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Drone Based Resilient Network Architecture for Survivals in Earthquake Zones in Pakistan

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Abstract: Earthquake is one of the unpredictable natural disasters which causes serious damages including human life and infrastructures. The gaining information about earthquakes before they occur in not possible yet, however, the efficient disaster management (DM) services and their arrangements are essential after the earthquake to save human life and restore communication services which can help to locate victims over or underground. The recovery from earthquake can only be managed and obtained by a proper planning, well equipped response systems and resilient communication networks. Earthquakes are well superintend by many countries such as Japan and governments have plans and facilities to provide the quick response just after happening of earthquake. The National Disaster Management Authority (NDMA) was established by the government of Pakistan for natural DM. The services of NDMA is linked with the army and they always appear in front to manage disasters with their teams. In disaster zone, the armed force establish their own communication services but no service exists which interact directly with victims over or under ground. No concept of resilient communication network exists in the policy of NDMA and never discussed at national level. Wireless communication networks play an important role soon after the earthquake, they just not help to restore communication in that zone but can be helpful to locate victims. The available smart technologies linked with high speed internet services via cellular communication and can be used to establish wireless Adhoc services. In this research, a resilient ICT network which is Drone Based Resilient ICT Architecture is usedfor Survivals in Disaster Zones.

Keywords: Disaster management, Early Warning techniques, Resilient Networks, adhoc Networks,

1. INTRODUCTION

Pakistan is geographically located in different disaster zones that are affected by global warming, climate change, earthquake, floods, landslides, drought and glaciers melting etc. During past decade, Pakistan is severely affected by earthquakes. In October 2005, the earthquake at Kashmir, in2013, and 2015, in various cities of Khyber Pakhtunkhwa province affected severely, thousands of people died and large property has been destroyed. The lake of communication mechanism and cooperation between different government services, absence of community awareness, unsatisfactory planning, and lack of technology awareness and the implementation of technologies were the most common challenges faced by Pakistan in recent years to handle different disasters.

In Pakistan, there is an organization known as National Disaster Management Authority (NDMA) who is responsible for handling all type of disasters. In worldwide organizations there are multiple things to engage with the disasters and follow some methods, planning's and some rapid response or resilient networks that are active on the occurrence of the disasters to handle the situation. But in Pakistan there is no proper mechanism to handle it under one organization, it is generallya combination of multiple International, National, Private and public organizations to face the disasters. NDMA have not any permanent and rapid response architecture for the DM under one umbrella (Ahmed, 2013). There is no proper early warning system which is available in response to any disaster except flood forecasting (Chatfield, 2013). The real time communication networks are also not properly used by NDMA and they do not have suitable mechanism of networks with continuous communication in disasters. Although there are various types of Networks which are used in disasters in other different countries. Disaster Management (DM) planning is a key factor to resolve the problems which are occurred in and after disasters.DM plan comprises a number of objectives to enhance the emergency planning, assessment and preparation, under different IT solutions with different issues discovered in SAGA (Self-protection Management Support System) Spanish organization. SAGA is the collection of different instructions to handle effectively many disasters. (Canós, 2013). The significance of understanding in emergency situations, the Delphi method is used in dangerous areas for the communication between different components in disaster controlling (Laakso, 2013). Different types of methods are used to build local resilient systems which further involve the local community to meet the emergency with different

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methods. The International organizations whenever are using the efficiency of the local community is increased due to the information provided by them and that can be effective to meet different types of challenges in different disasters. The combination of global and local groups play a vital rule in emergency situations (Olwig, 2012). There is a vital role of Large Information which can be used in maintaining social networks in the emergency Situations such like gathering information via twitters, Facebook, WordPress, Instagram, YouTube, Google, local news, and structured data, responses from 205 managers were involved in an earthquake relief actions in Nepal Disaster in 2015 (Papadopoulos, 2017) It is very important to conduct the study on the change in the surface during the earthquakes and aftershocks of disaster that would be assessed and analysed (Sharma, Babita, 2017). During the great earthquake in East Japan, the retrieval of the information from the existing network system was very poor and there was a need to build such resilient net works that can have high performance in earthquakes, therefore, an improved resilient network is suggested to meet the future earthquakes disasters(Shibata, 2016). The paper is sketched as follows. Section 1 consists of the outline of introduction, section 2 presents research background. In section 3, the designing of logical architecture is presented. Section 4 presents the result and discussion. Section 5 is the last section which present conclusions.

