Application of Q-Likert methodology to find factors affecting Information and communication flow related to transport-earthquake problems

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Abstract

This paper presents a new integrated method that focuses on quantitative measure of qualitative data for small sample size that consists of rich and high profiled data sources such as experts (heads) of Intelligent transport system (ITS) technologies, transport and earthquake management institutions. The details of the newly developed method and its application by considering a case-study from developing country is presented. The results are in the form of identified factors that are limiting the effectiveness of Information communication flow through Intelligent transport system technologies in transport-earthquake (a term introduced by the author of this study) management. The identified factors highlight information communication problems inter and intra departments, among different stakeholders and uneven ratio of ITS technology and transport-earthquake affected and managers. The model worked well and can be applied in many ways such as other case-studies and types of disasters.

Key words
Earthquakes, Q-Methodology, ITS technologies, Transport systems, Qualitative methods

1. Introduction

Information and communication flow (ICF) is of utmost importance in managing a disaster such as earthquake. Two activities i.e. transport system and ICF in any disaster, if are sustained then can enormously help in managing a disaster and relief activities (Comfort, Ko et al. 2004). Not a single institution / authoritative setup is involved in managing a disaster, but multiple institutions have to work in collaboration with each other to develop policies, (Aitsi-Selmi, Murray et al. 2016). ICF related to transport systems and earthquakes scenarios require information and communication technologies (ICT) and intelligent transport system technologies (ITS) for smooth carrying out of transport-earthquake (a term introduced by the author of this paper and might also be observed in other publications by the same author) relief activities. There are many factors that influence the effectiveness of role played by ITS technologies in transport-disaster situations. Therefore, an in-depth study is required to investigate those factor that are causing inefficient ICF in transport-earthquakes scenarios. There exist many schools of thoughts that are addressing different perspectives to address the dynamics of disasters such as people’s perspective, authoritative perspective and other stakeholder’s (such as army) perspective. There are different pros and cons of each perspective though the best approach could be to have as much information as possible by involving all possible stakeholder. However, this might not be practically possible with limited financial resources, time constraint, political will and other similar factors. Earthquake is very challenging disaster because its dynamics changes with every changing phase and so does the transport activities under earthquakes. Therefore, not a single stakeholder can bring practicable and effective solutions to the problem. In fact, there is need to further investigate the role of each stakeholder in-depth especially authorities who are transport-earthquake managers. This paper is a small part of extended research work and
focuses on authoritative perspective of transport-earthquake managers and experts with reference to ICF problems through ITS technologies. It is important to mention here that ICT technologies are part of broad ranged ITS technologies (Grant-Muller and Usher 2013) and the author of this paper followed an assumption i.e. “All those technologies (including gadgets, applications, WEB2/3.0 technologies etc.) that can be/or are used to facilitate transport system activities (journey planning, vehicle sharing, information exchange and evacuations) and users, under normal or disastrous situations, are termed as Intelligent Transport System (ITS) Technologies.”.

Every earthquake is different in nature therefore it needs multiple analysis approaches to understand the dynamics in detail to find practical mitigation solutions. Efficient handling of earthquakes require fluency of ICF and collaborative activities among different stakeholders, especially authorities who are responsible for managing earthquakes. To manage the complications of the transport-earthquake need simplified but in-depth data collection and analysis approaches, simultaneously. Literature shows that disasters are dealt in the past as social sciences problem, therefore, is mostly analysed from qualitative data. Whilst transport systems and related issues as dealt through both qualitative as well as quantitative methods. Therefore, there is need to develop approaches that can deal with maximum possible information. One of the such methodology is Q-methodology (more details are shared in next sections) and Likert-scale. This paper presents the development of Q-Likert methodology following its application through a practical example.

Research Question
How Q-Likert methodology be applied to investigate the factors influencing transport-earthquake related ICF by ITS technologies?

2. Literature review
Q-Methodology is developed to give a quantitative perspective to a qualitative study (Brown and Steven 1968, Brown 1968, Brown 1996, Brown 2006) especially in psychology. With the passage of time, many changes occurred to introduce new dimensions such as 11-point Q-sort, 13-point Q-sort, forced method, free method, different software were introduced in Q-Methodology (Cross 2005, ten Klooster, Visser et al. 2008). Q-methodology is used with large number of questions but less number of responders (Vandeyar 2008). Advantages of Q-Methodology are that it allows sorting patterns of different speech among speakers, an unbiased technique of developing a representative set of subjective statements drawn out from a sample and deals with feelings and reactions, responses or inclinations about a specific subjective condition. It allows making a case by case matrix of some sort of similarity measures to be analysed. Q-methodology is a set of procedures, theory, and philosophy supporting the study of subjectivity in qualitative research, provides a broad range to get a broad range data and is used in several ways and in several fields. (Brown 1991)

