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Developing ICT infrastructure for Disaster Risk Reduction (DRR) in India

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ABSTRACT:
The unique geo-climatic conditions cascaded with socio-cultural-economic and political diversities of India have made it highly vulnerable to both natural and manmade disaster. 54% of landmass is prone to earthquakes, 40 million hectares of landmass is prone to floods, 8000 km of Coastline is prone to cyclones and almost 68% of the total geographical area is vulnerable to drought. The occurrence of Bhopal gas tragedy (1984), Orissa super cyclone (1999), Tsunami (2004), and Bihar flood (2008) left a devastating blow on the country. Recent stampedes and casualties at religious places in India have exposed "total absence of crowd management, public safety and disaster preparedness". Country's increased sensitivity to terrorism has added more fuel to fire.

With 18 official languages spoken in 1600 dialects, by about1.2 billion people and other diversities (religious, social, economical, political, climatic etc) India offers greatest challenge to emergency and risk manager to develop and implement crowd management system, safety plans, alert and warning system keeping regional mix of participants into consideration.

Complete prevention of natural disaster is beyond human capabilities but the involvement of the state-of-the-art Information and communication technology (ICT) systems are panacea for implementing reliable disaster prevention and mitigational measures. ICT provides capabilities that can help people grasp the dynamic realities of a disaster more clearly and help them formulate better decisions more quickly. Advancement in ICT offers extremely effective decision support system, fail safe communication, data and computation resources that can be used to effectively coordinate a large number of geographically dispersed participants and assets, to exchange a wide variety of types of information, and to evaluate many scenarios and responses— all of which are changing dynamically.

This paper aims to address the role of ICT infrastructure as a framework for facilitating disaster management. A typical design and implementation of ICT infrastructure model comprising of communication, decision support and early warning components for enhancing efficiency and effectiveness in all level of disaster management activities is offered.

KEYWORDS: ICT, DSS, GIS, Facility Management, Disaster Management, EOC, Early Warning

INTRODUCTION:

Various disasters occur in different nations of the world at different occasions beyond national and international borders irrespective of the developed, developing or the least developed status of the country. Within the last decade, the world witnessed the Tsunami, earthquakes, hurricanes, cyclones, droughts and several other natural disasters. Neither man nor technology could prevent their occurrences but their impact can be managed significantly through the ICT (APT-ITU, 2005). ICT plays a very important role in early disaster prediction, impact assessment, resource tracking, disseminating disaster information to stakeholders, and ensuring a speedy communication system after the disaster to both government and non-government agencies for relief materials.

Damage to information and communications technology (ICT) infrastructure, along with other problems exacerbated the difficulties in carrying out response and recovery efforts following severe incidents. Design and deployment of ICT infrastructure for disaster management demands a very "cautious approach" keeping dynamics of disaster management and global best practices into consideration. Four design principles have particular importance:

- Effective scaling from routine to disaster operation;
- Exploitation of redundancy and diversity;
- Flexibility, composability, and interoperability; and
- Distinguishing between the user interface and the underlying technologies.

To assist Government planning in development of resilient ICT infrastructure for disaster management – state Government of Gujarat formed a committee in the year 2002. The committee, chaired by author, submitted its recommendations in the same year. Use of Information Technology to Enhance Disaster Management was reviewed and discussed again in author's doctoral dissertation (2009). One of the results is a tremendous improvement in the usefulness of GIS (Geographic Information System) and CAD as emergency decision-support tools. Computer-generated maps can help enormously by integrating complex "situational awareness" information from multiple sources. A robust communication backbone and reliable sensory network would be crucial for pulling together all the available data sources scattered across the geography.

Issues identified – needing special attention of the central / state level planner for harnessing potential of ICT in disaster management are -

- Availability comprehensive interoperable and resilient "Emergency Communications and IT infrastructure".
- Availability of comprehensive, robust and scalable "State wide emergency communications and IT infrastructure". Most public safety communication systems in the state are primarily oriented toward voice, with weak support for data or video and have no redundancies.
- Availability of National SDI (SPATIAL DATA INFRASTRUTURE) standards and resources - Geographic Information Systems technology for asset tracking, situational

awareness and decision support (GIS standards developed under the Open GIS Consortium-OGC or **Open Geospatial Consortium**)

- Availability of effective and efficient Integrated Alert and Warning System

In typical Indian scenario - Disaster management and the supporting IT infrastructure will be **firmly rooted at the state / local level**. Disaster management (DM) is state's responsibility and State Government organizations provide most of the infrastructure, personnel, and other resources during severe incidents. Majority of DM ICT infrastructure would be used (owned, operated, and maintained) by state government. National Government will have crucial responsibility to – facilitate common ICT infrastructure necessary for connecting state-central Government organisations and state-state governments (inter-state) in addition to guidelines on protocol and standards to be followed by each state while developing their ICT infrastructures. Standards ease interoperability and can foster increased information exchange and help lower costs.

Design, acquisition and adoption of ICT, on pan-India basis, for disaster management is challenging for several reasons including geo-political diversities across the country and distributed responsibility for disaster management within the Indian federal system.

Author reviews, discusses key areas / issues, identifies and suggest approach for development ICT infrastructures, both at National as well as State level, for enhancing disaster management capabilities. New guidelines issued by National Disaster Management Authority (GoI) and global best practices are considered while deliberating on approach and solution.

DISASTER MANAGEMENT ORGANISATION & NETWORK OF EOC:

India with its federal system of Government has specific roles for the Central and State Governments. The country has integrated administrative machinery for management of disasters at the National, State, District and Sub-District levels. The basic responsibility of undertaking rescue, relief and rehabilitation measures in the event of natural disasters, as at present, is that of the State Governments concerned.

The Central Government supplements the efforts of the States by providing guidelines/policies, financial and logistic support. Dimension of involvement of National response system during any disaster is generally based on - The gravity of a natural calamity, scale of the relief operation necessary, & requirements of Central assistance for augmenting the financial resources at the disposal of the State Government. At the state level the, relief was being handled by the Departments of Relief and Rehabilitation.

This system is now being restructured to have a SDMA (State Disaster Management Authority) will also look into preparedness and mitigation besides the present role in relief and rehabilitation. The Chain of Government revenue department's administrative hierarchy continues to play lead role in managing "response" during disasters. This system has already been introduced in several state and Union Territories of India.