2. RESEARCH BACKGROUND

In the literature review, many researchers proposed various types of information communication and telecommunication networks (ICTN) for disaster recovery management globally. For instance, the networks likeGSM Networks are used to find the location and the traffic for all the users in the cell through the mobile networks. The mobile network is essential to facilitate the localization of cell phones, mostly in disaster circumstances. There is a need of network which can deal with adjustment and an enactment of existing GSM networks. (Steenbruggen, 2013). The combination of the Mobile Ad-hoc Networks (MANETs) and Vehicular Ad-hoc Networks (VANETs) in terms of connectivity, better service quality, better message routing, flexible node motion, in the disaster application areas is very important (Narayanan, 2012). In micro unmanned vehicles, the mobile sensor networking architecture is using software defined network (SDN) Technology. This is a suggested architecture which aims to improve the performance of device panel, data transmission between moveable vehicles (MAVs) in emergency situation (Yuan, 2016). Communication Networks are the Lifelines and it is vital that those networks are still functional after major natural disasters such as earthquakes. Lifelines networks require four-dimensional analysis calculating constancy with respect to a given earthquake hazard map. For this purpose, GIS based software is very important for the spatial assessment. The GIS-based software ingresses seismic hazard and lifeline network layers and then creates a gridded network structure. The developed GIS-based software component that creates the GIS-based trustworthy map of the lifelines under seismic hazard. It is user available, adjustable, adoptable, and fast in performance, time, and explanatory and authenticated Network in earthquake especially (Selcuk-Kestel, 2012). High altitude platforms (HAPs) and Flying Ad Hoc Networks (FANETs) are the most likely efficient network technologies are used for space wireless communication systems. High altitude platforms networks typically exist in altitudes up to twenty five kilo meters above the ground and have the benefits of adjustable arrangement, with the wide-area transmission along with satellite and ground station for the flow of information. The UAV, have the capability to fly over the number of hours to several days at high altitude in different disaster operations which is impossible for ordinary manned aircraft. Therefore, the combination of both technologies have many advantages over the existing networks (Temel, 2013). A geo motionless balloon networks located at high altitude are cost effective and advantageously uses different techniques to collect the data from the transmission towers as compared to wireless revolving spaces and telecommunication networks associated with high speed wireless broadband internet (VanWynsberghe,2016). The telecommunication structure is frequently damaged in the disasters, so the reliable communication is much needed and recommended and it is very essential in rescue and search task in the disaster such as earthquakes. This problem can be solved by swarm quad rotor robots which are being developed and they are capable of self-deployment and also capable of extending the coverage of available Wi-Fi network. Since most hand held devices now have Wi-Fi connectivity, the most devices can join the network created by the quad rotors. Quad rotor is now built with Wi-Fi adapters and added GPS module. The quad rotor is based on Parrot AR Drone (Alvissalim, 2012). Drone machinery is altering quickly the existing manned helicopters and the micros drones which are called flying ad hoc networks are widely used now in disasters. FANET earlier can support the manned helicopters in different areas such as news reporting, safety operations patrol pipeline and power line. The macro drones range from five pounds to thousands of pounds. They are also used in support of manned helicopter which is used in short range missions at a very high altitude where the manned helicopter is unsafe and they can also fly near to the targets which can be too dangerous for the manned helicopter. Truly,

