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Utilization of Telecom Technologies for the Disaster Management in Underdeveloped Coastal Districts of Pakistan

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Abstract
Information and communication technologies plays critical role in all phases of disaster management, and enabler of e-services delivery to the underdeveloped areas. Unfortunately this critical infrastructure is highly prone to disasters. This paper is based on coastal areas of Pakistan, which were badly affected during floods 2005 -2012. Universal Service Fund (USF) Pakistan has started many telecom projects for broadband infrastructure, telemedicine and distant learning to uplift the livelihood of underdeveloped areas. The telecom infrastructure collapsed during disasters and population sustained heavy damages due to unavailability of disaster information. Causes of breakdown of telecom infrastructure are investigated. Remedial options are found from literature review, public's reports & case studies. Then, these technological options are applied upon Pakistan regulatory & telecom infrastructure context and two separate plans for survival of narrowband and broadband communication are proposed. Another contingency plan for easy deployable temporary infrastructure is given for the case of total blackout of communication. An overview of existing information & communication systems weaknesses & gaps are given, its remedies are discussed for the effective mitigation of disasters. This study can be extended to other underdeveloped regions of the world to serve the calamity struck regions with fewer economic and human losses.

Keywords: Information and communication system, Telecom infrastructure, Coastal areas management, Emergency communication, Floods.

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1.0 Introduction

The year 2012 is the third consecutive year of severe flooding in Pakistan(BR Research, 2012), took more than 500 lives, affected 5 million people, caused wide spread destruction in more than 14000 village. Coastal areas were severely affected, where there is un-functional early warning system, chronic level of poverty, poor infrastructure, insignificant health facilities, lack of education and sanitation amenities, deteriorated livelihood conditions, very few water resources that too is contaminated, no electricity in most of the areas (NDMA, 2010b). Only Karachi is the developed city in coastal areas; other cities and rural-coastal sub-divisions are mostly deprived of basic necessities of life.

The total length of coastal zone is 1020 Km, 350 Km lies in Sindh province; rest of more than 70% 770 Km is located in Balochistan province. Baluchistan's coastal belt spreads through Makran Coastal Regions. Coastal area of Sindh province consists of Karachi, Badin and Thatta districts. About 250Km of Sindh coast is linked with Indus delta region at Thatta and Badin Districts. Both of these districts lie at the tail of Indus basin (Khan, 1991).

In Pakistan fluvial floods are common during monsoon season from May to September originating from Bay of Bengal and resultant depression triggers concentrated rain, causes widespread damages in rivers especially in Indus and its tributaries. In Thatta and Badin, the river Indus terminates in Arabian Sea from Kotri Barrage via various streams, which undergoes severe flooding during passing of high volume of water from upper high elevation plains during floods(Akhtar, 2011). Due to decreased downstream flow after construction of Tarbela and Mangla Dams, sea water is destroying the irrigation lands via backpressure. Badin is victim of another manmade disaster Left Bank Outfall Drain LBOD, an Asian Development Bank catastrophic project failed due to wrong design and natural disasters, primarily made to lower water table and salinity from Upper (Northern) Sindh districts into Arabian Sea. The brackish water, instead of going into sea, made its way into water bodies and agriculture lands of Badin district, and causing erosion and destruction of income resources. During floods, standing water from upper districts is drained into LBOD which conversely causes widespread damages in Badin(SIDA, 2011).

During winter heavy rains are caused by Arabian Sea's seasonal low and Mediterranean (westerly) waves. Sometimes high floods also occur due to overtopping / breaching of small dam caused by landslide / manmade. Shadikaur dam near Pasni tehsil (sub-division) usually spills during heavy rains, causes deaths, affects livelihood and destruct property. The flash-floods are common in coastal districts of Balochistan i.e. Gwader, Awaran and Lasbela. They cause extensive damages to buildings, farmlands, orchards, livestock, water supply and other public utility infrastructures(Tariq & van de Giesen, 2012).

Coastal areas are occasionally hit by severe cyclones. The frequency rate is about 1.66 cyclones per year(Hussain M. A. et al, 2011).It generates a spell of torrential rains in the region. About 75% of the Arabian Sea cyclones travel towards western side at Oman, and remaining 25% journeys on eastern side to coast near Rann of Katch(MoE(Pak), 2003).

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2.0 History of Natural Hazards in Coastal Areas of Pakistan

The natural hazard occurrence rate according to Center for Research on Epidemiology of Disasters CRED shows an increasing trend from 1974 to 2003. The increased manmade activities are causing intensification of greenhouse effect, as a result of global warming the intensities and frequencies of natural disasters have increased to unprecedented scale during last ten years like rest of the world(Ainuddin & Routray, 2012). Following is brief mention of disasters in coastal areas.

