)	1.3
Social media websites	Contributory/informatio n websites/blogs	Police (Not to mildly prefer)	3.1	Contributory/informati on websites/blogs	Vehicle used in routine (Cycle/Motorcycle/Car)	-2.2	Contributory/infor mation websites/blogs	Emergency/ rescue auth. (not to mildly prefer)	-2.1
News Channels	No Model			Local news	Police (Not to mildly prefer)	-1.5	Both	Occupation (Student/Homemaker)	2.1

Social media public forums: In York, three important IDVs which seems interlinked in a way that the location of transport-flood affected community members, who acquired the information related to previous floods and associated transport problems used evacuation vehicles to vacate the flood affected area. Whilst in Head-Marala, the role of authorities and socially active characteristic compelled people to choose most relevant social media public forum.

Overall, in both case-studies, Facebook as well as Twitter was widely used. Transport-flood affected people of Head-Marala however found more comfortable with Facebook rather than Twitter. It is considered worth noted that Facebook has some limitations, that it follows very strict data sharing polices compared to Twitter which is an additional difficulty for authorities seeking to obtain data. Facebook users often keep their profiles secure and do not like to share their personal details outside their contact list. The same medium of communication is not used uniformly in communities, thus causing a break in the chain of ICF.

Social Media websites: Overall, the prominent IDV is the role of authorities in both case-studies which influenced people to use contributory/information websites, however, in case of Head-Marala IDV, vehicles used in routine, compelled people to use most types of social media websites.

Head-Marala's transport-flood affected people used diversified social media websites compared to York's people who only relied upon contributory/information websites. It is important to mention here that YouTube was banned in Pakistan since 2009 to around 2014, leaving fewer options for access to sources of free and frequently shared information. The data generated via social media websites needs a considerable and organized setup by institutions to utilize such extensive data generation in short time span and in an effective way. The shared information through social media websites has no identified audience and there is no certainty that those accessing it would get information with content of their own interest.

News Channels: The common variable between both case-studies is occupation. In both case-studies different IDVs influenced the use of ICTs. Both types of news channels were used, however, noticeable aspect is that during-flood only Local news channels were preferred whilst in post-flood local and international channels were used to get more diversified information.

4. Discussion

The city of York has a history of severe flooding including the worst flood of the century which occurred in 2000 *et al.,* 2016). Flood is still a problem in York, causing damage to homes, businesses, and delays to the transport system. There are persistent efforts from all stakeholders (environment agency, city council, met department etc.) to upgrade the defence system against floods and to mitigate the destructive flood impacts. In 2015, the Environment agency (York) issued many flood warnings, prepared a systematic plan but there were many uncertainties that were difficult to handle (such as unavailability of public transport, broken roads, abandoned transport plans and evacuations on short notice). These have severe impacts on transport system operations resulting in a considerable breakdown in services and operations. Managing floods is a continuous process and York's environmental agency has stated that "Flooding is a natural occurrence. We cannot always stop flooding, but we can help to prevent it". This problem can be coped with a more effective way by utilizing the potential of ICT technologies at the maximum level in flooding and a thorough investigation is required for its demonstration.

Head-Marala is also prone to widespread floods (Adnan and Kreibich, 2016) resulting in an extensive loss of lives, transport infrastructure and communication lines (Alam *et al.,* 2014; Alam *et al.,* 2015). Head-Marala experiences very high levels of flooding (volume and impact) compared to York. Many people are severely affected every year and according to a recent report issued by Pakistan national disaster management authority (PNDMA), of all the types of disasters that occur in Pakistan, flooding is the one that has caused most causalities. Head-Marala is credited for having its first flood warning system installed decades ago somewhat in 1960s. Unfortunately, that was neither maintained nor upgraded on a regular basis, hence, it has lost its' efficiency with the passage of time and is now a historical artefact. There is a lack of research regarding floods and its impacts on the transport system specially to facilitate flood-affected by utilizing technologies to help authorities to identify grass-root level glitches. PNDMA was established as a central body to deal with disasters after a major earthquake in 2005 and started taking note of flood damages after the 2010 floods. Provincial and district disaster management authorities were developed later. These authorities are still in the phase of progression. There is need to understand the flood phenomenon with respect to the influence of real-time communication from these authorities within different sectors of a community.

Similarly, another recent study (Miran *et al.,* 2018) established the fact that proximity to the disaster (tornado), information sources and personal factors e.g. age, location, socio-economic background, education and marital status effects the protective action of people to make decision. Simple ICTs take care of the needs of mixed ability community members (Santos *et al.,* 2016). Also it is already tested that mobile phones are more popular source of post disaster communication in developing countries because it is an affordable source of information (Baytiyeh, 2018).

Subscriptions were well received in UK (Twigg, 2015) compared to Pakistan where it is not that common so far. Subscription services were not specifically favoured or completely relied upon by people but were treated as an extra source of information on specific issues e.g. cancelations or rescheduling of train travel timings. The information delivered through subscriptions was of general in nature e.g. all roads in the city centre will be closed, as well as event specific e.g. XYZ bus service will be inoperative for two days and for ABC an alternative route will be advised. Mobile phone subscription services were useful when people had to deal with transport-flood facilities on their own rather than relying more on authorities to support them.