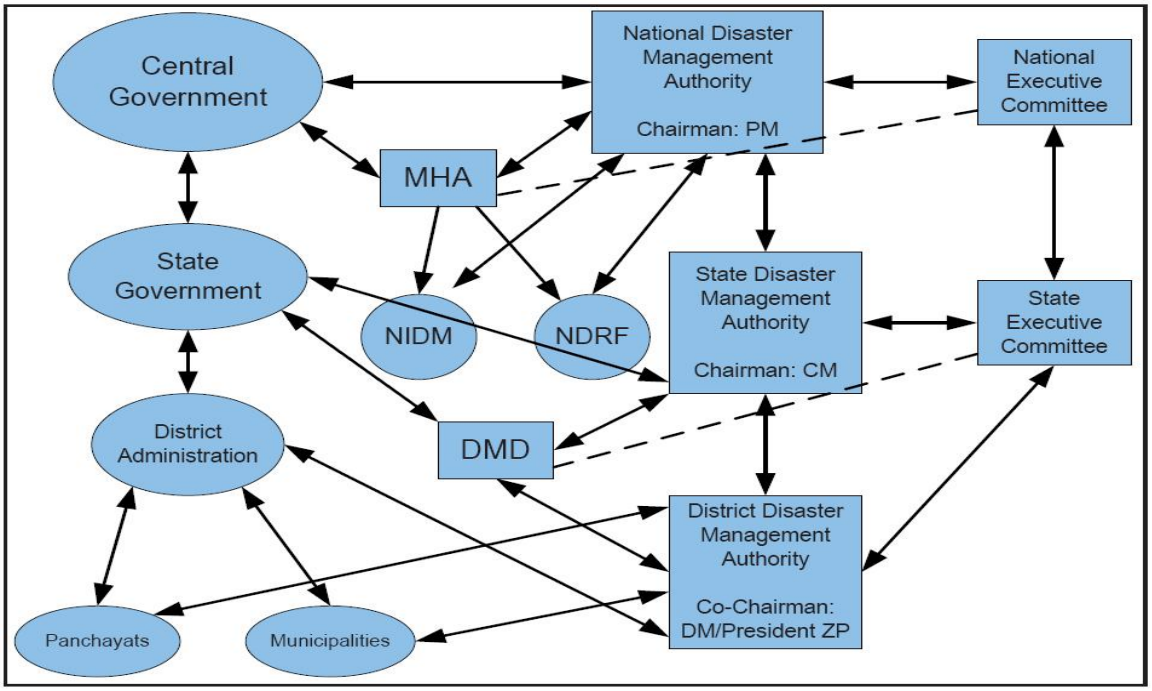


Fig-1: **Institutional Framework for Disaster Management in India**

The same system is being followed at the district level with the district Coordination and Relief Committee being reconstituted as the disaster management committee, with officers from relevant department being added into the committee. The district magistrate would be the nodal officer to coordinate these activities. Moreover, the district heads of department engaged in development are being made a part of this committee to streamline disaster management plans into developmental plans. At the sub-divisional and taluka levels, disaster management committees are being constituted. At the village level there would be disaster management teams and committees.

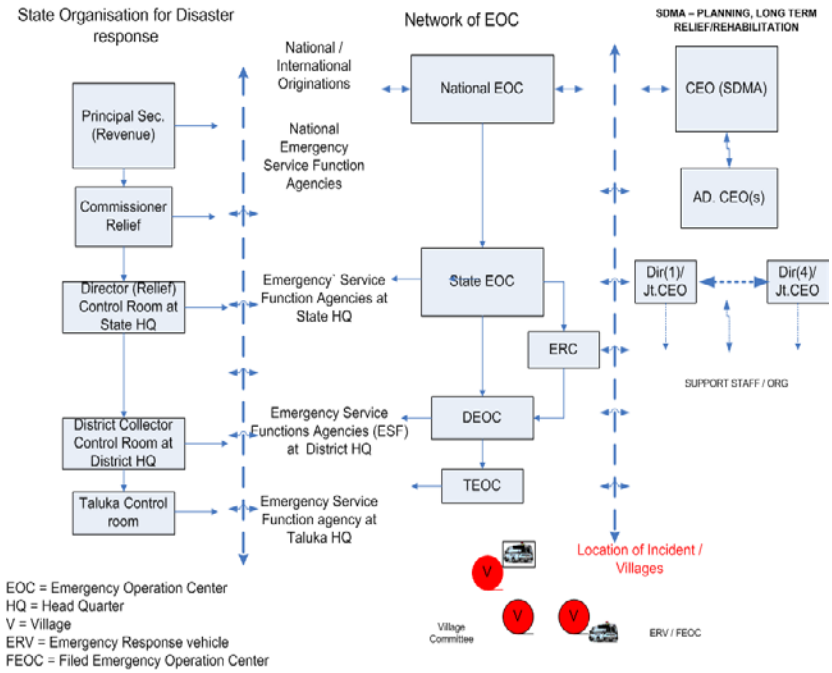


Fig-2: Operating Levels ***(Source: Dave R K, 2009)***

Incident Response System (IRS) guidelines, issued by NDMA, Government of India, recommends network of Emergency Operation Center (EOC) up to district level in each state for enabling seamless - Communication, coordination, and Collaboration during all phase of disaster cycle.

EOC as an offsite facility which will be functioning from the National /State / District headquarters and which is actually an augmented control room having data acquisition, compilation, analysis, video projections, risk assessment, communication, alert and warning facilities and space to accommodate the various ESFs.

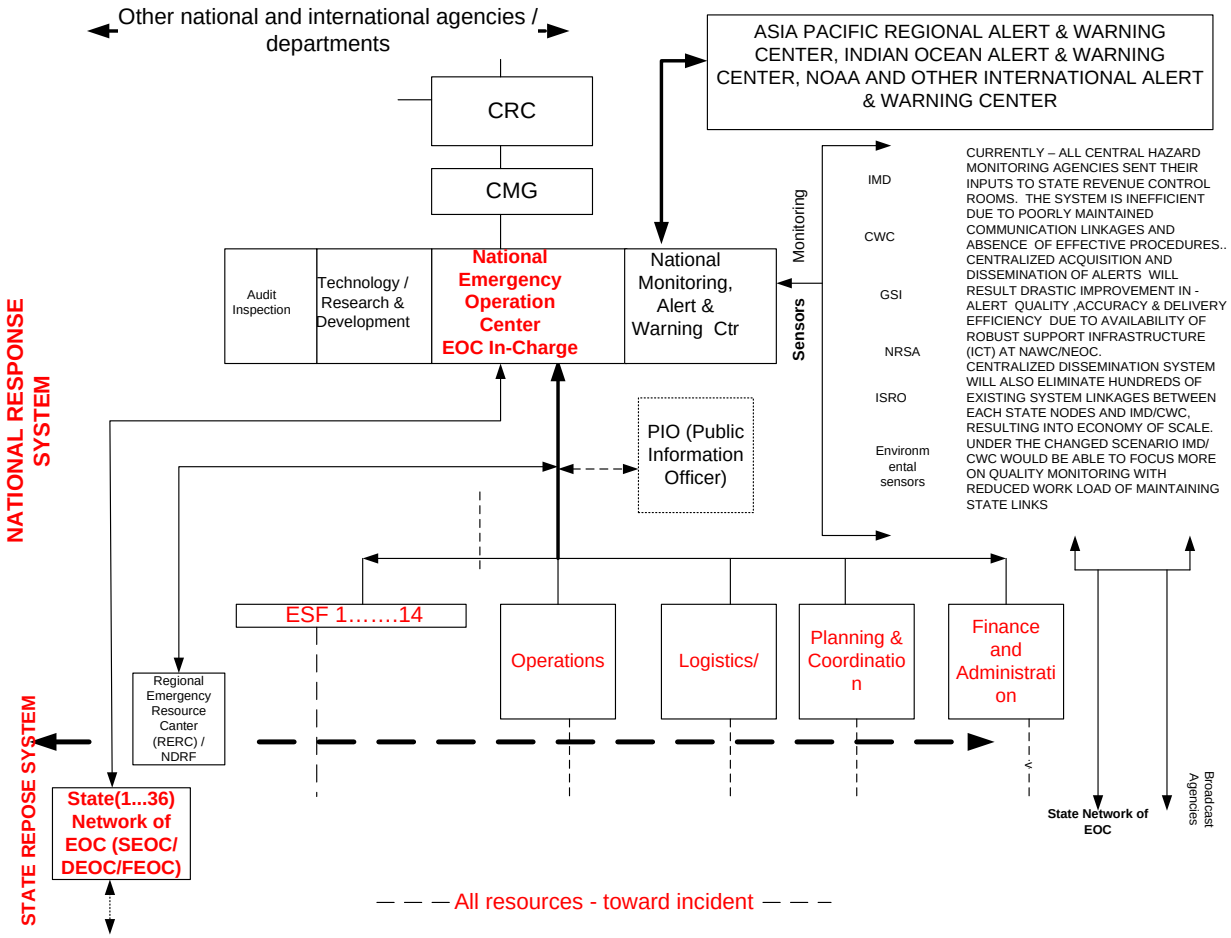


Fig-3: Typical Architecture of Emergency Response and Disaster Management System

(Source: Dave R K, 2009)

The EOC will take stock of the emerging situation and facilitate assessment, identification, mobilization and deployment of required resources. The ICT infrastructure for emergency response and disaster management need to be planned designed and established on the basis of EOC service requirements and geographical coverage considerations at national and state level.