now the drones are flying such dangerous missions in Europe and other parts of the world. But the planning of drones, even for demonstration and testing. The drones is not available in the United States because of the congress directed plan for the use of drones in the national airspace. Larger drones "macho drones" are not yet available outside battlefield and counter terrorism spaces (Perritt, 2014). Unmanned aerial vehicles also known as drones, are expected to provide diverse civilian, commercial, and governmental services. The usage of Unmanned Aerial Vehicles has now started in different civilian sectors. Unmanned Aerial Vehicles are used for environmental monitoring which includes the monitoring of land pollution and industrial coincidences. (Motlagh, 2017). The Unmanned Aerial Vehicles are used in different systems such as military and civilian. The future advanced technology; robotic systems such as communications, wireless sensors, multi core processors and resilient networking technologies have great advantages in the future upcoming technologies. Enhancement and expenditures of UAVs are quickly reducing and there isa more promising role of UAVs in futures large area task with different types of application that will play a vital and increasingly noticeable role that can face challenging tasks in the disasters. UAVs need to collaborate with other networks which are used in order to perform difficult tasks especially in areas that are unreachable from the ground and earthquakes. UAV, s deployment is rapidly needed with different effortless, cost effective networks. These networks like multi UAVs with single UAV can work together to reduce the time of mission, finishing point and also improves the reliable communication as compare with the single UAV alone. The multi-UAVs Networking is not only required but also a serious actions are required to increase the capability of the system by ensuring connectivity of the systems in non-Line-of-Site, hostile ,urban and in the noisy environmental managing systems. To increase the scalability of the system, there is a need of new networking standards concepts in multi-UAV systems. Because of the highly deployed mobile stations, with the networking structure constructed in ad-hoc manner, is called as flying adhoc networks (FANET), which needs accessible, dependable, simultaneous and peer-to-peer mobile ad-hoc networking between UAVs and ground stations.

2.1 Some existing Drones Technologies used to save survivals in different countries reported in Dà-Jiāng Innovations Science and Technology (DJI) report **(**Anon, 2017).

Table.1 Depicts the Number of technologies used in Drone Technology

Country	Technology used through drone	Technology limitations
Canada The Drone News (2017).	Infrared Camera and other Camera technology	In Canada, in three disasters the simple drones were used with the Infrared camera and with a normal camera embedded to save six lives.
USA DelPrete, C. (2017).	Camera/GPRS, Heat Sensing Cameraand Hook embedded with camera.	In USA, four types of the technology embedded drones were such as camera/GPRS, Heat Sensing camera, simple camera and hock. Attached used in eight disasters to save fourteen peoples.
China News.sohu.com. (2017)	Hook embedded with camera	In China, drones were used with very simple technology just camera with hock embedded to save twenty seven survivals in five different disasters.
UAE Sports Sina (2016).	High Resolution Camera technology	In UAE, two persons were saved with simple camera embedded drone technology
Turkey Mail Online. (2017).	Camera Technology	In Turkey, ten lives were saved by the single technology based drone

3. COMPARISON OF EXISTING DRONE TECHNOLOGIES

The comparative analysis of different drones was used to rescue the people were mostly single based technology as shown in Table 1. We have taken the actual data from the recently published report by Dà-Jiāng Innovations Science and Technology (DJI) in the USA, which claims that how much powerful and helpful the drone are which have saved numerous peoples in several incidents which were reported in media.

According to that published report byDJIthat the drones have saved 59 lives in 18 incidents and now it is reported that drones are saving one person per week. Here is the list of the number of disasters and the people saved by the drones in Table 2taken from the report published by DJI, **(**Anon, 2017). The Table is having three fields; the country name where the disaster occurs, numbers of the survivals saved by the drones. The survivals were saved by drones in all incidents.

Table .2 Shows Disaster report by DJI worldwide 2017

Country	Type of Situation	Number of Survivals located using drone Technology
Canada Franzen, C. (2017).	Heavy Snow, Darkness/ Night, Snow field	**05**
USA Drone360. (2017).	Flood victim Taxes, Flood Missing women, Victims of flood, Heart attack patient Lost hunter and dong Twitter tips help in saving, Finds Kayakers at Night	**14**
China Baoji.gov.cn. (2017).	Heavy rain ,Flood water Flood victims, High level of flood, Lost hiker	**25**
UAE Anon, (2017).	AJMAN Sea beaches	**02**
Turkey Mail Online. (2017).	Lost film crew in Snow	**10**

Canada was affected by the disasters in 2013, 2016 and 2017 by which the drones were used to rescue people. The no of people saved were 1, 1 and 4 respectively as per year as shown in **(Fig 1)**.