Q-methodology have been widely used in past. For example Vandeyar (Vandeyar 2008) used Q-methodology in policy making for ICT technologies for schools’ participatory approach. Liu (Liu 2008) used Q-methodology to explore the types of mobile phone users by the exploratory approach. Raje (Rajé 2007) used Q-methodology to evaluate the correlation between people and transport system. Doody (Doody, Kearney et al. 2009) used Q-methodology to check the awareness levels in individuals regarding sustainable development. Previte (Previte, Pini et al. 2007) emphasized the use of Q-methodology for qualitative social sciences research. Cross (Cross 2005) presented that studies dealing with behaviours and attitudes should be conducted by using Q-methodology because of its exploratory characteristics. For example, in response to each statement respondents responded by using their own mind math and shared their broad experiences i.e. whatever they wanted to share. Ellis (Ellis, Barry et al. 2007) highlighted the effectiveness of Q-methodology by suggesting that it contributes wider perspectives of the issues. Davies (Davies, Blackstock et al. 2005)
used Q-methodology for recruiting different people for various fields. However, he also admitted that Q-methodology has some limitations too. Such as, the statements provided to the respondents may be biased, biased in choosing sample, focusing a concourse but statements are not articulated, more than one concourse involved may result in complex interpretations (difficult to handle), if important aspects of the concourse are omitted then clustering might be biased, above all the specific design of Q-sorting exercise compels respondents to modify their real opinions about the statements and manage those opinions in Q-sorting process which they do not actually hold. This leaves genuine opinions unfolded. Two aspects are required to considered, first, as mentioned above that Q-sorting exercise leads people to refrain from sharing their heartfelt opinions that is a negative point in favour of research, conversely, this brings up new dimensions to the study as well that is positive but again gives a distraction from the true opinions about that concourse. This aspect is considered very genuinely and seriously in this study that the true opinions of the experts should not be influenced anyway. This is one of the reasons that Q-methodology technique was modified to Q-Likert technique in this research (explained in next section).

Many studies (described above) have emphasized the use of Q-methodology for qualitative social sciences studies where the sample size is less but Q-methodology still allows extracting detailed information. There is much more useful that can be done by using Q-methodology and may be with a little amendment. Before discussing modified version of Q-methodology, it is important to know how actual Q-methodology works and important to know this fact that it is difficult to get right experts and decision makers into the room, make them to listen each other effectively and communicate and administer the progress over a longer period of time (Robèrt, Borén et al. 2017). Further details can be found at (Brown and Steven 1968, Brown 1980, Brown 1986, Brown 1996, Brown 1997, Van Exel and de Graaf 2005, dit Dariel, Wharrad et al. 2010) where more detailed guideline to use Q-methodology and its components such as Q-sort, Q-set, concourse and analysis are discussed.

3. Methodology

In this section two main aspect are considered. First the development of proposed new methodology i.e. Q-Likert methodology is mentioned along with details of case-study. Second, the case-study and related data collection.

4. Proposed new approach as Q-Likert methodology and its purpose

In this section, Q-Method and Likert-scales are described. Likert-scale is very commonly used especially in psychological and social studies and is a self-reporting scale (Matell and Jacoby 1971) that was merged with Q-methodology in this study. A lot of literature is easily available on Likert-scale so is not discussed here in detail except for those focussable aspects that were needed to be highlighted with respect to this study. There are different school of thoughts about the number of Likert-scale index used, and which one to be used. Matell and Jacoby (Matell and Jacoby 1971) have discussed that how to select a Likert-scale index by comparing different studies and suggested that it is required to consider the sample size and sensitivity of the data to be analysed. Considering these facts and sample size taken i.e., 8 – 10 experts in this study five-point Likert-scale (-2 to +2) was used. It is believed that Likert-scale more than 5 point may cause ambiguity in the results and no defined (logical) patterns may originate (dit Dariel, Wharrad et al. 2010).

Q-Methodology technique starts with the data collection and its interpretation. The basic principal of Q-Methodology involves two considerations (i) it is the systematic study of subjectivity, a person’s viewpoints, opinions, beliefs and attitudes (Brown 1991, Brown 1996, Brown, Durning et al. 1999), (ii) small number of people (P-set) rate a (large) number of statements (Q-set) designed carefully and are based on concourse by considering extensive literature, practice and theory according to their own perceptions (Brown 1997, Van Exel and de Graaf 2005) and experiences. In Q-Methodology, individuals themselves are considered as
variables rather than individual’s traits that’s why factor analysis for Q-Methodology is called Inverse factor analysis (in contrast to R-methodology). Individuals are asked to answer several statements by selecting appropriate number on a scale to show difference in their opinions between extremes of agreements or disagreements (measuring scales traits may vary, e.g. happiness to unhappiness, love to hate etc.) (Brown 1991, Brown 1996, Brown 1997, Brown, Durning et al. 1999, Van Exel and de Graaf 2005, Watts and Stenner 2005).

The Q-sets are statements that are qualitative in nature. The scale against each statement is used to give quantitative measure to each qualitative statement. There are two ways of doing this i.e. (i) Forced method and (ii) unforced method. There is extensive literature available on both methods and debate is still going on to select which one is better (GAIT0 1961, Stephen 1985, ten Klooster, Visser et al. 2008).