The basic functions of State EOC, derived on the basis of functional framework of disaster management would be to:

- Receive, monitor, and assess disaster information.
- Keep track of available resources.
- Monitor, assess, and track response units and resource requests.
- Manage resource deployment for optimal usage.
- Make policy decisions and proclaim local emergencies as needed.
- Provide direction and management for EOC operations through Standard Operations Guide (SOG), set priorities and establish strategies.
- Coordinate operations of all responding units, including law enforcement, fire, medical, logistics etc.
- Augment comprehensive emergency communication from EOC to any field operation when needed or appropriate.
- Maintain EOC security and access control.
- Provide recovery assistance in response to the situations and available resources
- Keep senior, subordinate and tenant officials informed.
- Keep local jurisdictions (Village/town/City, district and State) informed.
- Operate a call center to log and post and issue all key disaster information.
- Develop and disseminate public alert & warnings system.
- Provide information to the news media.

NDMA has proposed to setup 22 State EOCs and 312 District EOCs in the next 3-4 years (NDMG 2012). In addition, Mobile Emergency Operation Centres (MEOCs) are also planned at ten NDRF (National Disaster Response Force) stations and Mini Mobile Communication Pack at all MHP (Multi hazard prone district) district headquarters for expeditious restoration of communication at the neighboring disaster sites. National guidelines enlist fractions / services to be performed at National EOC as follows –

- Establish and maintain cartographic base with GIS platform for all the districts
- Develop DMIS (Disaster Management Information System) for prevention, mitigation, preparedness
- Receive Early Warnings to disasters from EW (Early warning) Agencies and dissemination
- Cater for real/near real time “common operating picture” for situation awareness
- Information exchange in horizontal and vertical domain
- National crisis information management portal (multi-lingual)
- Establish -Data mining and Simulation Systems for the pre-disaster scenarios
- Establish Call Centre based help
- Interact ESF and coordinate the relief and rescue activities
- Prepare the daily situation report and apprising the Cabinet Secretary,
- Provide information to National Crisis Management Committee (NCMC)

COMMUNICATION NETWORK:

Communications systems are one of the first casualties of any disaster and paradoxically a most vital need when a disaster strikes. Public Switched Telecom Network (PSTN) and eGovernance ICT infrastructures do not survive during severe incidents. Large disasters upset physical infrastructure, such as the electric grid, transportation, and health care—as well as IT systems. Damage to communications infrastructure, along with other communications problems exacerbated the difficulties in carrying out response and recovery efforts following major incidents in the past.

Emergency communications capacity is critical in ensuring the effectiveness and efficiency of disaster response actions. Such capacity includes: the restoration or establishment of wireless telephony and Internet services; the expansion of the handling capability of local cellular mobile systems and Internet bandwidth to accommodate sudden increases in traffic; and the rapid deployment of standby Communications facilities to ensure communications among field teams and relevant headquarters and to make the above-mentioned restoration and expansion possible.

Appropriate and adequate information and communication network system is a basic need & functional necessity for any disaster management agency to perform effectively. The comprehensive ICT network system plan should address very precisely – the communication needs for all stake holders in "situation before disaster (SBD) and the communication needs in "situation after disaster (SAD)".The design considerations for ICT infrastructure to facilitate disaster management should include -"Resilience, robustness, scalability, interoperability, low MTTR (Mean time to repair) and user friendly.

The communication network between the National, State and Local (at the site of incident) EOCs is mostly based on the PSTN (Public Switched Telecom Network) in current scenario. As a part of National Emergency Communication Plan (NECP) - Government of India has established satellite network comprising of One VSAT terminal for NEOC at MHA (Ministry of Home Affairs), one mobile EOC for a disaster site, and six transportable communication sets for search and rescue teams of one NDRF Battalion (NDMA-2012). For providing communication cover to NDRF Battalions, six transportable communications sets, each comprising of one VSAT terminal, two INMARSAT type satellite phones and five VHF sets, have been procured for search and rescue teams of one NDRF Battalion under Phase1 of NECP 2004.

A high level committee in Government of India has recommended building a "network of networks" created by leveraging all existing terrestrial communication and satellite networks, including NICNET, SWANs, POLNET, DMNET (ISRO) etc and connecting them to various Emergency Operation Centers (EOCs) at National (NEOC), State (SEOCs) and District (DEOCs) Levels for assured bandwidth in all phases of DM.

Existing National Communication backbone operated and managed by National Informatics Center (NIC) connects each state capital with 2 Mbps leased circuits with dedicated satellite backup. NIC backbone also extends up to District HQ in most of the cases. NIC's tested national information network, with established technical support in all states, is superior to the POLNET in many ways. State Wide Area Networks (SWAN), already deployed in about 17 states (rest

under progress), are not designed to sustain during disaster. These networks are basically designed for eGovernance can be shared during normal and pre-disaster phase, as such network (working on PSTN backbone) would not survive extreme incident.

Based on the global best practices - a table is prepared highlighting the "preferred networks and their availability / usages" during various stages of disaster

	WIDE AREA NETWORK	LOCAL AREA NETWORKS
SITUATION BEFORE DISASTER	National Grid of SWAN / LEASED CIRCUITS / GSM (GPRS) VSAT NETWORK (including POLNET) / SAT PHONES All sensors installed at remote locations will use CUG VSAT network designed for GSDMA along with National GSM /CDMA backbone .	Need for local area voice communication would be insignificant for central agencies, barring situations like drills and training purposes. They will have VHF/UHF system inventories for deployment SoS.
SITUATION AFTER DISASTER (SAD)	VSAT NETWORK / SAT PHONES / HF	Central agencies, when involved in Incident Management, during notified National Emergency situation would use State Government/Local Government resources for local area communication (like VHF/UHF

Table-1: Preferred Telecom networks "before and after" disasters ***(Source: Dave R K, 2009)***

Under NDCN, a separate satellite network of NDMA, which will link NEOC, SEOCs, DEOCs and Mobile EOCs through VSAT Network/INMARSAT phones for providing fail-safe communication during disaster scenarios, is proposed. Disaster Recovery (DR) site for NEOC has also been planned in a geographically distant place viz National Remote Sensing Center (NRSC), Hyderabad (which is also less vulnerable to natural hazards).

Integration of existing communication infrastructure resources is proposed in the national recommendation on ICT infrastructures for disaster management. This would need a detailed technology and performance review on existing communication resources (POLNET, NICNET, DMNET, SWANs) proposed for integration into National Communication network for ascertaining interface/compatibility requirements and possible cost/benefits achieved. "Redundancies" should not add boxes, cost and operational complexities.

Emergency Communication resource should be "focused and dedicated" as shared resources may lead to multiple issues relating to regulatory, ownerships, accountability, interoperability etc. Some of the possibilities of sharing existing telecom network at National and State level are listed as below –

- National Government:
    - Situation before Disaster (SBD) or normal conditions – National disaster management authority may use NDCN's terrestrial network – either on PSTN leased / MPLS circuits or NICNET backbone. NIC network could be a preferred choice looking to the availability of skilled HR support available up to district HQ in each state for facilitating effective coordination and collaboration.

- State Government:
    - Situation before Disaster (SBD) or normal conditions – State disaster management Authority may use SWAN network, which covers vertical and horizontal offices at State HQ, District HQ and Taluka HQ. Interconnecting State EOC with the SWAN will enhance reach of emergency management system to almost everywhere in the Government (including ESF agencies at State and District HQ).