The flood in irrigation plains of Sindh is a usual phenomenon. The worst floods were observed in 1950, 1955, 1956, 1973, 1975, 1976, 1978, 1992, 1995, and super flood 2010. Of all the country's population affected by natural disasters, the major chunk of 90% was by floods alone. Coastal areas of Indus delta spread through south of Sindh are affected during discharge of flood water of the entire Pakistan to the Arabian Sea. Flashfloods due to torrential rains are very common and lethal in South Balochistan as well. Flashfloods were observed in 1998 in Turbat, 2005, 2007 due to cyclone Yemyin and 2010 in coastal districts of Balochistan(NDMA, 2010c).

The vulnerability of cyclone in Pakistan is moderate. But due to increase in temperature of Arabian Sea and other environmental factors in recent years, more severe and higher cyclone rate is expected. Cyclones mostly hit the coast of Sindh than Balochistan Coast. During past 100 years severe storm hit the Pakistani coast in years of 1895, 1902, 1907,1944,1948,1999, 2007 and 2010. During past 11 years i.e. from 1999 to 2012, the Indus coast has been hit by the four severe cyclones TC 02A 1999, TC 01A 2001, TC Yemyin 2007 and TC Phet2010(MoE(Pak), 2003; Sarfaraz & Dube, 2012).

3.0 Disaster Management Framework and Institutional Setup

The disasters in Pakistan were historically tackled through Calamity Act of 1958. After 2005 Kashmir earth quake National District Management Authority NDMA was formed as centralized point for relief activities coordination, disaster recovery and risk reduction strategy implementation in federal, provincial and district level institutions for disaster management. The current National Disaster Risk Management Framework NDMRF implemented under NDM Act 2010 calls for integration of Disaster Risk Reduction DRR strategy in all planning, design and implementation of development and infrastructure projects. Due to worse economic conditions the progress towards funds allocation and enablement of Districts' Management authorities from provinces is not satisfactory. The disaster management setup is heavily relied on international donor agency support and national input is insufficient(NDMA, 2009, 2010a).

For trainings, documentation and research coordination with other stakeholders National Institute of Disaster Management has been established. National working group (NWG),

including key ministries, has been constituted for formulation of national policies. For achievement of goals on objectives of NDRMF a ten point agenda has been defined. This agenda includes various activities including risk assessment and development of Risk Atlas, Early Warning System, formation of response teams, advanced research studies on disasters, capacity building of planning commission, education awareness and training on DRM, setting up of urban emergency response team, operationalization of provincial and district management authorities, establishment of National and Provincial emergency operation centers and National Capacity Building on Disaster Risk Management(WB & GFDRR, 2011).

4.0 Measures for Disaster Risk Reduction

Pakistan economy is heavily based on agriculture based products and industry. Droughts and floods management is central point for Disaster mitigation strategy, the focus is irrigation related measures include schemes for water reservoirs, early warning system, protection measures and flood forecast system. The water sector projects are mainly managed through Federal Flood Commission (FFC). FFC plays a pivotal role by implementing a ten- year plan submitted by the provinces, from 1978 to 2007 three ten- year National Flood Protection Plan NFPP have been completed. The new NFPP project NFPP-IV 2008-2017 is planned for approximately US $ 222 million(FFC(Pak), 2012).

The water related safety arrangements can be classified into structural and non-structural measures. The structural measures are provided through construction of large scale civil infrastructure to control and contain the high intensities of river flood. These include river bunds / embankments, spurs, gabion retain walls, protection walls, diversion and distribution structures, delay action dams and sectioning of flood water. For water storage dams are constructed in hill torrents. Embankment are constructed to control the over topping of flood water, spurs are constructed to guide the flow of flood water and preventing land erosion(Tariq, 2011). By and large sea shores are unprotected, except concrete walls at deep sea ports and maintenance schedule of dredging of soft sea beds at Karachi Ports & Pasni for removing sediment siltation. Most of the seaports in Pakistan are underdeveloped having small fish harbors with no commercial activity (Ahmad, 1997). The non-structural measures include establishment of measurement and early warning systems, weather forecasting systems, community preparedness, disaster responsiveness programs and effective land usage policy.

4.1 Structural measures

The largest contribution for the structural measures is the FFC projects under integrated national approach, which are carried out by provincial irrigation authorities and consultants. The federal expenditure and foreign aid for rescue, relief and rehabilitation are in addition to capital expenditures on these projects.