In forced method, the Q-sorts are arranged on an already designed log with a uniform normal distribution. The arguments in support of already suggested log for Q-sorts (Forced method) are that it gives uniform distribution of the opinions. Individuals select statements in a controlled environment which further lead to meaningful factor analysis. The forced method demands individuals to play an active role rather than passive, that’s why, they are forced to fill the log by consuming their time and efforts to show their opinions. The placements of the statements in the log are relative to the other statements within the same log. The resulting variance, deviations and distributions remain same for all the logs and for all the studies because the shape of the distribution is already defined (i.e. normal distribution) (Brown 1996, Barry and Proops 1999, Brown, Durning et al. 1999, Cross 2005, Van Exel and de Graaf 2005, Watts and Stenner 2005, Rajé 2007, Watts and Stenner 2007). Some studies claim that the Q-sort method was used even before the introduction of Q-Methodology but before it was not recognized in the same context and with similar perspective (Brown 1997). This shows that its’ not specifically a Q-Methodology thing (i.e. it does not necessarily belong to Q-Methodology, there are no hard rules about it and is a changeable entity) and have already been used in various other contexts. This point is emphasized in this research with a believe that Q-sort then can be replaced with Likert-scale keeping all the principals of Q-Methodology intact and should not create a considerable difference but provides an opportunity to the respondents to deliver their unbiased and uninfluenced opinions. The results (discussed later) showed that the Q-Likert technique was successfully developed and tested in this research.

The unforced or free method is also in debate and is used in studies (GAIT0 1961, Stephen 1985, Kampen and Tamás 2013). It is argued that forced and unforced methods do not make a considerable difference in the opinions of respondents while factor analysis and interpretation of results (GAIT0 1961, Watts and Stenner 2005). Rather forced method is used just for the easy data collection so that the collected data is in a more sophisticated form to save the efforts and time of the researcher for analysis of data at later stages. Some studies claim that the forced method can put an extra burden (saved from the researcher) on the respondents in terms of time consumption and mind consumption (GAIT0 1961, Watts and Stenner 2005, Watts and Stenner 2012, Paul Stenner 2007) which may, not only irritates the responder (participant) but also be the cause of some biases while Q-sorting on a log. For example, consider 50–60 sets of statements to be arranged by participants who may have different ages, mental capabilities, attitudes, temperaments, and different time spans to spend for ranking of statements. The forced working environment, time constraints and laborious Q-sorting procedures may also affect the representation of different statements in the log while Q-sorting process. If the research is on attitudes, behaviours or psychology and ranking of statements are purely person’s judgement then forced method is already affecting attitudes, behaviours, and psychology and may be already affecting person’s opinions while Q-sorting process (GAIT0 1961, Brown 2006, Watts and Stenner 2007, Watts and Stenner 2012, Paul
Stenner 2007). This important point is considered in this research and a possible solution is presented.

Following the discussion above, according to the need of this research, it was intended to collect data from individuals of high profiles i.e. authorities, rescue officials and government officials who are considered as of some high-profile experts and are busy members of society holding huge responsibilities of peoples’ safety, security and comfort due to the nature of their jobs. On realistic grounds, Q-Methodology must show flexibility (Jackson and Bidwell 1959) towards such responders (experts) who are a rich source of information but cannot (or do not) want to donate time and efforts towards engineered experimental design of Q-Methodology i.e. compilation of Q-sort log with response statements. Q-sorting is not the only thing in Q-Methodology, but it follows note taking too and further (missing) details in the context. Dziopa (Dziopa and Ahern 2011) claims that there is need of new and innovative changes in conventional Q-Methodology and this is unavoidable. Supporting this argument, there should be some changes in Q-Methodology data collection without changing the main theme of Q-Methodology and so is suggested in this research. For example, use of Likert-scale in Q-Methodology (i.e. combination of both), to collect data in freestyle and quantitatively as Likert-scale itself is known for a quantitative measure of attitudes and opinions. Ten (ten Klooster, Visser et al. 2008) has compared Q-sorts and Likert-scale and suggested that Likert-scale should be used after Q-sorting to draw further information and useful conclusion.

It is emphasized in this research that instead of going into more time consuming and laborious exercises (with not very different results in both cases), Likert-scale should be used instead of Q-sorting but by keeping all basic principles and assumptions of Q-Methodology. This will not violate any of the basic principle assumptions of Q-Methodology (also mentioned above) and will give an innovation and flexibility to the Q-Methodology. As an observation, it should be mentioned here that, even if same person has to Q-sort same number and nature of statements on the same Q-sort pattern for many times, each Q-sort will still be different and not the same every time. So far, both two techniques (Q-sorting and Likert-scale) are widely, successfully but separately used and both techniques have their own advantages and disadvantages. This research attempts to amalgamate and bridge the gap between these two techniques by bringing them together for a greater benefit to the research, especially, multidisciplinary research that involved both social sciences and engineering.

To simplify this suggestion, merging Q-Methodology with Likert-scale to accommodate broader perspectives and rich sources of data can give more realistic results. Such as in this research, different data sources i.e. qualitative and quantitative data (questionnaires, additional information notes) and different targeted data samples from personals working in different institutions and have different expertise are taken. These personals are rich sources of information and very difficult to get hold on to get information from them. Also, as in the beginning of this research while piloting during initial stages of questionnaire design and data collection, many experts from across case-study areas were contacted and requested to respond for data collection through conventional Q-Methodology (and with 50-60 statements) but the response rate was zero (disadvantages of Q-Methodology as discussed above). Likert-scale itself was not serving the data collection requirement for this research because of no post information notes and interactions with the experts took place so the reason of their answer for each statement was unknown. This issue generated a necessity-based space for amended Q-Likert methodology as through pilot study it was established that not any of these techniques (Q-sort and Likert-scale) alone can collect broad range of data that is required in this research, but a modified Q-Likert technique can. Thus, Q-Likert methodology is developed in this research and a practical example with details about collecting and analysis of rich and meaningful data from precious information sources without asking much of their
efforts and time. In addition, same experts who were contacted for all three methods (Q-sorting, Likert-scale and then Q-Likert technique) gave their opinion that the later method appealed and facilitated them the most and they were willing to add further information with a feel of best utilization of their time in sharing their work experience rather than laborious engineered game (Q-sorting) or picking a number on a scale (Likert-scale) just like any lame TV show.