In the situation after disaster or when the terrestrial channels fail - both national and state disaster management authorities shall use NECN (VSAT network for voice, video and data communication). National network will facilitate "inter-state" and "state-central government" communication linkages during sever incident. State may require to plan a dedicated VSAT network for connecting various nodes in network of state EOC(s) due to various reasons.

Current guiding principles for National Emergency Communication network Plan are too broad to be pragmatically coordinated and implemented. It needs a more focused approach for defining exact ICT needs during all phases of disaster management and mitigational activities and pin-point network system which are "Dedicated, Assured, Reliable and Efficient (DARE)" with attached portability and Coverage (Local as well as Wide area) flexibilities.

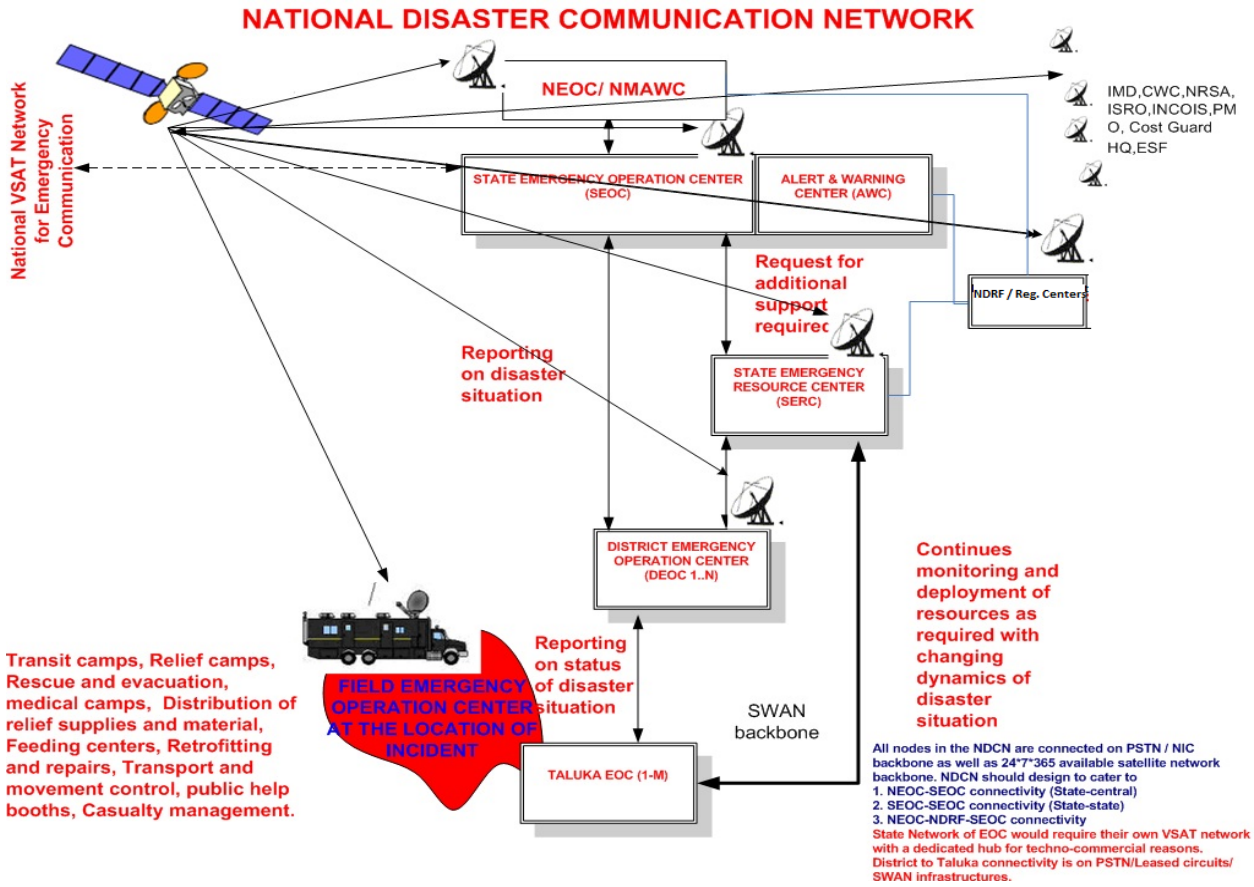
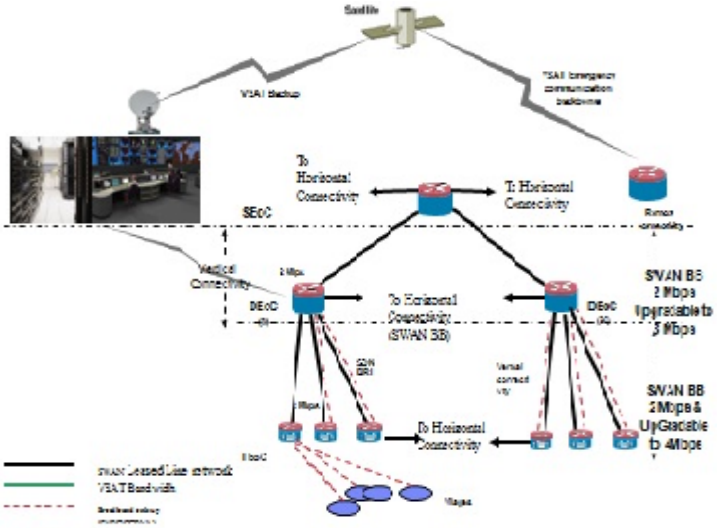


Fig-4: National / State Disaster Communication Network (NCDN) ***(Source: Dave R K, 2009)***

State Government will need to plan, design and establish emergency communication system commensurating with vulnerability footprints and plan for network of EOC. State VSAT network for emergency communication with a captive hub would be necessary for enabling



"single-hop" communication and portability (Under Indian Telegraphy Act) in addition to various other techno-administrative reasons. Government of India should facilitate free satellite bandwidth upto 5 MBPS to each state based on the size and spread. The state Governments would need to strengthen and expand SWAN (implemented or under implementation) backbone for catering to needs of SDMA.