In Sindh, under aid of World Bank started Water Sector Improvement program phase-I, a 175 Million USD project in 2007-2013. The major share of the project 139 Million USD is for structural improvement of irrigation, drainage facilities and remedial measures for deficiencies of LBOD project(SIDA, 2011).

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4.2 Non-structural measures

Early warning dissemination and information system is the responsibility of Pakistan Meteorological Department PMD. PMD daily bulletin of weather from polar orbiting met-satellite animations/images is available on website and dispatched to respected agencies. Flash bulletin are instantly updated on cyclones, Pakistan is member of WMO and technical aid in form of cyclone detection radar is provided by Japan to enhance the prediction of cyclones originating in Bay of Bengal and Arabian Sea(WMO, 2012).
For recording sea activity and early warning of Tsunami in the region, 4 Global Sea Level Observing System standard tidal gauges are provided to PMD by United Nations Educational, Scientific and Cultural Organization Intergovernmental Oceanographic Commission UNESCO-IOC in 2009 with training on advanced software for tsunami prediction(UNESCO, 2009), 2 gauges at Karachi and Gwader are operational. Another two gauges at Ormara and Keti Bandar Thatta are still not functional(GLOSS, 2013).
Sindh Coastal Community Development Project SCCDP is an ADB funded project in 8 coastal Talukas of Badin and Thatta from $40 million during period 2008-2014. The projects focus on environmental rehabilitation and community development. Various initiatives have been taken including mangrove plantation, fish / prawn hatchery and small / medium scale civil works i.e. shelter construction etc. Other steps include; to increase community income generation capacity via various vocational trainings and capacity building of Sindh Coastal Development Authority SCDA in GIS based development survey & planning(SCCDP(Pak), 2012).
A number of community development programs in coastal areas been started under the supervision of Pakistan Poverty Alleviation Fund PPAF, a public-private partnership program. The programs include microcredit, water and infrastructure, drought mitigation, education, health, electricity via solar panel/wind energy and emergency response interventions(IndusEarth, 2010).

For community preparedness and disaster response three activities were carried out under NDMA(NDMA, 2009, 2010a).

1) Area evacuation drills in coastal tehsils were conducted, each drill involved several thousand area residents including significant number of female participants.
2) Volunteer preparation in Kech district and few other districts via community based flood early warning system program.
3) The search and rescue drills involving three national level teams and local participants.

5.0 Research Methodology

The objective of this paper is to ensure emergency telecommunication for information dissemination, coordinating relief activities and provision of distant medical consultation services in coastal areas. Communication blackouts are common during disasters in Pakistan (Malik, 2011; Sadiq, 2006), which is one of the main reasons for high number of causalities and economic losses during the disasters. To curtail the heavy damages of disasters, the information sharing regarding the intensity and timings of disaster enable the residents to take appropriate

decisions for the safety of their lives, agriculture, livestock and other belongings (NDMA, 2010c). After disasters, victims desperately require outside world help in the shape of food, shelter and medicine. Government and other relief agencies at that moment tries to setup communication links to control & monitor the situation in the affected areas and provide necessary relief & support to avoid epidemics outbreaks and further deterioration of livelihood conditions.

The structure of the paper is given as follows. In the next section coastal areas' telecommunication infrastructure & causes of breakdown are discussed. This is followed by section seven on technologies to remedy the telecom blackouts and their regulatory aspects. In the eighth section shortcomings and weaknesses in Pakistani deployed telecom infrastructures are removed by the application of technologies discussed earlier; and an information & communication technologies management plan for disaster mitigation is given. The paper ends with the summary and conclusions.

6.0 Telecommunication infrastructure & its breakdown causes

The telecommunication infrastructure in coastal areas is based upon landline and wireless technologies. Coastal areas except Karachi are low average revenue per user ARPU areas. Universal Service Fund USF is a public-private partnership setup by Government of Pakistan for proliferation of telecommunication in underserved areas; USF provides financing to telecom operators to setup telecom facilities in uncovered areas and subsidies to run the network. In 2009 USF started *USF Optical Fiber Projects* for broadband to every corner of Pakistan by linking districts to the national optical fiber backbone network. More than 90% of the projects have been completed, and by the end of year 2013 it is expected that broadband will be available to every district in Pakistan. For the provision of basic telecom services through wireless access GSM / CDMA technologies, USF is running *USF Rural Telecom Program* for rural areas, the program is going at a rapid pace, and by 2014-2015 telephone will be available to every town and village(USF (Pak), 2007, 2009).