5. Case-study, ITS technologies and questionnaire

Islamabad, the capital of Pakistan, was chosen as a case-study because it is a developed city of a developing country who is rich in resources and is well maintained in terms of authorities (i.e. ITS, transport and earthquake management). Islamabad has faced many earthquakes including October 2005’s devastating earthquake that engulfed many lives.

ITS technologies were chosen and categorized into two groups based on the users i.e. ITS-1 (used by both people and experts) and ITS-2 (can operated by experts only). ITS-1 includes Newspaper, Newsletters/Brochures, Landline/Mobile phones / smartphones, Newsletter (mobile phone and email subscriptions), Smartphone earthquake site specific information Applications, Smartphone communication applications (Skype) and messengers (Viber, Whatts app, line), Social media website : Facebook and twitter with geo-tags (Earthquake information pages), Information web sites / blogs (specific disaster websites and information pages to offer help and earthquakes related information), New channels both national and international), Pictures or videos on YouTube, Metacafe, daily motion , Web technologies / contributory websites, (Google Mapia, Google Media), (Internet based), Radio, Evacuation (Variable message signs, diversions, loud speakers) whilst ITS-2 includes Remote Sensing technologies (Satellite images/ RADAR, LIDAR), Air Bourne technologies (Aero plane and Helicopter), Small drones, Boat, Bluetooth Technology (wireless and non-wireless), Navigation System (GPS).

Questionnaire was designed, piloted and ethically approved by the ethical approval committee of University of Leeds, to understand the hurdles in using above mentioned ITS technologies in transport-earthquake scenarios by the experts who are ITS technologies, transport and earthquake managers. Questionnaire was designed following a concourse (theme) that covered the use of Each ITS technology in transport earthquake with respect to phases of earthquakes. Further design of questionnaire, data collection and method of analysis is discussed in detail in later sections.

6. Sample

The sample size of 10 experts (details are mentioned in next sections) from were data was collected. The identity of participants is kept anonymous and data was collected through voice calls and private visits to offices. Expert1 Town Planner and GIS expert (earthquake experienced), Expert2 ITS expert / Transport planner, Expert3 Meteorologist, Expert 4 National disaster management (emergency operations at national level), Expert 5 Emergency officer (district level), Expert6 Environment protection agency, Expert7 Earthquake monitoring manager, Expert8 Rescue and rehabilitation, Expert9 Roads and infrastructure plg. and construction / environment and economics and Expert10 City Traffic Police.

7. Q-Participants and data collection

In this research (as described above) normally distributed Q sorts were not used so the mean of each of the Q-sort was not the same because respondents were given opportunity to select an index on the Q-Likert sort that was most appropriate to eliminate any biasness or pressure on the respondents. For the same number of Q-statements, the means, standard deviations and responses to the categories from strongly disagree (-2) to strongly agree (+2) were used.
Unlike Q-sort, Q-Likert sorts did not have fixed mean because respondents were given full liberty to respond against each statement and no pre-defined normal distribution was followed as used in Q-Methodology. In this research, neither forced (normal distribution pattern) nor free Q-sorting (matrix form) was adopted but responses were received on Likert-scale as both forced and free Q-sorting methods are biased methods. It is to remember here that even in free-Q-sorting method respondents must adjust statements in a predefined matrix that again attracts biasness though not to that extent as in forced Q-sorting but even then, it matters if opinions are biased and can be avoided with meaningful amendment as done in this research in the form of Q-Likert methodology. In Q-Likert methodology every response was independent of each other and yet had correlation which while rotation was exposed. The reason was because statements were designed carefully with a concourse and were coherent. A five-point Q-Likert sort from -2(strongly disagree) to +2(strongly agree) is used in this research.

Data from 10 (Islamabad) experts was collected. Each expert responded on Q-Likert sort separately. Each Q-Likert sort was evaluated against each other to unveil the hidden factors and relationships in the expert’s opinions. The statements were designed to find the underlying factors involved by evaluating the effectiveness, usefulness and failure of ITS technologies under different earthquake phases.

8. Q-Likert Factor Analysis

Q-factor analysis (analysing factor technique used in Q-Methodology) is quite different from simple factor analysis. Q-factor analysis is also known as inverse factor analysis because variables are the Q-respondents (participants) rather than Q-statements (array of responses). The difference between Q-factor and factor analysis is that factor scores for each array element is determined in Q-factor analysis and respondent is considered as a variable while in factor analysis each element of array is considered as a variable. Both (i.e. Q-factor and factor analysis) are used to analyse the latent variables. There are special packages available to compute Q-factor analysis. Factor scoring (one of the steps involved in this analysis) cannot be done in statistical package such as SPSS. In this research, to run the analysis of Q-factoring excel in combination with SPSS were used to calculate the factors, factor loadings, factor rotation and factor scores. The name of the technique “Q-factor analysis” was modified and introduced as “Q-Likert factor analysis” and was used in rest of the research.