Fig- 5: SWAN-SEOC Connectivity

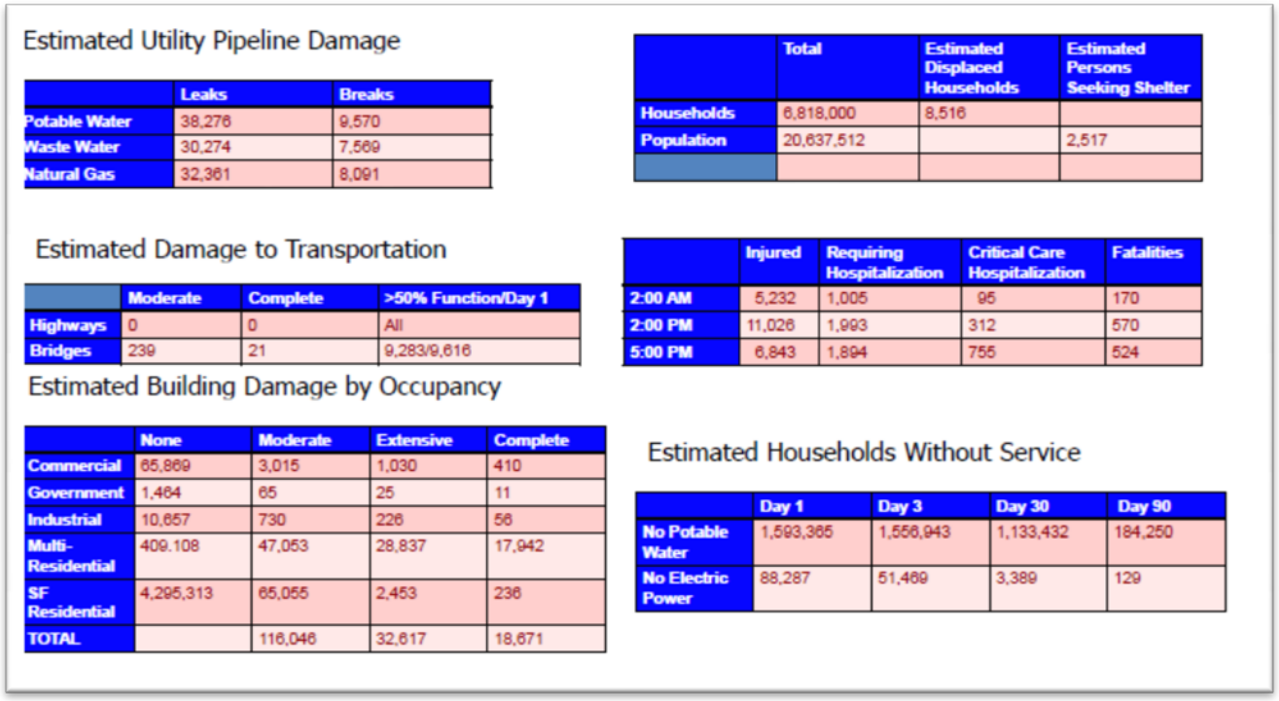
State Disaster Management Agencies will have extensive use of ICT infrastructures design and commissioned around network of EOC. In addition to telecommunication, EOC(s) will have facilities like - Audio / video management, remote monitoring and surveillance, data storage and analysis, DSS, call dispatch, Crisis information management portal, IS/GPS applications, Mass messaging and early warning systems.

GIS & DECISION SUPPORT SYSTEM (DSS):

Spatial data and GIS have proven crucial in preparing for, mitigating, detecting, responding to, and recovering from natural and technological disasters (Amdahel, 2002). Without spatial data one cannot expect effective and efficient disaster management, as spatial data are the initial input for GIS and Emergency Response Modeling and Simulation Systems (ERMSSs). A problem of particular interest for disaster management is the ability to fuse data from disparate sources. For example, how can geospatial data about the location of victims be integrated with online data about the location of medical facilities to provide information needed by emergency managers, first responders, and others. Advances in visualization of information are critical. Humans process visual data very efficiently but text data slowly.

The employment of recent advances in spatial data management and Geomatic engineering technologies in disaster management, including Information Communication and Technology (ICT), Geographical Information Systems (GIS), Remote Sensing (RS), and Global Positioning System (GPS), has considerably improved disaster management through facilitating data capture, integration, analysis and visual display. The integration of such technologies with each other and with other technologies such as decision support systems (DSS), the world-wide-web and simulators has created more effective process for disaster management. Recognizing the crucial

importance of Geographical Information System (GIS) as a decision support tool for disaster management.



Estimated Utility Pipeline Damage

	Leaks	Breaks
Potable Water	38,276	9,570
Waste Water	30,274	7,569
Natural Gas	32,361	8,091

	Total	Estimated Displaced Households	Estimated Persons Seeking Shelter
Households	6,818,000	8,516	
Population	20,637,512		2,517

Estimated Damage to Transportation

	Moderate	Complete	>50% Function/Day 1
Highways	0	0	All
Bridges	239	21	9,283/9,616

	Injured	Requiring Hospitalization	Critical Care Hospitalization	Fatalities
2:00 AM	5,232	1,005	95	170
2:00 PM	11,026	1,993	312	570
5:00 PM	6,843	1,894	755	524

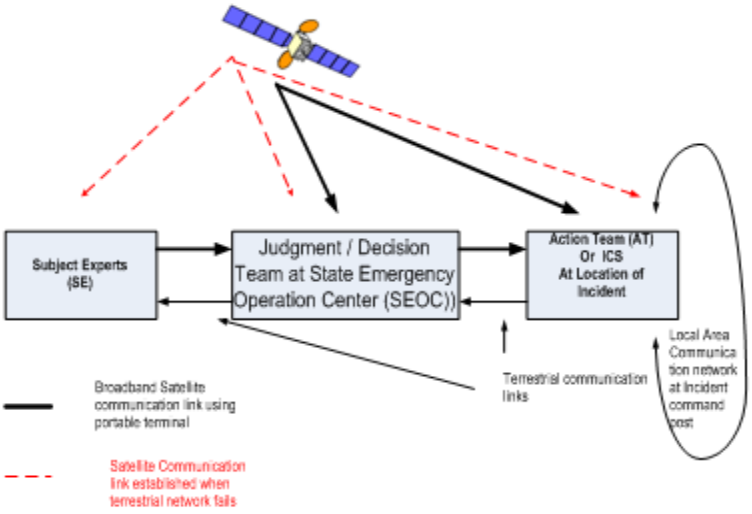
Estimated Building Damage by Occupancy

	None	Moderate	Extensive	Complete
Commercial	65,869	3,015	1,030	410
Government	1,464	65	25	11
Industrial	10,657	730	226	56
Multi-Residential	409,108	47,053	28,837	17,942
SF Residential	4,295,313	65,055	2,453	236
TOTAL		116,046	32,617	18,671

Estimated Households Without Service

	Day 1	Day 3	Day 30	Day 90
No Potable Water	1,593,365	1,556,943	1,133,432	184,250
No Electric Power	88,287	51,469	3,389	129

Fig- 6: Impact Assessment – Decision Support System



The ability of decision makers to make sound disaster management decisions – to analyze risks and decide upon appropriate counter-measure can be greatly enhanced by the cross-sartorial Integration of information. For example, to understand the full short and long term implication of flood and to plan accordingly would require the analysis of combined data on – meteorology (real time and historical), topography, soil

Fig-7: Knowledge Management in Situation After Disaster (SAD) ***(Source: Dave R K, 2009)***

character, vegetation, hydrology, settlements infrastructures, transportation, population, social-economic and material resources. Experts (Knowledge bank) who are familiar with the subject matter and the local dynamics would need to analyze multiple data and then interpret them to

decide whether there is a genuine threat of an impending disaster. Ability to seamlessly share information and collaborate in real time has become essential for effective and efficient disaster management. GIS based DSS can help in making information actionable to the responders and to the decision-makers when there is an ongoing and escalating crisis by matching incident report against a supporting data base, or a supporting piece of information from another source to paint a picture of how bad is bad, or what is the actual situation, or what are my options, now you are making that information actionable.

Key requirement of a Disaster Management Decision Support System (DMDSS) would be accurate and updated data base of –

- Hazard Assessment Mapping
- Vulnerability Assessment
- Demographic Distribution
- Infrastructure, Lifeline and Critical Facilities
- Logistics And Transportation Routes
- Human And Material Response Resources
- Sensors and environmental monitoring system
- Communication and Networking Facilities
- Alert and Warning network systems
- Various simulation models for data analysis and forecasting

Following are some of the categories under which various decision support data can be further divided –

Base Data	***Scientific Data***	***Engineering Data***	***Economic Data***	***Management plans***
-Topography -Political boundaries -Public land survey system -Geographic names -Demography -Land ownership/ use -Critical facilities	-Hydrography / hydrology (surface and subsurface flows and levels) -Ocean levels and tides -Soils -Geology: rock types/ ages/ properties/ structure -Meteorology and climatology -Archeology -Seismology: active faults, seismicity, seismic wave propagation, ground motion -Volcanology -Wildlife: habitat, spawning areas, breeding grounds	-Control structures: locks, dams, levees -Pump stations -Building inventories/ codes -Offshore facilities -Transportation, bridges, tunnels -Utility infrastructure, pipelines, power lines -Critical facilities -Communication systems	-Financial -Insurance: holdings, -losses -Exposure -Environmental Data -Threatened and endangered species -Hazardous sites -Water quality -Critical facilities (CIKR) -Response Data -Evacuation routes	-Aircraft routes -Personnel deployment -Equipment deployment -Warning system -Shelters -Monitoring system -Loss estimates