People preferred to develop connections within their own known social circle (i.e. with peers rather than with authorities) and were familiar with establishing individual level plans (e.g. evacuation from a flooded area) and information sharing (e.g. availability of vehicle for transport with peers). Messengers helped in promoting community strength, public initiatives on their own, public participation and lesser burden of responsibility on government authorities. This might lead to equal distribution of attention, resources, relief, and logistics to the other affected members of community. A study from Pakistan showed that the role of female in disasters is yet to be explored further and women should be involved in disaster management (Shaw, 2015). In this study the females from Head-Marala were found to be active participants in circulating transport-flood information through messengers.

The role of Smart phone applications in crisis management is highly emphasized from the perspective of affected people (Tan *et al.,* 2017) therefore, this study considered people cantered use of phone-applications. It is required to consider this source further for generating data out of it that could be used by the authorities to help transport-flood affected people. Self-sustained people with their private vehicles, evacuated the flooded area by using self-guided applications i.e. GPS trackers for as are already used in the past (Biba, 2015). However, it is strongly required to design local transport-flood applications that are event specific, very localized and can deliver real-time information to transport-flood affected people.

In social media public forums, Facebook is considered more convenient and secure for transport-flood information sharing compared to Twitter (Kulemeka *et al.,* 2014). Facebook was prominently used in both case-studies as a social media public forum. Twitter was used where people tried to develop contacts with outer world for the purpose of gaining quick and necessary event specific information. This contrasted with Facebook, where communication within the social circle was preferred.

Even though a very few of social media websites such as (Web 2/3) are addressed in literature to some extent as social software application where different communications between various authorities is investigated but it left many grey areas such as authenticity of the information and then transfer of information to the affected public (Reuter *et al.,* 2012; Stute *et al.,* 2020). This study found that social media websites, if backed up by trusted sources such as Police (in this case) compared to government authorities and emergency/rescue authorities are widely used by the flood-affected people to seek transport-flood related information (Kavanaugh *et al.,* 2012) because trust is the critical factor to assess and respond to risky situations in disasters (Richard Eiser *et al.,* 2012). Contributory/information websites/blogs as social media websites were used in both case-studies and in all three phases of the flood.

News channels, both national/local and international are quick and effective source of information (Haraguchi and Lall, 2015; Tan *et al.,* 2017). The use of news channels was similar in both case-studies and throughout all three phases of the floods. In York, trip purpose such as occupation is an influencing factor to decide between information sources because transport-flood affected people had to make their travel plans, chose specific transport mode and had to get information about travelling routes with respect to time to reach their destinations. The community of Head-Marala used their personal capabilities in managing transport-flood information independently.

Overall, there is an absence of organized transport-flood information for the residents of Head-Marala compared to York. People were not aware of any authority that could provide them with relevant information in a timely manner. As a result, individuals necessarily relied on emergency authorities for information, who were already heavily engaged with their primary duties (i.e. working on the front line).

This reliance created an extra burden on the emergency/rescue authorities and indicated a shift in responsibility from the local authority to the emergency/rescue authorities, albeit unintentional. The need for staff's trainings to cope with transport-flood scenarios has historically been given scant attention, but this research argues to consider it as a priority. Local news channels and similar platforms need to be further engaged to support the training of members of the public, despite needed to have their own carefully designed and managed disaster strategy.

5. Conclusion and recommendation

This study concludes that Simple ICTs are suitable for majority of the members of communities despite diverse characteristics (i.e. socially active, age, socio-economics) and is an easy mean to access a broad range of information when any specific source of information e.g. information about para-transit and public transport availability is unknown to people. This group of technologies should not be discarded upon emerging of new technologies but should be merged with them in the great interest of needs of all community members in disasters.

Both mobile phone and email subscriptions were used, but during a flood, mobile phone subscriptions were more effective compared to emails and fliers because of the loss of internet connectivity, as well as inoperative physical infrastructure that caused hurdles in delivery of newsletters/subscription messages. Also, the content, frequency and length of the subscription notifications is still a matter of concern and needs careful handling.

In both case-studies, the utility of smart phone messengers was specific to individuals' characteristics e.g. gender. Even though women prominently effectively used messengers yet, there is an unacknowledged role of females in transport-flood management which needs recognition and further investigation.

Smartphone applications were preferred by those who independently dealt with the transport-flood circumstances. It was an independent source of information for those who were stuck in destructed area and needed a way out or for those too who wanted to find nearby emergency shelter locations' identifications. Region specific smart phone application can play a vital role in managing transport-flood situations.

In social media public forums, Twitter was used for the sharing of event specific information whilst Facebook was used for communication within one's own social circle. In social media websites, the main influencing factor was the priority of contacting different flood-transport management authorities and people's trust on them. News channels were effective to attain event and location specific information that mainly influenced people to make a choice between niche and broad information sources.

It is found that irrespective of development of the area and the phase of flood, the influencing factors and type of required information determine the choices of ICTs by individuals. In this research, all ICTs that are analysed are useful one way or the other. This study is a step towards the out of the box idea of integration of ICTs into the existing transport and flood management system to enhance efficient ICF by the affected people in such a way that no new big investments are required but to utilize existing resources i.e. ICTs. This can conveniently be done by exploiting ICTs' potential and effectiveness in a various challenging setup.

This study has a limitation of limited data set because this type of data is not found in repositories or archives but have to be collected through questionnaires which pretty much are dependent on the opinion and experiences of community members. However, this study is broadly beneficial for academia, consultant, transport and flood planners, managers and policy makers.

Further study is required to apply same models for different disasters such as earthquakes to investigate how the communities choose ICTs' when type of disaster changes. Similarly, different communities can be investigated with same sets of DVs and IDVs. Further investigation may lead to the type of transport-flood related information sharing. These three related directions are considered in next steps of this research.

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