Disasters and Recommender System: Setting the Research Agenda for Developing Nations

Shashi Kant Srivastava and Sanjog Ray

***Abstract*—The purpose of this study is to search for the potential applications of the recommender system in the event of a disaster. Furthermore, the present paper evaluates the existing technological capital of nations and its suitability for the deployment of a responsive recommender system. The result of the study suggests that the uninterrupted Internet network is an essential requirement for recommender system. In most of the developing nations, this system is either unavailable or becomes non-usable in the event of a disaster. Therefore, continuous Wi-Fi is the most desired requirement to deploy any recommender system to mitigate the effect of a catastrophe. Facebook's new solar-powered Internet drone is the solution for it. Towards the end, the paper presents a decision matrix for the deployment of suggested Wi-Fi system.**

***Index Terms*—Context aware recommender system, disaster management, emergency management, location based recommender system, risk management.**

I. Introduction

We organize this section into four sub-sections. First, we present an overview of disasters in India, Second, we introduce the technology of recommender system and its current applications. Third, we explain about our current research. In fourth sub-section, we are arguing that in evolving technological scenario our research is a major step of disaster mitigation studies and policy strategies. A disaster natural or non-natural phenomena which seriously disrupts the normal functioning of a human society causing human lives, economic or environmental losses to the extent that it is beyond the ability of the society to cope using its resources [1]. Presently disaster management area receives increasing attention from multiple disciplines of research [2]. In this respect, the GPS, GIS, and remote sensing technology have proved to be efficient in fighting against disaster [1]. In this research, we study one of the applications of information and communication technology (ICT), recommender system to mitigate the after effects of disasters.

"India is one of the most disaster prone countries of the world" [1]. Commonly occurring natural disasters in India are cyclones, floods, landslides, drought, and earthquakes. 80% of the total area of India is vulnerable to these disasters [1].

The recommender system is an area of information system (IS) which provides personalized information to the user. Literature define recommender system as systems that produce individualized recommendations that guide the user in a personalized way in a large space of possible options [3]. In the present time, recommender systems are one of the most used and efficient tools that provide users, the most appropriate information considering their personal preferences [4] and also need. In the field of a recommender system, the context means a feature of environment specific to time and a location based on which we may recommend services to the user [5]. Till date, the context-aware research is focused on the restaurant, tour guide, commercial and service oriented recommendation. Academia and industry are actively doing the research on recommender system for the last 10-15 years [6]. The research interest in recent years in this field has become even more popular [7]. The research area of recommender systems explores the ways by which we provide the most appropriate recommendation for service or product to the users, based on his context or previous information [6]. Personalized information's for various purpose to the user are extensively studied to recommend automatically him his most suitable options [8]. Personalized recommendation systems recommend the information required by a user using automatic information filtering method [8]. With the help of a mobile device, we may easily recommend the information's and services related to the physical location of user's. In particular, such research has focused on user interface and location. In this paper, we propose research agenda based on location aware recommendation system to recommend emergency measures with the help of the mobile device.

Individuals and institutions are required to response in a very narrow range of time with very limited options during emergencies. The ignorance of the most appropriate response to such situation leads to severe human and property loss. The existing system of appropriate response recommendation during and prior such unfortunate incidents are not in place. The objective of this paper is to search for ways to achieve higher and most suitable levels of responses following recommender system technology. In this paper, we illustrate the challenges faced by an individual in an event of the disaster. Furthermore, we also illustrate the potential help recommender system may provide during such disruptions. Research of use of recommender system for the purpose of disaster mitigation is not very old. To set the ground for future studies, we review the existing literature on context (location) aware recommender system and disaster management. After that, we focus on research themes to be addressed.

Rest of the sections we present as follows. Next we explain the overview of relevant literature and generate research gaps. In section three we illustrate the methodology adopted for research and share the experiences of the victim of 2014 Kashmir flood. Section four describe the technology

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of location based recommender system. Section five highlights the challenges of application of recommender system for disaster mitigation. Section six proposes various research agenda and section seven conclude with policy recommendation for deployment strategy of complimentary technology.

II. Literature Review

We present the literature review section into four sub-sections. First, we explain disaster and preparedness in the context of developing nations. Second, we illustrate the current models of the disaster management studies. Third, we analyze the literature and mention the gaps. Fourth, we formulate the research questions that we attempt to answer in the current effort. According to empirical evidence, the less developed countries are more vulnerable to the calamities happening due to disaster [9]. The sole reason for this is the inefficiencies of the governance and government of these countries [9]. The principle objective of disaster management is to provide appropriate preparedness before a disaster and efficient and reliable response and recovery following the disaster [10]. Disaster management is not only limited to the preparedness of disaster management authority, but it encompasses the whole system. We require the preparedness of the other facilitating institutions and also of the community. The ultimate goal is to respond efficiently and appropriately when a disaster happens to minimize the calamities and actual loss. Disaster management effectiveness implies that all the actors related to disaster including individuals have adequate personal and collective abilities. Furthermore, system capacity and plans are in place to mitigate the consequences of disasters [10].