Table-2: Categories of Decision Support Data ***(Source: Dave R K, 2009)***

The role information search and response processes in emergency management are strongly influenced by three conditions. First, the types of information needed for effective decision making vary with the different requirement of action in each phase. The quality of information search accomplished in one phase affects the capacity for effective organizational decision making in succeeding phases. Second, the type of information needed for appropriate emergency response, also, vary with the kinds of responsibilities assumed at different levels of governmental jurisdiction (Comfort, 1985). For example, during response phase – fire personnel need to know exactly where to dispatch fire trucks; police personnel need to know where streets are blocked before evacuation route can be designed. At the district level, emergency operation center need to know extensiveness of the damages in different cities or villages, what would be immediate resource requirement and where required resources are located for optimizing the deployment schedule. At the state and central levels, respectively, loss estimations in various categories (casualties, live stock, roads and buildings, lifeline services etc), extent of geographical area affected, and allocation of available resources are necessary to mobilize state assistance or to implement the central disaster responsibilities as may be applicable under a national emergency situation. Third, the rapid escalation of complexity in the operating environment of disaster affects the capacity of emergency service personnel to assimilate and process information. Emergency personnel, operating under routine, single agency information procedures, become simply overwhelmed with the amount, diversity, and the rate of requests for assistance or reports of changing conditions in an actual disaster. The effect this enormous increase in complexity upon emergency operations is to slow down the ability of emergency service personnel to make appropriate decisions and to increase the chance of error. Effective management of the complexity generated by interacting events, people, and conditions in disasters requires an information system (called Decision Support System or DSS) capable to meet the vastly increased demand for accurately receiving, processing, and ordering the information in the form that is usable for the decision maker.

The primary information output from a DSS - on the likely impact of the event in terms of the extent of the area affected, location specific details, population affected, availability of resources for evacuation of the people & relief and quick assessment of damage, are critical in emergency management disciplines because it allows us to start proactively preparing for an event as it is occurring, or even before it occurs, without having to wait for the phone to start ringing or damage reports to start pouring in. DSS helps ability of planner, decision makers and responders to get ahead of problems.

Essential components of the decision support system include (Wallace, 1985) -

- Data bank / Data base;
- Data analysis capability
- Normative models, and
- Technology for display and the interactive use of the data and models.

Indian National Government and few state Governments have taken few initiatives in the direction of disaster information management, but the “big picture” approach is missing. The management information systems currently being designed and developed at Central and State jurisdictions:

- focus on data processing with the functional’ and routine activities of the agency;

- emphasize periodic reporting with some capability for ad hoc inquiries;
- typically include only data on the internal' operations of the organization;
- No modeling is done for running simulation tests;
- Non standard risk and vulnerability mapping in absence of standardization;
- are not integrated with the national information grid (India do not have any systematic national disaster information grid)
- are inflexible and difficult to change to meet new demands;
- are designed for use by computer processionals, not managers; and
- Absent unifying software application navigation to sub-systems.

Ministry of Home Affairs, GoI, is planning to establish a GIS database, 'National Database for Disaster Management (NDDM), to assist in hazard zonation, risk assessment, preparedness and emergency response management. But the most crucial part is "data", which is available at local level.

Plan/Proposal for establishing – data Fusion at National level (NDMA, GoI) along with GIS based applications with a SOP for data collection, compilation and management at different level (national, state and local) by NDMA is an step forward toward effective use of DSS . Presently no effective Data Fusion Centre has been established. Even the Data Centres established in a few States and Districts have limited functional capabilities, as the Data available is mostly generic in nature and not disaster specific.

In a typical disaster situation - National EOC will have representatives of involved organizations (14 ESF departments / ministries) involved in coordinating planning and response activities. Similarly SEOC data base would have interface with data base of different departments attached with the ESF identified at the state level. In ideal situation - NEOC data base will have seamless connectivity with SEOC data bases of all states .The N/S EOC Database contains base maps as well as fundamental required datasets for disaster management. Each of the organizations involved would be responsible for producing and updating one or more datasets within the EOC database before and after a disaster. Each organization can then utilize required datasets from the EOC database for their own use. This demonstrates the important concept of standard based data base as enabler of partnerships in

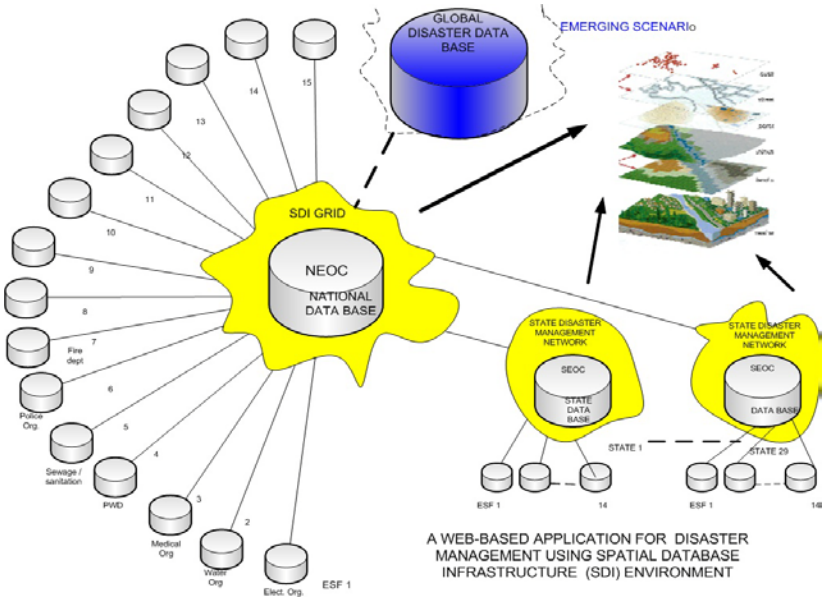


Fig-8: SDI Environment ***(Source: Dave R K, 2009)***

Producing, updating and sharing datasets. Under the "Virtual India Model" for GIS based disaster management decision Support System, each stakeholder (at national and state level) will maintain their data, and then share it, and NDMA will fuse it at all different level based upon the needs of subscriber. The application should be interoperable with all different set of standards and languages viz. EDXL (emergency data exchange language), CAP, GeoRSS, XML etc..

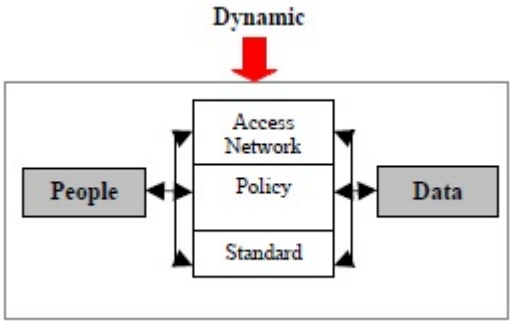


FIG-9: SDI COMPONENTS
(Rajabifard et al, 2002)

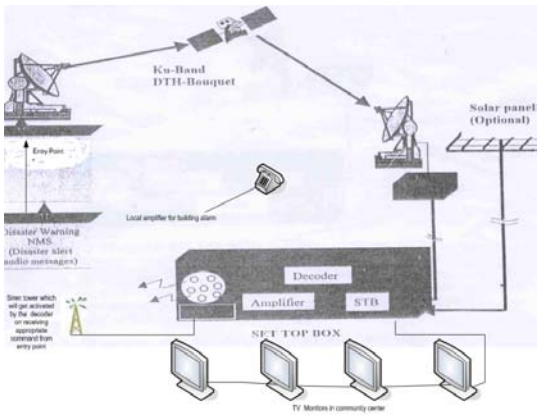
Government of India will need to develop a framework for Spatial Data Infrastructure (SDI) defining standards, policies (partnership, accessing rules, etc.), people (training etc.), access network and data/information framework. An SDI encompasses the policies, access networks and data handling facilities (based on the available technologies), standards, and human resources necessary for the effective collection, management, access, delivery and utilization of spatial data for a specific jurisdiction. SDI will help in quality decision making for disaster management at all levels in the organizational hierarchy.