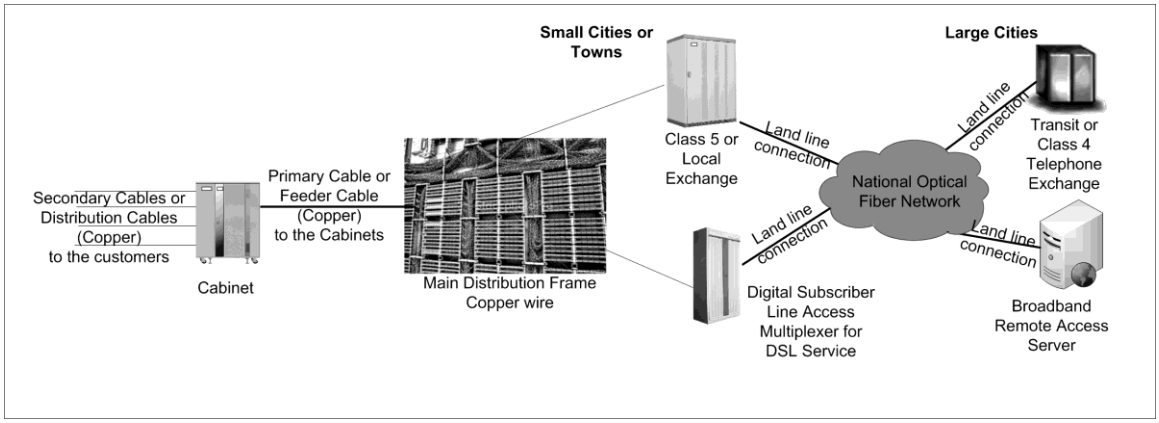

Figure 1: A typical setup of landline communication in small cities and towns

The telecommunication setups are interconnection of large networks. Figure 1 represents a typical setup of landline telecom infrastructure in small cities and rural areas i.e. ordinary telephone lines and broadband ADSL connections. The service delivery depends upon

interconnection to other networks through national optical fiber links, which are badly affected during floods. Another type of telecom networks are mobile & wireless networks, which are also very dependent on national optical fiber links for working with different network stations to setup data/voice calls. Figure 2 represents a typical setup of wireless communication using CDMA / GSM technology. In under developed countries like Pakistan mobile towers' backhaul connectivity via wired infrastructure is a problem. Only few aggregation sites are provided optical fiber connectivity to the national optical fiber links, the majority of the mobile towers are provided microwave connectivity to the aggregation site(Linkquestme, 2009; Tipmongkolsilp, 2011).

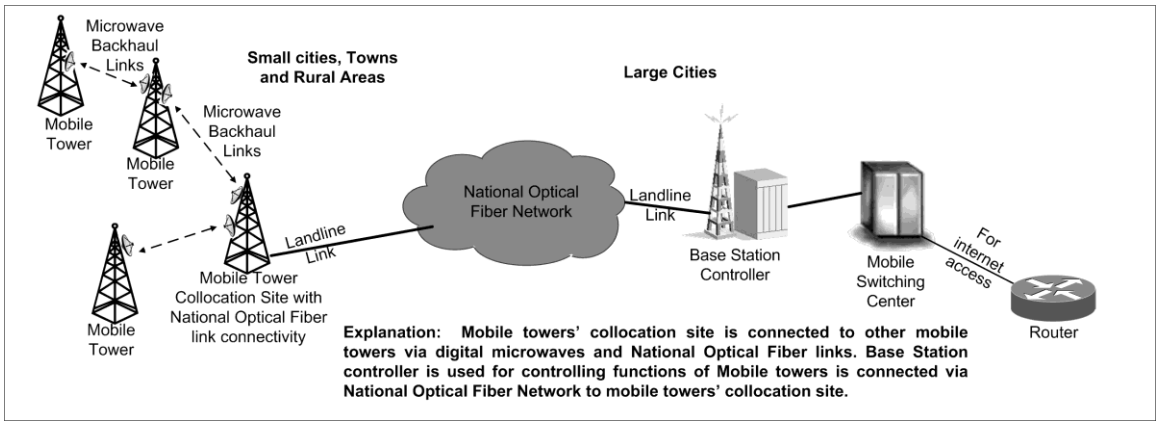

Figure 2: A typical setup of mobile communication network in suburban and rural areas.

Thus, breakaway of national optical fiber links result in total collapse of terrestrial communication. Other causes of communication breakdown are ingress of rain/flood waters in telecom equipment & lines and destruction of communication tower etc. In summary following disasters are the causes of communication blackout.