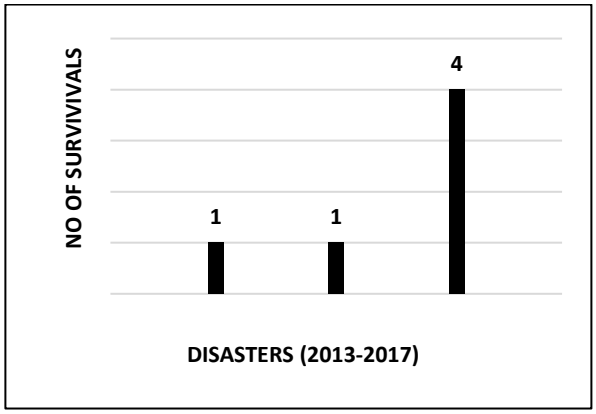

Fig 1. Survivals in Canada in disaster by the year - (2013-2017)

The result of different disasters in the USA and the number of lives saved each year is shown and discussed as referred in Table2. The above mentioned Table 1 depicts saved survivals through the usage of drone technology during the different disasters in the U.S.A by the years of 2014, 2015,2016 and 2017 respectively. **(Fig 2)** shows graphical representation of various data from the different years.

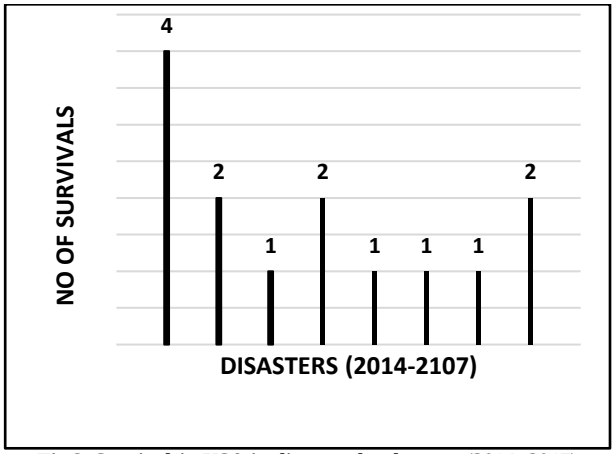

Fig 2. Survivalsin USA in disasters by the year (2014 -2017)

The results of different disasters occurred in China according to the years and the total number of survivals saved by drone was 27.In disasters (2015-2016);in China 14 survivals were saved in 2015 and 13 survivals were saved in 2016by drones as shown in **(Fig 3)**.

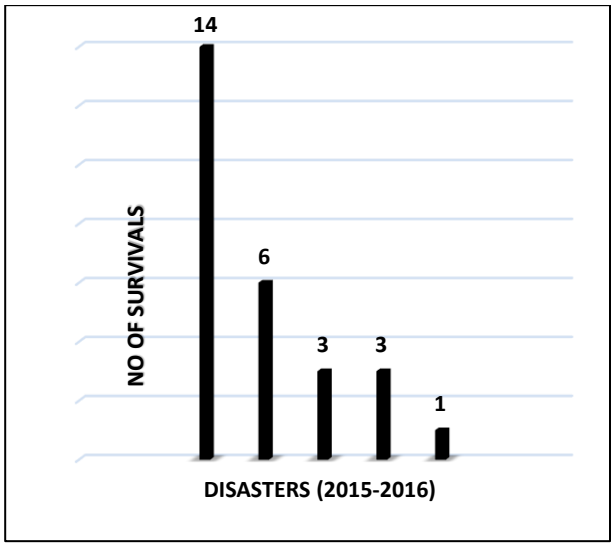

Fig 3. Survivals in China in the disaster in the year-(2015-2016)

The overall results are taken from the Table 1. Total number of disasters in various countries during recent years and the number of survivals saved by the drones. In 2013, in Canada, one survival had been saved. In 2015, 14 survivals in China and 6 survivals in the USA were saved by drones. In 2016, 13 people in China, 10 people in Turkey, 6 people in the USA and 1

individual in Canada was saved by drone. In 2017, 4people in Canada, 2 people in the USA and 2 persons in UAE were saved by the help of drones as shown in **(Fig 4).**