Whilst analysis some of the guidelines were followed from the original model presented by Brown (Brown 1980) and for further information on analysis and interpretation (outputs) see, Andy Field (Field 2013).

Initially, every single step while analysing collected data was performed by programming in MATLAB, via formula calculation in Excel as well as in SPSS. The purpose was (i) to perform analysis in the absence of Q-factor specific software, and (ii) to get a firm hold on the methodology and calculation procedures and to avoid maximum ambiguity, (iii) to investigate, how far calculations can be done in SPSS and what are the limitations of SPSS while analysing for Q-Likert factor analysis because the method is introduced for the first time. The results were compared and were almost similar until factor rotation (in Q-Likert factor analysis, when analysis on same data was tested through excel and SPSS. Factor rotation was calculated in SPSS (as if opportunity is available to save time) because of its complicated nature when performed with MATLAB/Excel software. SPSS was not useful for the calculation of factor scores and factor interpretations (in specific case of inverse-factor analysis). For factor score calculations Excel was used. Later, to save time correlations, factor analysis and factor rotations were performed in SPSS. The already available software especially designed for Q-factor analysis were not used because of the introduction of Q-Likert technique used in this research. Those software were suitable for “forced “and
“unforced (matrix form)” Q-sorts but in this research totally free and Q-Likert-scale oriented Q-sorting was done and was called Q-Likert sorting.

9. Analysis
Whilst analysis it was considered that either Factor analysis or Principal component analysis is used based on their relevancy with the research. It was assumed that there were many factors involved in this study and the focus was to understand the underlying correlations among these factors. Also, it was assumed that the existing variables and factors had some sort of linear correlations and explanation of these underlying correlations was required which suggested that the factor analysis was more suitable analysis method over principal component. The steps involved in Q-factor analysis were correlations, factor extraction, factor rotation, factor scores and factor interpretation.

While interpreting factor and drawing results from the analysis, correlations, scree plots and factor loading plots, communalities (variance explained), eigenvalues, pattern and structure matrices and additional shared information notes by the experts were considered.

10. Q-Likert sample size (Kaiser–Meyer–Olkin (KMO) measure and Bartlett's Test)
Before proceeding to further analysis and results it was important to check if the sample (collected data) was adequate or not. KMO was conducted, check (Field 2013) for further details.

The test showed that the sampling adequacy for the case-study was greater than 0.5 which is the minimum limit to draw meaningful results. In addition, Bartlett’s test reconfirmed sampling adequacy by showing statistical significance (p= <0.05).

<table>
<thead>
<tr>
<th>Sample</th>
<th>KMO</th>
<th>Bartlett’s Sig.</th>
<th>Sampling Adequacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITS technologies 1</td>
<td>0.802</td>
<td>.000</td>
<td>Great</td>
</tr>
<tr>
<td>ITS technologies 2</td>
<td>0.628</td>
<td>.000</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

The reason to conduct KMO and Bartlett’s sampling adequacy test in inverse factor analysis (rather than common factor analysis) because, as described above, Q-Methodology requires very less sample size compared to number of statements (array). With respect to the number of statements i.e. 71(ITS-1) and 45(ITS-2) statements, sample size of 10 participants clearly followed the assumptions of sampling adequacy and Q-Methodology already but as mentioned above that Q-Likert methodology was introduced for which data collection method was modified too and arrays from each Q-Likert sort were also analysed, that’s why KMO and Bartlett’s test became necessary to check sample adequacy.

11. Factor extraction
The analysis was run to find the latent factors. The obtained scree plots were based on Eigenvalues (< 1 = factor ignored and ≥ 1 = factor retained), factors for both ITS technologies’ categories were extracted. Communality is a good check to understand that how much explanation can be obtained from the extracted factors and the rest over information (i.e. explained and unexplained information) can be estimated because when factors are extracted then some of the information is discarded too (Brown 1986). Communality value ranges between 0–1 and represents common variance. The extracted factors do not provide all the information about the variance and when extracted, the recalculated communalities change every time as more and more information is extracted from them. Communalities closer to 1 showed that the factors extracted were better in explaining the whole data. i.e. useful information that each expert held in their response while defining variance and explaining the whole data (0 (least) to 1 (most)).

Pattern and structure matrices were obtained through factor rotation. Both matrices were computed because the pattern matrix presented factor loadings because of rotation whilst the
structure matrix presented the relationships between the factors obtained. Researchers suggest (Field 2013) to use pattern matrix (as it is easy to use and interpret) with an additional check of structure matrix, if in case, pattern matrix exaggerate the values then it can be cross checked through structure matrix. That’s why both matrices were computed and utilized in this research. It is important to mention here that factor loadings tell us about the contribution of information that a variable(s) makes to a factor. The structure matrix is the product of pattern matrix and coefficient of correlations between the factors and gives information about the unique contribution of the variables to the extracted factors. Structure matrix involves two things, first, correlation between factors themselves and second, loadings from the experts whilst pattern matrix presents relation between variables (experts) and factors only. Both matrices were developed, analysed and interpreted. Further to this is factor rotation in the next section.