1) In coastal areas of Sindh, Indus fluvial inundation is caused by breaching of Guddu Barrage embankments & allied structure. Due to low lying areas water remains standing for about four to five months(FFC(Pak), 2012). The National optical fiber links are laid at the side of national and provincial highways that is why these sustain damages due to destroyed or flooded away roads. For example floods 2010 & 2011(MoIT (Pak), 2010).
2) The heavy concentrated rains or cyclone induced rains causes floods(Tariq & van de Giesen, 2012), which damages the national optical fiber links or telecom equipment. For example cyclones Gonu & Yemyin 2007 induced heavy rains(ADB & WB, 2007).

7.0 Technologies for the failure of terrestrial telecommunication & regulatory aspects

During the disasters the terrestrial network becomes inaccessible, world statistical analysis of fifteen years' disasters reveals following reasons(Townsend & Moss, 2005).

1) Physical damage to the network.

2) Disruption of links between the networks.
3) Network overload & congestion.
4) Power breakdowns and backup supply depletion.

The technologies for the remedy of communication's breakdown can be broadly categorized into space & ground technologies. The details of available options and regulatory aspects are discussed below.

7.1 Telecommunication satellites

Telecommunication satellites present a readily available, rapidly configurable, disaster proof solution for the failure of terrestrial communication at the cost of expensive terminal equipment & usage charges. Satellite communication is the only option for the far located isolated places, where no other means of communication are available. Pakistan too has its Satellite Paksat-1R, a geostationary satellite, whose footprint is from South & Central Asia to the Central Europe. Paksat-1R is employed in Pakistan telemedicine project for distant medical teleconference facilities(Mudassar, 2006), at present it has more than forty five customers. Two type of services are offered fixed satellite telecommunication and very small aperture terminal VSAT services in C and Ku band communication(Paksat, 2011; Siddiqui, 2011).

The most popular choice for disaster management is Inmarsat Global Satellite system. Inmarsat system support data & voice services using briefcase-size Broadband Global Area Network (BGAN) terminals & handheld telephone sets (Sadiq, 2006). During 2010 floods international telecommunication union ITU provided twenty Inmarsat BGAN terminals for the emergency communication(Maqbool, 2010).
Other two authorized options for satellite telecommunication services in Pakistan are Iridium and Thuraya that support only basic telephony and low data rate services(Kose, 2012; Navein & O'Neill, 2009). Pakistan Telecommunication Company Limited PTCL is using Intelsat Standard B satellite stations at Gwader, Gilgit, Skardu and Islamabad for national connectivity and Intelsat earth stations at Islamabad & Karachi for international connectivity(PTCL, 2013).

7.2 High Altitude Platform (HAP)

Mobile phone services play active role during relief, coordination and recovery activities due to its wide user base and affordability. A potential solution to keep the mobile service alive is aerial platform with broadband relay capabilities such kind of arrangement is called High Altitude Platform HAP. This idea is not new but the concept has gained popularity in recent years due to possibility for quick deployment and meeting demand in events like Olympics & expos etc. The aerial platform can be used to provide second generation wireless services i.e. voice and data, or high data rate services for variety of purposes like telemedicine, news broadcast, remote sensing and navigational aids.

The aerial platform is typically operated at the height of 17-22 Km using airplanes or airships; the vehicle is manned or unmanned with automated or remote control operation. The

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International Telecommunication Union (ITU) has allocated frequency for HAP services in IMT-2000 at 2 GHz range. Many countries have made significant progress in HAP projects including USA, Canada, Japan, Korea, Indonesia and EU (Mohammad, 2011; Mohorcic, 2004; Pace & Aloi, 2008; Qiantori, 2012).

7.3 Wimax

Wimax is short form of "Worldwide Interoperability for Microwave Access" also known as IEEE 802.16 standard, is a licensed wireless broadband technology. In Pakistan four operators are providing wireless access & short point to point metro LAN services at 3.5 GHz band, whose range is around 5-15 Km. Wateen Telecom is the largest Wimax operator covering 23 cities. The frequency allocation for long haul 50 Km is not done and mobility is not allowed; so the true potential of the technology i.e. mesh networking and other features are not available to the market(Asif, 2007; Gunasekaran & Harmantzis, 2007).