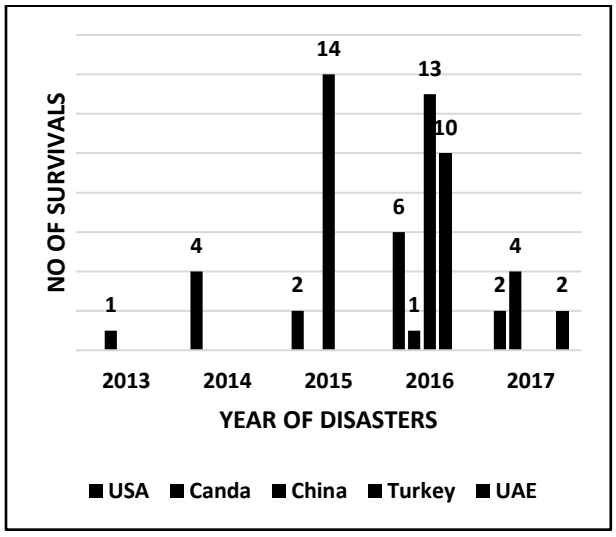

Fig 4. Survivals of different countries in disasters by the year (2013-2017)

4. The proposed Architecture of Drone Based Resilient Networks (DBRN) for disasters in Pakistan

The Drone based resilient network (DBRN) architecture is been proposed because of the best technology available to replace the existing technologies such as fixed wings aircrafts and helicopters which are being used in various disasters specially earthquakes. One of its other features is that it can be also used on the ground, sea and in search and rescue operations as well.According to the Dà-Jiāng Innovations Science and Technology **(**DJI) report and other facts that were found in various disasters that there is vital role of the drones in the future technologies which will be used in the search and rescue operations, as they are easy to manage, very cheap to other regular available resources such as manned aircrafts and helicopters, and can perform better in the disaster situation to locate survivals.

Conversely, the drones are not capable of doing everything which is required in the search and rescue. Mostly drones consist of a camera which is like sky eye through which the operator can see for what he is searching for. The drone camera view is very narrow as compared to the human based helicopters that can search in wider areas. Nowadays, drones are used by large of persons, the organization in groups and linked into military, police emergency operations to save human lives, the future rescue network would consist of mostly drone based networks to take a prominent role in saving the lives in search and rescue operations.

DBRN will comprise of various aspects of disaster management, one can say it is communication architecture with the related technologies which will be used in disasters such as earthquakes. Fig-1 shows the components of proposed DBRN architecture. Once the proposed infrastructure is established, it can be used for disaster management other than just earthquakes. **(Fig 1)**. shows the general framework architecture of proposed DBRN system in Pakistan.

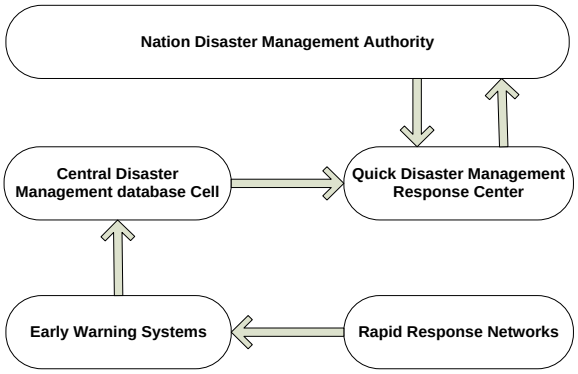

Fig 5. Proposed General Architecture of DBRN

The Proposed general architecture of DBRN is shown in **(Fig 5)**. The DBRN architecture can be incorporated with NDMA, with its components such as Quick Disaster Management Response Centre (QDMRC), National Disaster Management Organization Database (NDMOD), Early Earthquakes warning System Networks (EWSN) and Rapid response Networks (RRN) respectively.

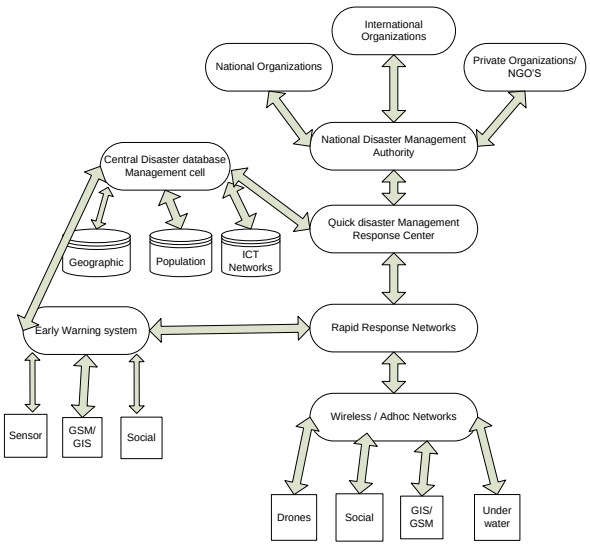

Fig. 6 Proposed Logical diagram of DBRN

The Proposed DRRN has various kinds of the component which are used to retrieve and transmit the information from disaster zone to central data base system.