EARLY WARNING SYSTEM:

India does not have elaborate public alert and warning network system – like western world. Country has many hard lessons in past – when absent timely warning to the people proved devastating. Failure of administration in alerting people at risk in 2004 tsunami and 2008 Bihar flood attests absence of progress made in planning and establishing required monitoring and warning systems in the country. Lack of preparation, absent review and re-engineering mechanism within the core agencies responsible (IMD/CWC..) for managing early warning, inadequate infrastructure, absence of coordination and alert education still remain major bottlenecks of governing systems in India.

Existing Cyclone warning dissemination receive systems installed at each District HQ were relevant 20 years ago when we had limited telecom and broadcast service spread. India needs to harness newer alert and warning technologies and plan systemic integration of wide-spread cellular and TV / Radio broadcasting networks for improve efficiency and effectiveness of emergency disaster management in the country. Even in USA - Emergency Alert System (EAS), relies primarily on broadcasting media, and the NOAA Weather Radio All-Hazards Network.

Fig-10: Activation of Siren through DTH decoder



Direct To Home (DTH) TV, which has the potential for practically 100 % national coverage, needs to be engineered for national alert and warning backbone with automated and voice enabled siren systems located at "the last mile". Community TV / DTH sets will have provisions to operate on AC / DC power supply so as electricity outages in the local village(s) does not impede TV

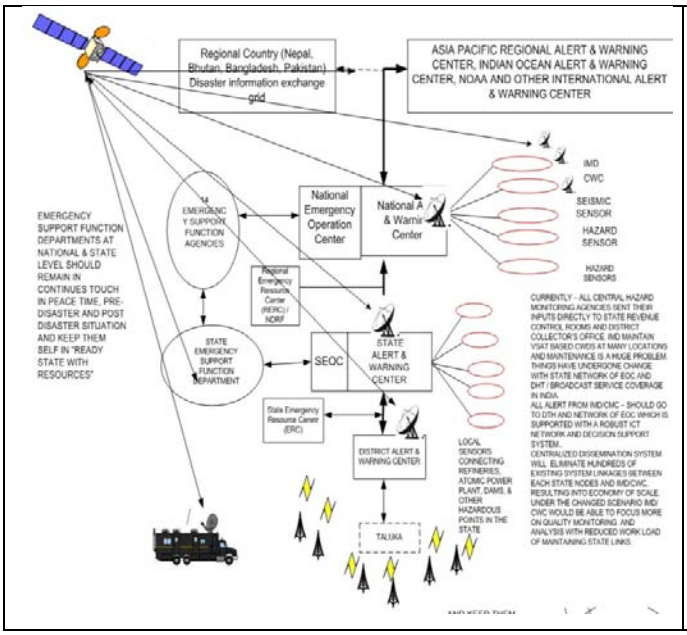
reception. Prashar Bharti's project on interfacing and activation of a siren using DTH set-top-box need to be investigated as this will offer much needed redundancy in the dissemination network. Modern sensor and communication technology has revolutionized the disaster monitoring and early warning scenario globally. Tremendous growth of mobile telecom and broadcast infrastructures offers huge opportunities for improving alert and warning system in India. The success of National Disaster Management mandate would largely rest on how effectively National Government lead in planning and standardizing norms for - Integrated National Alert and Warning System. Core national service organisations (IMD / CWC / NRSO /ISRO etc) engaged in monitoring and assessing environmental and other hazard parameters needs urgent - review and re-engineer, end-to-end, alert management system, by leveraging modern technology under EOC regime.

Pro-active disaster management system – "alerts should accompany with resources and authority and action advice" at first hit. A typical scenario – Alert flowing into EOC at NEOC/SEOC - passes through DSS for assessment of impact and resources requirement - District Collector receives alert and resources at the same point. District may not require turn-back and looking toward state relief commissioner for "resources and authority" - as use to happen in the past. Action and alert go "concurrently" in emerging disaster management systems. GIS based decision support system at National and state EOC will play an important role in producing a "common operating picture" on impeding disaster so as authorities at all level can act in time with resources required.

Alerts should connect to "National/ state EOC – for government action and to broadcasting channels, including social electronic media for alerting public at large. VSAT based district and taluka cyclone warning dissemination system were relevant in 80s-90s and not now when almost 100 % of Indian geography is covered with DHT broadcast foot prints.

Some of the crucial issues to be included in design of the Indian national Alert and Warning Network would include –

- Single window "National Alert and Warning Center" for International and National threat coordination and management.
- Standardized and pre-notified policies and procedures for International disaster Coordination and information exchange.
- Standardized infrastructure for information exchange needed for effective international and national coordination.
- Effective and efficient observational network (Land, Ocean and Satellite)
- Effective and efficient Monitoring, surveillance and detection network for manmade disasters.
- Effective and efficient data monitoring, analysis and forecast systems on disasters.
- Leveraging modern decision support system (DSS) attached with normative simulation models, which are more users friendly and capable of producing reports understandable by one and all.
- Effective and efficient mass notification system to provide real-time information to all stakeholders and people at risk.



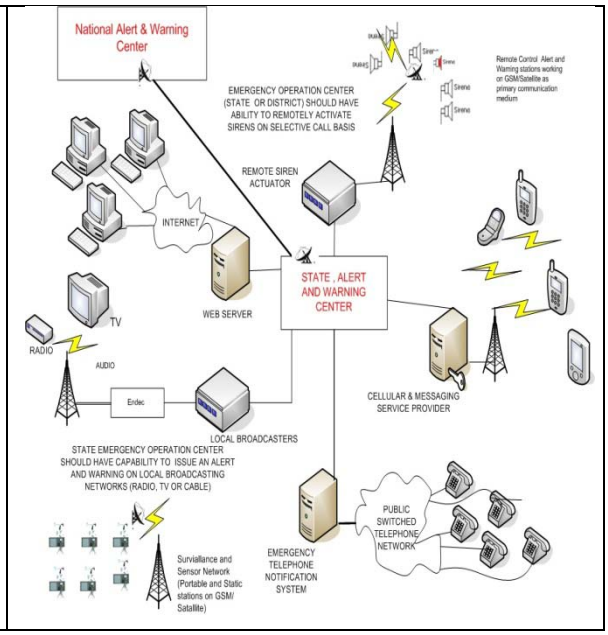


Fig-11: National Alert & Warning Dissemination **Fig-12: State early Warning System** ***(Source: Dave R K, 2009)***

In a typical scenario "National Alert & Warning Center (NAWC)", which will be sub-set of NEOC, would work 24*7 and 365 days a year and benefit Indian states and regional countries. The NMAWC would be notified as the "single point of contact" for international warning centers (like -NOAA / Pacific Tsunami Warning Center/ etc.) and national agencies working on the early warning and forecasting activities (like IMD, CWC, Remote sensing etc...).