12. Factor rotation
The purpose of the factor rotation was to analyse existing relationships but from different angles (perspectives) to unveil further details and make details lesser ambiguous and more explainable. There are two types of rotations that can be performed i.e. Orthogonal and Oblique. The former rotates the factors by keeping them independent of each other whilst the later allows factors to co-relate with each other. In factor analysis, factors already correlate, and it makes more sense to prefer Oblique rotation over Orthogonal rotation. Oblique rotation is very complicated compared to orthogonal rotation because correlations are permitted to happen in oblique rotation. Brown (Brown 1980) has suggested to use Varimax or quartimax rotation methods that comes under orthogonal rotation. The test was run initially by using Varimax and then quartimax method of rotation, but no fruitful loading trends were observed to serve the purpose.

There are further two types of oblique rotations i.e. direct oblimin and promax. The difference between both is that in direct oblimin there is a constant called delta whose value is between 0 to ±0.8. This delta is the degree of correlation between the factors (Δ=Error! Reference source not found., default value that does not influence correlation between factors) (Field 2013). Promax is suitable for very large data sets. Based on these facts, keeping the delta value default (0) direct oblimin method in oblique rotation was applied. Another compelling aspect to prefer oblique over orthogonal rotation was that the variables in this analysis are humans (experts) and the nature of their professional commitments might co-relate with each other rather than being totally independent. This fact should not be ignored and was considered while analysing data.

13. Factor scores
Pattern matrix showed that after rotation how much loading each expert contributed towards driving each factor. Each set of statements called array (responses from experts on statements against Q-Likert sorts) and the loadings it carried were further interpreted with respect to the calculated and standardized loading scores along with additional information shared by experts as informational notes during completion of the questionnaire. Three types of Q-Likert sorts (i.e. significant, confound and bipolar) were observed when pattern matrices were made and were treated accordingly see (Brown and Steven 1968, Brown 1997) for details.

After factor extraction, it was important to investigate the details of the factors and their association with the variables to explain that what were these factors and what they should be called. Factor loading plot (after rotation) and matrices showed that each Q-Likert sort (array) and its elements had a different association with each factor so there was a need to give weight to each Q-Likert sort with respect to each factor. Some of the guidelines were followed from the original work of Brown (Brown 1980) where centroid method was used to give weight. Factor loadings from pattern matrix were used to calculate factor scores. It was described before that SPSS cannot calculate factor scores, so these scores were calculated
separately in Excel. The factor loadings from the pattern matrix were symbolised as “f” and “w” showed the factor weight calculations from these factor loadings.

To determine which factor loading was significant in the pattern matrix was determined by the expression called standard error of factor loadings (SE), $1/\sqrt{N}$, where $N$ is the number of statements (Brown 1968, Brown 1980, Barry and Proops 1999). Experts with loading greater than 2.58(SE) were considered statistically significant at the level of 0.01 and was indication of meaningful relationship between respondents Q-Likert sort and the factor type (Brown 1980, Barry and Proops 1999).

Standard error of factor loading for (ITS-1) 71 statements = 2.58($1/\sqrt{71}$) => 0.31

Standard error of factor loading for (ITS-2) 45 statements = 2.58($1/\sqrt{45}$) => 0.38

In this study loadings more than 0.31 (ITS-1) and 0.38 (ITS-2) were statistically significant at 0.01 level. In case where loadings on more than one factors were greater than these values, then the highest loading was considered by following the guidelines given by (Brown 1980) to calculate the factor loadings. But in case where the loadings were not statistical significant then the significance level was modified (raised) to accommodate the loadings (Brown 1980, Rajé 2007). In case if any two factor loadings are statistically significant for the same expert then that loading qualifies to be used with bigger value. It is suggested in studies that the selection of factor loading is totally dependent on the researcher’s decision (Brown 1986, Van Exel and de Graaf 2005, Watts and Stenner 2012). In this study, bigger value is preferred, however, the influence of lower but statistically significant Q-Likert sort is accommodated in general discussion to avoid discarding any information.


- Each rounded weight value was multiplied with the array of respective expert response.
- The standardization of all arrays of respective experts relating to each factor was determined.
- For standardizing, the array responses from experts for each factor, first, Q-Likert sort factor loadings (f) from pattern matrix for each extracted factor were separated. After separation, $w$ (weights) were calculated ($w= f / (1-f^2)$).
- Then inverse of the highest weight was taken and was multiplied with the weight calculated.
- Then the obtained results were rounded by multiplying with 10. Because of which each Q-Likert associated with respective factor gained a value.
- The weighted (rounded) values of each Q-Likert sort were then multiplied with each statement of the array (raw responses from the experts) of that respective Q-Likert sort.
- Then the sum of each statement score was calculated for which Z-scores for each statement were computed by using formula $(Z = \frac{T - \bar{X}}{s})$, where “T” is the total of each weighted statement and “s” is the standard deviation of the Total (T).