5. FEATURES OF PROPOSEDDBRN ARCHITECTURE

DBRN comprises of various aspects of disaster management, one can say it is a communication architecture for related technologies which are responsible for the better and efficient communication just after the earthquakes

- DBRN Model can be incorporated with NDMA
- It will contain Rapid Response Communication
- It will restore communication just after earthquake
- It will provide multimedia information to Central Database centre
- It will also locate the victims above the ground and under the ground
- It will provide Exact information about the damages and infrastructure destruction of the earthquake zones
- It will be beneficial for the surveillance services and rescue services as well

5.1Central Disaster Management Database Cell (CDMDC) Proposed DBRN

This component of Drone Based Resilient Networks (DBRN)has performed the following activities to manage the incoming and outgoing data from the system as shown in Fig.3.

- Central Disaster Management Database Cell(CDMDC)
- All the Earthquake zones will be marked as Red Zones in Pakistan and AJK
- It will have all Geographical Information about the Red Zones of Earthquake Area
- Population records
- All Cell Phone Number Records in the Red Zones
- Records of buildings Lakes and Rivers
- All the Red Zone area will be equipped with Some EWSN and RRN
- Also, have some existing Networks

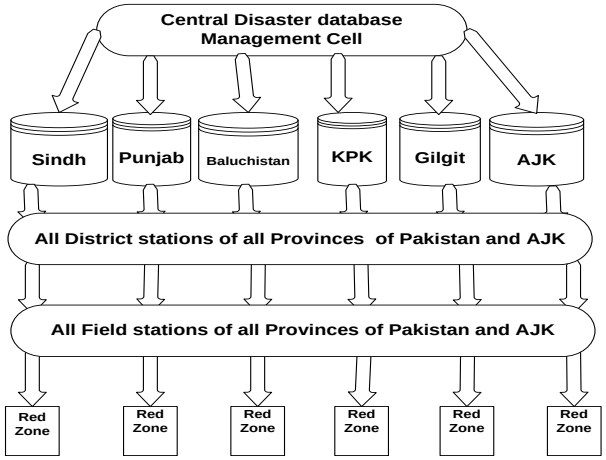

Fig.7 Central Disaster Management Database Cell (CDMDC) of Proposed DBRN

5.2Early Warning System Networks (EWSN) Proposed DBRN

The EWSN will consist of the followings components that would generate the early warnings to the concerned organizations and it will transmit the early warnings to the NDMRC and will consist of the following as shown in **(Fig 8).** A lso,it will generate the early warnings to the QDMRC through RRN and will consists of the following systems

- Drones
- Sensors
- Radio/TV
- GSM Mobile Networks
- Internet/Social Media
- GIS

5.3 Quick Disaster Management Response Centre(QDMRC) of Propo

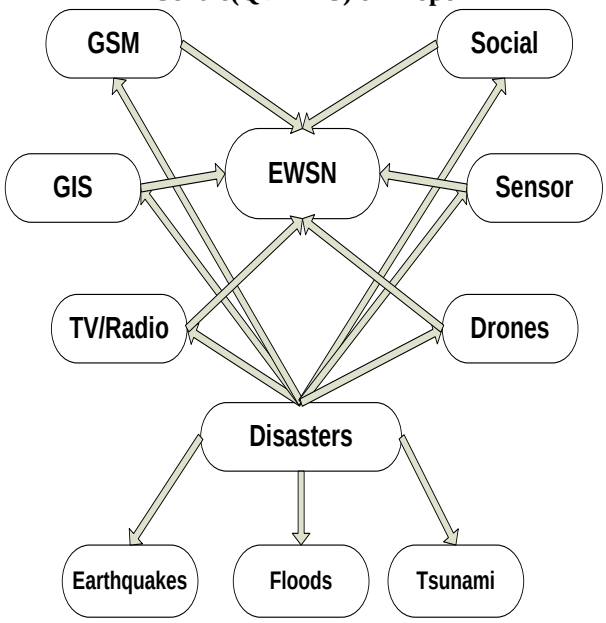

Fig 8.Early Warning System Networks (EWSN) of Proposed DBRNsed DBRN

- QDMRC will have all the basic information of entire DBRN Model and its Network Components
- Information given by the EWSN will be sent to the RRN for the necessary action should be taken by them in Emergency Situation
- RRN will decide which network should be activated according to the geographic area and situation
- NDMA will also convey its information to International, National and Private NGOs for the aid and help that would be required during Emergency. **(Fig. 9)** shows the associated database of the DBRN.