7.4 Wireless LAN / High speed Wireless LAN

Wifi or WLAN is a popular "unlicensed wireless technology" based on IEEE 802.11 standards. There are number of devices such as laptops, gaming consoles, tablets or PDAs which connects to the internet via Wifi network access points. It can work around 20 meters in indoor and 300 meters on outdoors environments. Pilot telemedicine projects in rural India employed ordinary WLAN technology with relays covered 10 Km plus (Surana, 2008) and specialized WLAN telemedicine project attained 30 Km plus distances in Japan(Nakamura, 2008). The disadvantages in Wi-Fi as compared to Wimax technology are its contention & quality of service issues.

7.5 Vehicle Based Networks

Satellite News Van for on-site news broadcasting is nowadays commonly used by news channels. Similarly mobile vans equipped with pico size cells can be used to provide mobile communication in the disaster area (Chen, 2012; Iapichino, 2008; Patricelli, 2009). The networks known as vehicle to vehicle and infrastructure based networks are active area of research of many conferences and journals. During floods 2010 Holy Family Hospital made a customized telemedicine mobile van with VSAT antenna on top and provided distant consultation facility. During floods 2011 NDMA used a mobile van on EDGE based mobile internet to provide telemedicine facility in district Badin(Malik, 2011; NDMA, 2011).

8 Proposed plans of emergency communications for disaster management

The emergency communication network is intended to provide alternate arrangements during collapse telecommunication infrastructures. Since, telecommunication infrastructure is composed of two types of networks i.e. narrowband and broadband communications.

Therefore, two separate plans for survival of narrowband and broadband mobile communication are discussed. Another plan for easy deployable temporary telecom infrastructure is discussed utilizing mobile van and high altitude platforms for areas with collapsed infrastructure. Last but not the least, this paper highlights flaws in disaster information and communication systems & its remedies for effective mitigation of disasters.

8.1 Proposed plan for survival of narrow band mobile communication.

NDMA provided 80 wireless phone sets in Gwader, and 60 in Sindh. Because the early warning system in coastal areas is SMS based (NDMA, 2010a). Due to collapse of national optical fiber links during disasters these arrangements are useless. The remedy of this problem is to provide VSAT backup link at mobile tower collocation site as shown in figure 3 , this arrangement is normally followed for remote sites in USA (Tipmongkolsilp, 2011), or clients located in extreme remote locations in the rest of world (Asif, 2010).

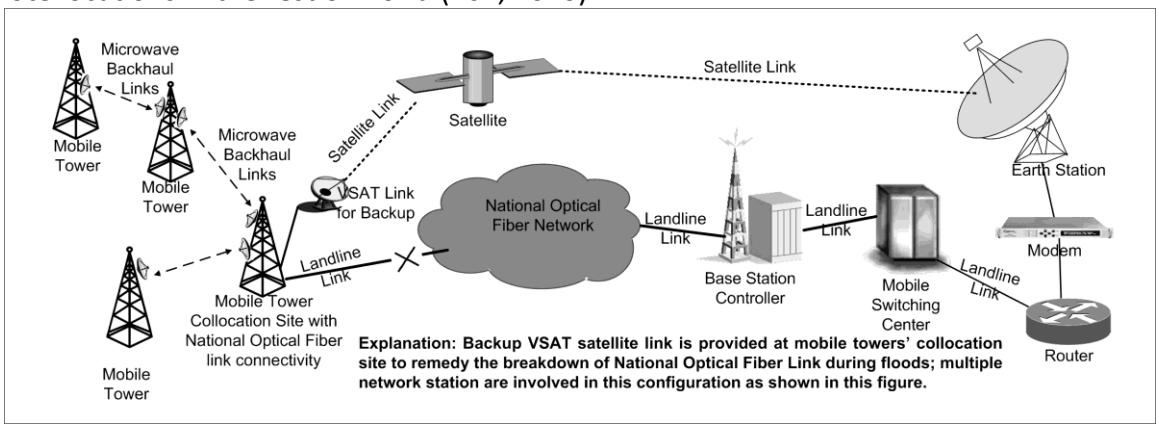

Figure 3: Remedial plan for breakdown of narrowband wireless communication in coastal areas

8.2 Proposed plan to avoid collapse of broadband communication

The recently completed USF optical fiber projects in Sindh include coverage to floods prone areas for example Keti Bandar & Sujawal sub districts of Thatta. These sub districts submerged during floods 2010 & 2011 and the whole area was evacuated. The paper proposes to overlay Wimax infrastructure in parallel to the national backbone optical fiber nodes. In this setup two frequency bands are utilized, for that purpose Wimax backhaul frequency band should be allocated. The users within 10 Km range connect to the Wimax base station by using non-line of sight communication (point to multipoint distribution) on 3.5 GHz band, while the far located users within 10 to 50 Km range connect to the Wimax base station on backhaul frequency band (point to point connection) by using line of site antennas (NDMA(India), 2012). A simplified diagram of Wimax infrastructure overlaid with optical fiber network is given in figure 4. In Pakistan, DWDM long haul technology is employed in backbone optical fiber networks. The distance between two stations is 80 to 120 Km. At least three to four Wimax backhaul stations are required to cover this distance. Furthermore due to this technique distant learning and

telemedicine facility can be provided to disperse population on wireless connections at lower initial capital requirements compared to landline infrastructure. The survivability of Wimax network could further be enhanced by employing mesh topology.