The Z-scores were calculated for sake of comparisons as well as to standardize (normalize) the effect of different statements in different arrays because each array had different effect on the factor. The process was repeated for every extracted factor. Based on Z-scores, an array was generated using the same scale that was used while collecting responses from the respondents i.e. Likert-scale. The index used for Likert-scale was kept compatible to Q-Likert-scale (-2 to +2). It was also noted that if Likert or Q-Likert-scale have index from (1 to 5) or (-2 to +2), they do not make any difference while interpretation of results and they are interconvertible too. Each statement was given a Likert-scale value ranging from -2 to +2. The procedure was that certain range was established, and the scale was allotted to each statement based on the range in which Z-score values against each statement were falling. The range determined to allot new scales for interpretation i.e. if computed Z-scores fall
between -1.5 to -2.5 then the allocated score for further interpretation is -2 and same procedure was repeated for other Z-scores’ computations. The standardized scores range from -2 to +2 (compatible with Likert-scale used while data collection). Each statement was interpreted with respect to its scores.

If any statement had same score but with negative signs, then both possibilities about the concourse were discussed. In other cases, higher loading was preferred over lower loading.

14. Factor Interpretation

The last step of Q-Likert factor analysis is factor interpretation. The statements designed were according to a concourse to serve the objective of this study and are discoursed (i.e. interpretation of results) in detail in next section. The results are presented in two ways. First, factors were identified, named and explained case-wise. Second, comparisons of the use of ITS technologies by authorities (experts) were explained in accordance with pre, during and post phases of disasters (not included in the scope of this paper). The first (discourse and discussion) and second part are explained below but before proceeding further it is important to check the reliability of the identified factors.

For reliability, \( r=0.80(p)/(1+(p-1)0.80) \), where \( r= \)reliability of factors (ranges from 0 (non-reliable at all) to 1 (extremely reliable)) and \( p= \)number of persons (experts) defining a factor. For further details check (Brown and Steven 1968, Brown 1986, Brown 1997).

Following are the results from reliability analysis for three identified factors for each ITS technology category.

**Table no 2: ITS-1 and 2 scores**

<table>
<thead>
<tr>
<th>ITS-1</th>
<th>r1=0.96, p1=6</th>
<th>r2=0.92, p2=3</th>
<th>r3=0.80, p3=1</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITS-2</td>
<td>r1=0.95, p1=5</td>
<td>r2=0.92, p2=3</td>
<td>r3=0.89, p3=2</td>
</tr>
</tbody>
</table>

15. Identified factors and discussion

As explained above that the Q-Likert statements were designed according to a concourse and now after identification of factors the concourse is discoursed to understand the depths of the interpreted analysis. It is to remember that Q-Likert sorts, additional information notes (used to support results drawn from analysis and add missing or further information), correlations and Pattern (and structure) matrices, factor loading plots, Eigenvalues, standardised factor scores and reliability checks were the main procedures to draw results. Further discussion about identified factors is given below.

16. Earthquake-Islamabad (ITS-1)

Three factors were extracted, and the obtained factor loadings showed that the responses from expert 5, 3, 1, 6, 7 and 8 loaded factor 1, expert 4, 9 and 10 loaded factors 2 whilst expert 2 loaded factors 3.
Figure 1. Factor plot in rotated factor space for ITS-1 (Earthquake-Islamabad)
The factors are explained below.

16.1 **Factor 1: Unnecessarily formal and laborious information flow/procedures among departments (time efficiency is slow if proper channel is followed)**

This identified factor can affect the other two factors too. As mentioned by almost every expert, from Pakistan that there is always a formal and laborious procedure involved to follow while communicating with higher authorities to take written permissions while performing responsibility/duties of any sort in managing transport and other systems in earthquake. A formal paperwork through proper channel is required every time to be gone through by neglecting sensitive moments to save lives which are quite time and effort taking. Often disasters such as earthquake do not allow time to go through prolonged and unnecessary procedures when lives of hundreds of people are at stake. Experts shared that if authorities take any action without going through such procedures then either it is not encouraged at all or if something goes wrong then that particular (personal) authority must bear all the criticism and negative results by public, media, politicians, judiciary and other sectors of society. It was also mentioned that conventional procedures are no more acceptable by newly hired experts staff and they feel very frustrated with laborious procedure so sometimes they by-pass these procedures and take actions on their own and do necessary settlements later, which is a risk to their job if they caught doing that which indicates a moral dilemma. Saving life should be priority and this act is greatly ignored. The problem is often observed in multilevel organizations, multilevel information flow with in same organization too (McMaster and Baber 2012). Though the role of the army dealing with major disasters is not covered in this research but, major disasters in Pakistan cannot be coped without the help of army where civil organizations are weaker to respond further levels of information flow and formal procedures are added (Ali and Kandhro 2015). There is need to show flexibility in prior paper works to respond and act efficiently. Modern ways of communication should be adopted within the organizational structure. In addition, the abilities of authorities should be trusted to get their best performance without unnecessary political, social or other influence.

16.2 **Factor 2: Lack of collaboration among all stakeholders (from top to bottom including transport and disaster management sectors) directly or indirectly involved**

The identified factor indicates the aspect that not all the stakeholders are usually taken on board while defining disaster relief plans. Mostly major disasters in Pakistan are handled by army and of course army is self-sufficient in accessing and utilizing resources, setting priorities, taking decisions and execution of plans (Ali and Kandhro 2015). Whilst civil
institutions are still in the process of developing skills. The way to progress is that take all stakeholders on board rather than progressing in separate directions and cross each other’s lines (Sahay, Menon et al. 2016). Experts shared that, unfortunately earthquake management agencies are not collaborating with transport system management sectors and with other institutions too. The problem has massive impact on the relief operations.