The technology of recommender system is very new. Whereas, disasters are as old as the earth. Therefore, before recommender system, there are various models of disaster management mitigation. Some of these approaches and models are as follow:

A. After Action Reviews [11]

In any significant disaster, after-action reviews happen after field operations. The intention of examination is to determine how to improve performance for the next event. These reviews and recommendations suggest changes in existing design, strategy, and tactics. In the age of information technology, this approach is highly redundant and against the human kind. At the most, experience gained from the past by this approach may be integrated with the help of information system. We propose this integration will ensure an effective and appropriate mitigation measures for the present.

B. Decision-Primed Decision Making [11]

Decision-making capacity often drops under stress is a well-researched phenomenon [11]. This dropping usually happens to anyone in the case of disaster. It is notes that managers under stress engage in "recognition-primed decision (RPD) making" [11], [12]. Due to RPD at the time of emergencies managers do not relate the environmental conditions with the conditions written in standard operating procedures. They analyze the situation based on their mental map. Therefore, opting a wrong strategy rather than most appropriate. We argue that the recommender system will help managers to refrain from their (RPD) responses.

C. The Edge of Chaos [11]

Literature refers any event in the natural world that happens in a complex manner as complex adaptive systems. Biologist Stuart Kauffman [13], [14] suggest that all systems operate in the continuum. This continuum ranges from order to chaos. Every present state is nothing else but a prerequisite and compulsory state of later. Concerning environmental change the transition phase is most vulnerable. He terms this as the "edge of chaos," and executive require the most creative decisions. Managers and decision makers who are active and effective in this phase of transition are likely to be most effective for organizational growth. We require the similar management skills at the time of disaster. Disaster management of the recent disasters suggests that the present form of disaster management and disaster mitigating mechanism are not at all effective. They are not efficient enough to react rapidly in the turbulent transition situation. Such incidences happen, even after the presence of trained and efficient managers. Locus of responsibility is on the inherent friction of the present system. We argue that the automated recommender system will minimize this friction.

Surprising in all the models explained above to fight the disaster most important agent is missed. The most affected segment of the society is the least concern in the above-said processes. It is the affected society that needs the appropriate information first in such events. We commonly use electronic mediums for communications [15]. Researchers agree that there is a lack of the mechanism to access information electronically in case of an emergency [16]. Furthermore, theoretical work in disaster management is limited [17]. Limited knowledge base could be one of the reasons of poor response mechanism of the system. Integration of recommender system with disaster management network will make the system effective. At present this system is missing in most of the developed nations. Furthermore, due to its presence the affected population will be in the center of the whole disaster operation. This population will do two-way communication. One, in the form of recommendation and two, in the form of feedback. Based on our analysis of literature and the present gap we formulate our research questions.

Research Question – 1: Does recommender system technology has potential to influence the present disaster mitigation process positively?

Research Question – 2: What are the various research direction to which recommender system research should focus to influence the disaster mitigation process positively?

III. Methodology

To address the posed questions we have adopted qualitative research methodology. We combine literature knowledge and one case study to formulate research agenda. We examine the experiences of an Individual Mr. Baljeet Singh Saini, who witnessed the flood disaster of Kashmir, India in 2014. Taxonomy of IS research permits the

possibility of technological objectives within the case study approach [18]. The Case Study tries to uncover the foundational questions unique to individual cases. In Case Study research we argue: What are the characteristics of this single case? Case studies can achieve through verbal propositions that apply the rules of formal logic [19].

Case Study of Kashmir 2014 Disaster

It was very unfortunate 2014 for Jammu & Kashmir (J&K). In the month of September, J& K witnessed the worst ever flood in its known history. For more than seven days almost all the areas of Srinagar, which is the capital city of the state was under water. The case study of this disaster is taken as part of the study to understand the actual situation of the individual affected. Furthermore, we wanted to understand the real difficulties faced. The subject of this case study was in the affected areas during this disaster. For three days the subject was to live on the third floor of his residence because first two floors were under water. The ceiling of the second floor was only about a foot above the level of the water. It was 3.30 AM in the night when water started penetrating the floor of the basal level, and it took only one and half hour to submerge the whole storey completely. Within this one and half hour, the subject of case study could only take his mother, father, some eatables, precious belongings, and some electronics item to the upper floor. As a consequence of water logging, they lost the electricity and mobile network immediately.