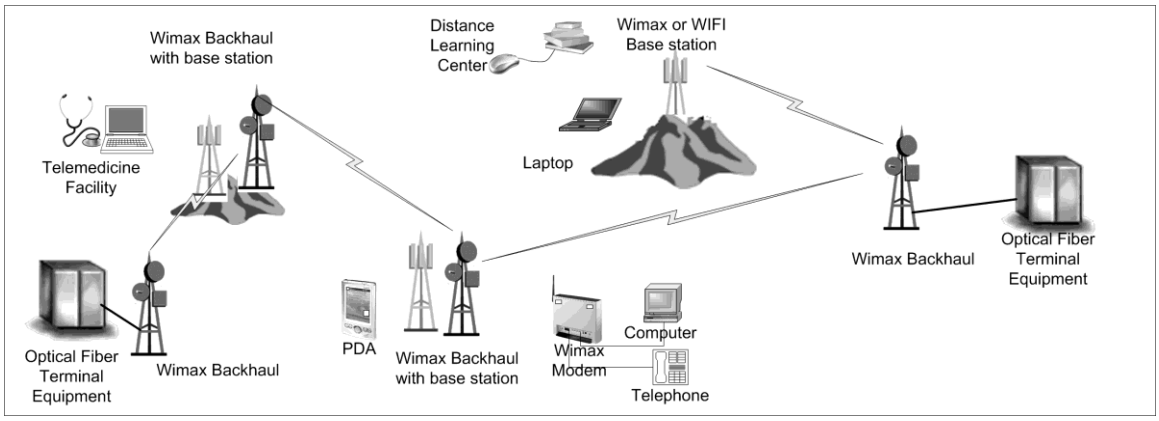

Figure 4: Proposed overlay of Wimax + optical fiber infrastructure for survivability of broadband services.

8.3 Proposed model for easy deployable temporary telecom network

Within a decade Pakistan has faced three massive natural disasters that affected millions and destroyed the complete infrastructure. Pakistan urgently requires development of easy deployable temporary telecom infrastructure for disaster events. Figure 5 represents schematic diagram of easy deployable broadband infrastructure using high altitude platform & vehicle infrastructure. The area covered by HAP is around 50-120 sq-Km, vehicle based infrastructure can cover approximately 02-05 sq-Km. The high altitude platform can directly serve the coverage area from onboard equipment or it can be used to provide backhaul facility between ground station and the terrestrial networks. The inter platform link is used to link up two or more HAP, thus coverage or resiliency of the network can be increased.

Furthermore, healthcare infrastructure in coastal areas is inadequate(Mehdi, 2009; WB, 2005), primary health care delivery via mobile vans has proved a successful venture in Africa(WB & ADB, 2008). Mobile van equipped with wireless broadband connection and telemedicine equipment can be a successful primary & secondary health care delivery mechanism in coastal areas.

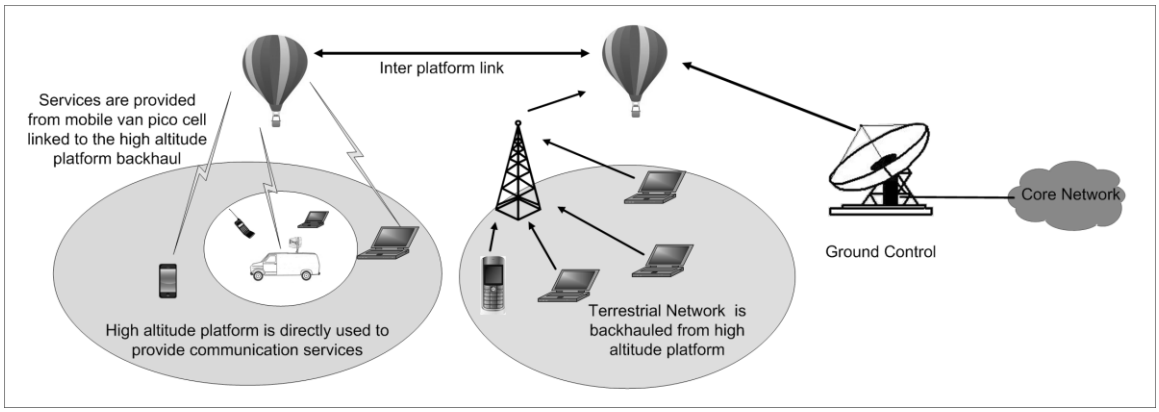

Figure 5: Schematic diagram of quickly deployable temporary telecommunication infrastructure.