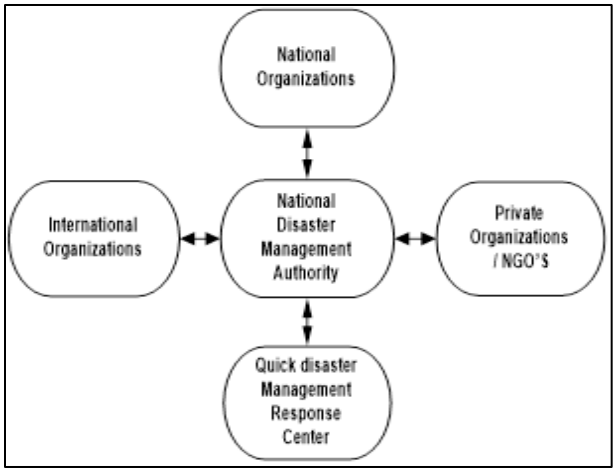

Fig 9. Quick Disaster Management Response Centre of Proposed DBRN

5.4Rapid Response Networks (RRN) of Proposed DBRN

Fig. 9 represent the proposed technologies for rapid response network. Which is used to send the various kinds of alerts before occurring any kind of natural disaster. The various alerts incudes as following.

- The RRN is the most important part of the IRA
- All existing and resilient networks will be activated through RRN
- RRN will consist of following types of Networks, Wired, Wireless, and Adhoc Networks
- RRN will be responsible for establishing the communication between all components of the DBRN model.

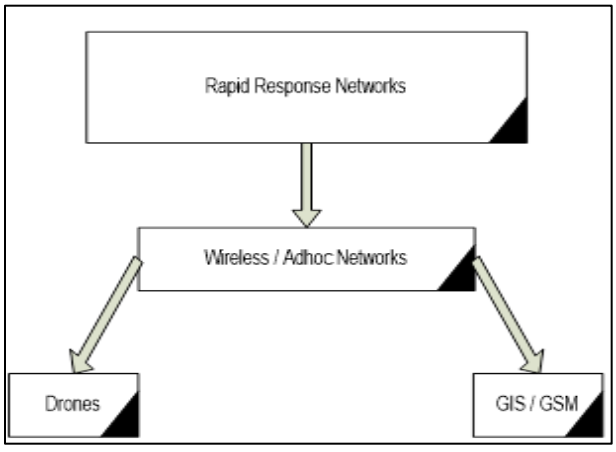

Fig 10. Rapid Response Networks (RRN) of Proposed DBRN

5.5 Proposed Resilient DBRN response after earthquake and will be able to perform following tasks

- It will restore the communication
- It will share the real time information
- It will locate the earthquake survivals through different types and ranges of Sensors, GSM Technology, GPRS and GPS Module Technology.

6. CONCLUSION

In various disasters which occurred in different countries, the drones used were based on a single technology and although with that they manage to save lives. To face the disasters, we have proposed a technology that is multiple-based technology which will be the best option to be used in such types of disasters. The DBRNarchitecture has different sensing devices like Respiration sensors, presence detecting sensors, thermal sensors, passive infrared sensors (PIR), infrared sensors, and high pixel camera, GPS, GPRS and GSM module can be used to locate and identify the human body within upper and under the surface of disaster zones. Once the proposed infrastructure is established, it can be used for disaster management other than just earthquakes. The novelty of the proposed approach is that it is not going to abolish the existing infrastructure regardless how weak it is. It is revitalizing the old infrastructure by adding a number of technological and managerial elements as well. It is going to involve various governmental and private organizations to play their role in national disaster management program. It will be versatile enough to comprehend all kind of environmental effects and geographical zones like urban, rural, and mixed. Furthermore, this infrastructure can incorporate more sophisticated technologies over the time to combat with the disasters in an even better way in the future.

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