IV. Location Aware Recommender System

In location-based recommender system, the GPS technology plays its role. Presently most of the mobile devices are GPS enabled. Therefore, these devices offer a significant advantage for providing the location based information [20]. With the maturing of smartphone technology location aware recommendation is becoming, even more, efficient [20]. Furthermore, due to the proliferation of smartphone technology, delivery of location-based advertising services to targeted user is very easy [20]. The built-in capability of the smartphone gives owner opportunity to share their real-time location with rest of the world. This technology also enables them to receive the location-based recommendations such as getting directions or availing relevant services [21]. There are particular location-based social network sites as well. Foursquare is one such network that is capable of providing superb location-based data of its users [22]. Foursquare has availability of rich data for multiple purposes. As a location-based service provider, Foursquare provides a unique information about the event from multiple angles (temporal, spatial, and geosocial) [22]. Due to this, we know the time and place of the event along with the people in our social network who attended the event. In coming section we explain the challenges faced in deployment of recommender system in event of disaster.

V. Challenges of Recommender System Research for Disaster Management

This section comprises of three parts. One, we explain the stakeholders involved in the disaster management process. Two, we describe the various phases of the disaster. Three, we explain the most important stage of disaster for recommender system. Disasters have their greatest impact at the local level, especially on the lives of ordinary people [23]. To implement comprehensive disaster prevention programmes at this level, Government and other organizations have insufficient resources [23]. Therefore, an involvement of the community is one of the essential requirements. Not only the government and the community, in a case of recommender system parties involved are many. These are community leaders, experts, local emergency management agencies, local governments, public institutions, and academia [24]. These partners contribute a broad range of assistance per their expertise. We classify these partners into two categories, one at receiver's end and another at provider's end. Beneficiaries are the receivers, and relief workers are providers. We further classify providers' into two categories, first, as immediate relief provider, and second, as long-term recommendation or knowledge provider. A recommender system is more to do with the immediate recommendation for the context, hence academia and experts for the purpose of present study is kept out of the study scope. The partners or agents in the present study are beneficiaries, Society, National Disaster Management Agency (NDMA), state government and central government. On the contrary, for popular recommender system, it is only three party recommendation i.e. user, society and service provider. This fact illustrates the complexity of recommender system in the disaster context.

To further understand the relevance and appropriateness of recommendation for disaster context it is important to know the various phases of disaster management and complexity. Different stages of disaster areas below. We may apply recommender system to these stages.

- Pre-signal phase
- Post-signal phase
- Disaster phase
- Post-disaster phase
- Lesson learnt documentation phase

No exact time duration we may assign to any of these stages of the disaster. With experience, we may conclude that there is an overlap in pre-signal phase and lesson learnt documentation phase that may be around a year or more. Pre-signal phase based on previous experience can be utilized to recommend the nature and level of preparedness in advance to all the residents. These recommendations will not only alert the society but also create a social awareness for possible disaster. A social awareness may be an important pressure to mobilize the not so motivated segments.

Post signal phase may not exist for many disasters particularly when disaster is immediate without warning. Earthquakes are an example of such disaster. Even in the case of the existence of post signal phase, it will not be more than a couple of days. Mostly only a couple of hours is available. The role of recommender system becomes very significant at this stage, and appropriate recommendation may save precious lives and belongings of beneficiaries. Information flow between all parties involved in post signal phase is critical to utilize the benefit of a recommender system effectively. During disaster phase the need of

recommendation is as follow:

- Beneficiaries need recommendation about what to do, what not to do, where to go, whom to contact
- The local administration needs recommendation whom to protect, how to protect, where to inform about an incident, how to inform.

Furthermore, it is a responsibility of authorities to minimize the panic. Here we would like to mention a quote, "*it is not the disaster that kills people but the panic*". Disaster phase normally does not exceed more than some days and hardly more than a week. During this period, GPS enabled mobile may give a good picture of the number of disaster influenced population to authorities and authorities may immediately contact these people and give the appropriate recommendation.

VI. Proposed Research Agenda

In the area of recommender system a good amount of research has already been done [6]. Existing approaches lack in additional contextual information, such as time, location, weather and the user's current need. The research agenda presented in this paper takes into account the existing gap in the recommender system research. Furthermore, our research is centered on location, weather, time, and user's device for the recommendation during the emergency. Following flow chart depicts the needed logical decision and direction of information flow in the event of the earthquake one of the very critical disasters.