ITS technologies are used by all institutions and every department holds different expertise (such as earthquake monitoring, traffic and transport management) so working together and sharing resources while managing transport system in earthquake will create a huge difference.

16.3 Factor 3: Lack of an ITS enhanced rescue and emergency system
The identified factor highlights the need that rescue and emergency system that includes vehicles, rescue and searching operations and communications should be enhanced with ITS technologies. Experts shared that when drivers from other areas were asked for help to drive ambulances to the nearest hospitals (the ambulances in that specific area were destroyed) then those drivers could not help much because they were not aware of the roads, alternative paths and emergency land uses of the earthquake-affected area. If they could use ITS technologies in those vehicles, then it would have been more useful. Based on that experience now new vehicles are having radios, phones, walkie talkies, GPS system and other gadgets are inbuilt and installed with-in emergency vehicles and drivers are trained to use them efficiently.

17 Earthquake-Islamabad (ITS-2)
Three factors were identified and factor loading plots showed that expert 8, 4, 1, 7 and 5 loaded factors 1, expert 6, 9 and 10 loaded factors 2 whilst expert 3 and 2 loaded on factor 3.

Figure 2 Factor plot in rotated factor space for ITS-2 (Earthquake-Islamabad)
The identified factors are discussed below.

17.1 Factor 1: Lesser flexibility in sharing information data and absence of data bank
The identified factor highlights a dark side of the institutional system in Pakistan, that usually authorities do not have specific data, are not sharing their data and useful information with other authorities (Cheema, Mehmood et al. 2016) and do not prioritize collecting sensitive data (data is wasted). The reasons may involve rigid policies about data sharing, lack of trust, personal and professional issues, fear of criticism and unfamiliarity with the type of data to be collected. This also shows lack of coordination among different institutions because every institution may require different types of data. This creates a need of proper training of civil institutions to work in collaboration with each other and with a positive and professional attitude. There creates a need of another layer of dedicated experts who could have been a bridge between the army and civilian institutions and can perform in the same manner as
army does but utilizing civilian resources and practicing army’s traits. This could improve the access to ITS technologies and other resources while dealing with the effects of earthquakes and will generate a database too. In addition, there is need to get benefit from especially trained local people who can help with the immediate support before any help arrives. Sharing of data is very important to account for performance, gradual improvements and amendments in plans and performances. Follow up of every action taken should be done and used in further planning.

17.2 Factor 2: Fewer available resources and more disaster affected people
The identified factor shows that the available resources to manage transport system under earthquake are not sufficiently compared to the number of vulnerable who need it. This shows two aspects, first, it enhances community strength in return and secondly the fact cannot be denied that even though there are lots of hurdles, but authorities still use these resources and put their maximum efforts to handle difficult situations and give relief to people too. ITS technologies, if used, in a variety of ways and are deployed to their maximum potential can improve the performance of all operations regarding transport system and earthquake management in many ways.

17.3 Factor 3: Lack of implementation/practice of planned strategies
The identified factor shows some limitations of the system that there are lots of plans and strategies already designed but unfortunately most of them are only on paper and are not practiced so far. There may be many reasons for that such as shortage of budget, undefined priorities and political influences. As mentioned by experts of government authorities that now is the time to implement more and plan (as just a formality) less. Follow up of practiced strategies and plans are very important to evaluate the practicality and effectiveness of the applied plans. Continuous review and flexibility in amending plans according to the needs can enhance relief operations, information and communication system as well as transport system in earthquake. ITS technologies should be considered while developing every plan. The case is totally different from York where every activity is noticed, recorded, planned, implemented, followed up and planned again to implement. Learning from practice is not practiced in Pakistan (Cheema, Mehmood et al. 2016).

18 Conclusions
New methods to deal with qualitative data is need of the hour especially when complex problems are to be dealt in simpler ways whilst having small data set such as 10 participants. Q-Likert methodology is one of the methods that is introduced in this study to address complexity of data sources, collection and analysis. The method worked well as indicated by its application presented through the case-study of Islamabad. Further applications are needed to be generated to understand and extend method in various situations such as floods (which is done in further to this study, not presented here though).

A broad range of ITS technologies were included in this study to understand the problems in ICF when used by people and authorities. The identified factors highlighted many dimensions to be addressed by the authorities. The identified factors showed shortcomings within transport-earthquake management systems. Laborious procedures and unnecessary protocols lower the effectiveness of ICF even though many useful ITS technologies are present to be used effectively. Interrelated stakeholders do not share data or extend their concerns and favours to the other departments cause declines of useful efforts. Lack of flexibility towards other institutions in the time of need may cause further damages to live. As mentioned above that being Capital of the country Islamabad is a developed city and have enough resources even then there is lack of ICF with in departments, stakeholders and with other institutions. This lack of proper ICF is due to lack of ITS based transport-earthquake plans and strategies which needs collaborative efforts. Because collaboration among institutions reinforce
remedial measures taken in transport-earthquake managements. In last, it was surprising identified factor that even though Islamabad s rich in resources but still there were lesser resources observed compared to the density of people. The possible reason might be that there was uneven distribution of resources as VIP culture is quite common in Pakistan as is in other developing countries.

Further directions could be to apply same model on other case-studies of different nature, different disasters such as floods and with different complex scenarios. These recommendations are taken up in further papers by the author of this paper.

19 References