8.4 Information and communication systems disaster management plan

During survey it was felt that existing communication & information systems for disaster management is flawed. To address this urgent need improved information and communication system plan is compiled through observations, group discussions, newspapers and international donor organizations reports. This plan is composed of three phases i.e. pre, during and post disaster phases.

8.4.1 Pre Disaster Preparation

This phase consists of preparation for disaster situation. The important step is to identify weak areas, removing those loop holes and formulating a strategy for the moment of disaster. Following points have been completely missed in ongoing disaster management practices, which should be included in disaster mitigation plans.

1) There is no registration process of disaster affected people/area. Also land, livestock, relief items and health databases are not implemented. Data centers are a new state-of- art- facility by telecom operators. PTCL has the largest Data center in Pakistan with most advanced data security and telecom infrastructure facility. Centralized database of disasters management should be utilized for effective control.
2) Doppler radar should be installed in the rivers of south Balochistan and LBOD Sindh for accurate prediction of water toppings. The disaster management authorities should linkup barrage breaking decisions & flood levels telemetry system to automatic SMS dispatcher to the selected community members to empower them in devising plan for their safety.
3) Area inundation simulation maps using GIS technologies have been prepared by PMD for various disasters like cyclones, floods etc.(Lubna, 2010). The telecom companies should use these projects' data to prepare their operational plans for disaster.
4) Safety level of diesel for diesel generator sets should be maintained and solar panels should be provided at difficult access telecom sites to ensure power supply availability during disasters.

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8.4.2 During Disasters

At this stage, the strategy is to minimize damages of disasters. Smooth information delivery with accuracy and maximum lead time; streamline the process of emergency response and management of shelter for displaced population. The earlier disaster mitigation plan is lacking following points.

1) The most important task is to make district emergency operation center operational on 24/7 basis to monitor and control the situation through resilient communication, keeping the mobile based information dissemination system alive is necessary since early warning system is defective. Also for conducting search & rescue operation communication system is very important.
2) Current disaster management heavily relies on international donor support, which follows a different structure than government based organizations i.e. cluster based approach. So the foremost need is flawless coordinating associations with international agencies through linking of databases through telecommunication. Clear operation principles for NGO and INGO should be defined. Transparency in relief operations, special focus on vulnerable groups i.e. woman, minorities and hard to reach areas should be maintained through resilient telemetry system.
3) Refugees' camp sites are vulnerable to chaos like epidemic breakouts & thievery etc. In recent disaster events law & order situation was very poor. Goods dispatching system & other surveillance systems need to be linked up to avoid chaotic events in future.

8.4.3 Post Disasters

After disastrous lapse of devastating event, the foremost priority is accessing damages for rehabilitation and recovery of affected population get back to their feet and enhancing their resilience to disaster, and taking preemptive actions to avoid the recurrence of the same incident or if unavoidable better coping mechanism for the occasion. The damages to protection structures are accessed and repair / strengthening of bunds & embankments is carried out on priority basis before next season. The damage assessment in Pakistan is done through Suparco prepared satellite maps and site surveys. High altitude platform and distant surveillance system provide an intermediate solution between the two above stated methods. By employing visual & other sensors on the HAP, better area inundation maps and other metrological data can be collected for prediction of weather and future planning.

9.0 Summary & Conclusions

This paper provided a case study of natural disaster in coastal areas of Pakistan. For effective mitigation of disasters and emergency communication management plans for survivability of different telecommunication infrastructure have been presented. For better risk management strategy unsolved issues in information and communication systems were highlighted and their remedy is given. Pakistan has to devote more resources and build capacity for readiness, awareness and disaster response to curtail the heavy impacts. By working on the lines given in

this paper, Pakistan can develop a better information & communication system and curtail high losses associated with floods and cyclone disasters. The livelihood of the residents will be improved due to provision of health and education facilities from telecommunication infrastructure. The national education sector, research organizations and other information technology stakeholders should input their response by developing projects for disaster management so that the functionality & usability of the concepts presented in this paper are materialized for the benefit of the people.

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