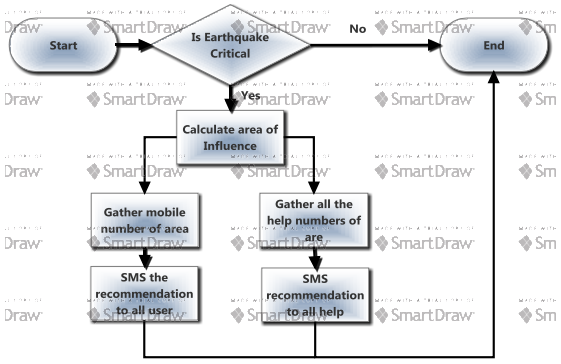

Fig. 1. Suggested recommendation flow chart.

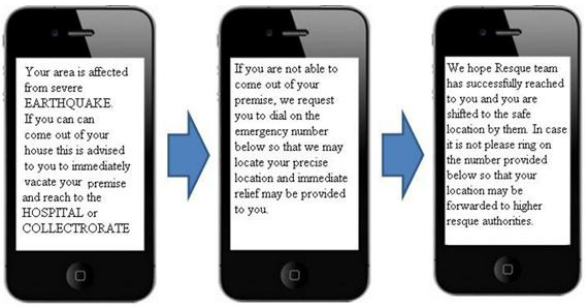

Fig. 2. Example of Recommender System to Earthquake affected population.

In Fig. 1, all the branches of information flow network and nodes represents a potential area of research. Future researchers may also include the practical possibility and management challenges for the process suggested before. Furthermore, as a result, of this recommendation followings, electronic messages may timely reach to the affected population and responsible authorities, to act accordingly.

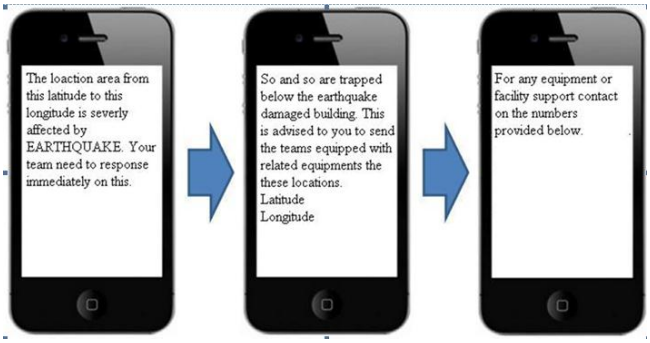

Fig. 3. Example of recommender system to be forwarded to Disaster Management authorities.

VII. Conclusion

In this paper, we identify the opportunity that recommender system offers in the event of the disaster. The present research suggests that there is an unlimited possibility of the design of system architecture that immediately responds to the influenced population and the responsible authorities in the event of the disaster. To overcome the present limitation of appropriate information access and emergency response recommendation, we suggest GPS enabled mobile based recommendation. The proposed system is location aware and personalized. Furthermore, we propose predefined disaster response mechanism that immediately comes to action once there is an emergency. This emergency activated response system will immediately interact with all the mobile users of the emergency area. Furthermore, if a user is already familiar with the user interface, response time will further reduce, resulting in the minimum potential loss. For future works, researchers should take into account the usefulness of usability tests for all the relevant phases, and enlarge the scope of study recommendation to NDMA, state government, and central government.

All of the above recommendations are fruitless if mobile networks are not available during the time of disaster. Furthermore, it has been observed in all of the disasters happened so far that in the event of the disaster, electricity and mobile network are first to collapse. Therefore, above recommendations are practical only in case of uninterrupted mobile or Wi-Fi network. Fortunately, Google and Facebook both organizations are working in tandem with Government of India to provide uninterrupted Wi-Fi. This technology is possible with the help of drone [25]. However, as we know India is colossal country and most of the India (around 80%) is affected by disaster [1]. India being a developing and huge nation, there is the possibility that such installations may not be feasible all at once. Policymakers need to prioritize the region over which they decide to deploy such facilities. To assist policy maker for such scenario, based on two parameters we have prepared decision matrix. The severity of the disaster is one parameter of this matrix. On the severity of the disaster, we

propose the deployment of the drone Wi-Fi. The second parameter is the technological capital of the deployed area. We have taken the technological capital as the number of mobile and smartphone connections. In case the area is highly vulnerable to disaster but if most of the people in the region does not possess mobile. The investment will not reach to the majority of the population. Therefore, high proneness to disaster and high on technological capital are the areas where we should deploy such drone Wi-Fi immediately.

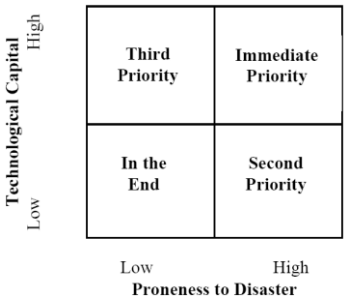

Fig. 4. Priority matrix of drone Wi-Fi installation.

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