All State Alert and Warning centers (or SEOC) will have direct interface with the NAWC through reliable communication channels. NMAWS would use state of art mass notification tools for flashing alerts on email, pagers, cell phones, national emergency and disaster information network system, and landlines, to states, emergency managers and other stakeholders instantaneously. Objective of the web-enabled National alert and warning system may include -

1. Management of Alerts and warnings to the public and Government (s) via the Internet / intranet
2. Geographically targeted alert/warning calls to residences, businesses, and public facilities in multiple languages
3. Video / Audio alert messages via the Internet / intranet and subscribing TV / Radio stations and sirens
4. An opt-in facility that will allow the public to elect to receive warnings and alerts via pagers, cell phones, computers and other devices connected to the Internet

National Alert and warning system design for the rural India would need some specific considerations. Basic Infrastructures in remote rural area are still poor and majority of people living in these areas will not have electricity, or telephone at their home - despite broadcast and telecom coverage feasibility. Rural folks still depend on the village / community center for information and education. Following are few of the additional design factors to be considered -

1. Multiple language translation
2. Multiple methods of communication and
3. Multiple level of operation and management
4. Siren based / or DTH based Community alert and warning system in rural area
5. Battery operated TV / DTH set-top-box

Resources needed to provide alerts and information before, during, and after an emergency need elaborated mention in NRP(National Response Plan) so as same can be linked with the current NDCN(National Disaster Communication Network) design under consideration. There is huge investment plan for improving systems for monitoring earthquake activity, but there appears to be no consistent planning for how this information could be used to save lives of earthquake victims. Forecasts about the probable location and intensity of aftershocks could guide evacuations to comparatively safe areas of refuge: information that could be shared in real-time not only with first responders but also with the evacuees—if alert technologies were linked to seismic information networks. Similarly, although plans are widely in place to provide life-saving resources such as shelter, food and water, and medical care and health services, the communications plans that would direct disaster victims to these resources appear to be absent. Communication requirements (alert and information) for community should be an integral part of emergency response communication plan defined in NRP.

For realization of a standard base – National Alert and Warning System, National Government need to -

1. Evaluating existing resources for reengineering alert and warning system in India;
2. Standardization of alert protocols and procedures required for interoperability
3. Plan, establish and support necessary communications facilities (WAN and last mile);
4. Plan and standardize training, testing, and exercises;
5. Plan and promote public education about emergency warnings;
6. Review and coordination of national alert and warning system with all states and other stakeholders.

Conclusion and Recommendations:

Poor quality and inadequate / absent connectivity remain at the top of the identified problems during severe incidents. Connected Government is the prime need for managing disasters and resource management system (data based cascaded with decision support tool) is the prime enabler. Reliable ICT infrastructure and electric power are critical in emergency response. Access to reliable, accurate and timely information is crucial immediately before, during and after a disaster.

Responding to disasters involves such information and communication-intensive activities as - marshaling available resources and materiel, mobilizing and organizing sufficient skilled personnel, deploying them with those resources to where they are needed, and finally coordinating their actions. Specific tasks include establishing connectivity with potential resource providers, authorizing the use of resources and coordinating their use into something akin to a supply chain, integrating information from diverse (including ad hoc) sources, reducing

the volume of data to relevant information for recipients, directing ongoing operations based on an overall awareness of the situation, adjusting and altering prior plans and commitments based on the evolving situation, and supporting collaboration and distributed decision making.

Disaster Management system based on 3C principles (communication, coordination and collaboration) would need uniform and interoperable ICT systems for exchange of information and services. Disaster information network consensus standards would allow more efficient and accurate integration and use of information. Protocols would define communications, database structure, data formatting, hardware/software requirements, networking, quality control, and other issues needed to assure the linking of users, information providers, and other agencies.

Emergency response communication networks (both in state as well as national level) need to be planned and designed keeping – "services and coverage" considerations. These resources have to be D.A.R.E. (dedicated, assured, reliable and Efficient). Impact of integration of POLNET and other satellite communication resources would need detailed assessment on "objective vs. performance" of these networks. Converging multiple systems working with different satellites and different frequency bands would - add boxes, increase integration / interconnection complications and may bring down reliability, and at the same time increase cost of ownership (TCO).

Success of disaster management system will rest on the quantity and quality of the required contents and services made available in electronic form, in vernacular language, and availability of reliable access by by all stakeholders to such resources. Specifically in case of early warnings "Ease-of-use (including the right language) will be an important factor in view of the low literacy levels in rural India. Voice based alert messaging would help in improving – "Alert effectiveness coefficient". India needs "managed and voice based siren systems" with remote health management and "location independent activation (can be operated from any level – i.e. village, taluka, district, state or national) capabilities.

Substantial improvements in early warning dissemination systems in India could be achieved through- review and reengineering of existing procedures and mechanism for management of early warnings – keeping current status of national ICT infrastructures, which has grown beyond imagination during last a decade or so. MHA in consultation with MOC&IT (Min. of Information and Communication Technology) and MOB (Ministry of Broadcasting) should draw a strategy for use of broadband plan that includes a plan for use of broadband infrastructures and services for National alert and warning system. Use of GSM/CDMA combined with satellite (inmersat) would be obvious choice for connecting remote warning towers with the management nodes with state and central administration under the current conditions.

Globally - ICT has become a critical tool for facilitating the communications and information-processing activities in Disaster Management and Decision Support System. Information and communication network systems "as effective enabler" for coordination and integration of the resources, in concurrent fashion, from the various nodes throughout the four phases of the disaster management process would constitute foundation for effective "emergent emergency and disaster management". Such networks are "self-organizing" and adjust with the shifting contingencies in the aftermath of the disaster.

The current situation in India is characterized by numerous shortcomings that inhibit optimal decision making for disaster management. The inability to access information and the lack of standardization, coordination, and communication are all obstacles that a disaster information and communication network could overcome. Institutionalized approach toward disaster management is relatively new in India. There exist ample opportunities to plan and establish interoperable systems under short and long term strategy befitting to new organizational models being adopted both at national and state level.

The mitigation process is a complex and can involve many situation- and location-specific details, and it relies heavily on tools such as predictive models of the impacts of particular disasters. Remote sensing is judged to be extremely useful but has not been employed in as many ways or places as are needed. Number of state and central agencies, including NRSA, ISRO, CWC, IMD etc, is working on development of strategic geospatial database and related models, but these critical important resources could never be effectively used in preventing disasters or minimizing their impact I absence of a “common integrator”. In most of the cases the available database resources were / are used for “postmortem” in the aftermath of disasters!

India need a “National data / Information Fusion center” for integration of all diverse information and data resources and bring them to a common plate form for access of all states under a SDI policy framework. Central Government need to come out with the “National Continuity Program (NCP)” with detailed deliberation on strategic plan for developing State and National Network of EOC(s) with Disaster Communication network; DSS supported with spatial data base infrastructure (SDI), associated GIS based applications, early warning system, implementation-operation and maintenance plan, sharing of resources (like mutual aid system working in USA) and funding mechanism. CIKR (Critical Infrastructure and Key Resources) policy, also, need to be spelt under the preview of national Continuity Program (NCP).

Operation and management of ICT network system needs highest order of training and skill set and also there is always a scarcity of HR due to greater market demand. Information and communication technology (ICT) scenario is changing fast in each state with their eGovernance endeavors and every state has a dedicated IT department and State Wide Area Networks. Outsourcing implementation and management (as is done for State Wide Area Network) of disaster management ICT infrastructure facility would be more appropriate at state level compared to other options available for technology adoption. In a model with EOC facilities establishment and maintenance being outsourced, response management team would be free to focus on the incident management with minimal disruption from the environment in which team is operating. Outsource SLA (Service level Agreement) may also cover technology obsolescence in addition to system / subsystem uptime and deployment requirements under normal and emergency conditions.

NIC’s role in the state IT affairs has gone to the lowest ebb during last ten years, and majority of their state resources are underutilized. Under these conditions, National Disaster Management Authority has a great opportunity to tap the vast potential of existing NIC’s network and other resources for management of emergency and disaster management information backbone. National EOC should be manned & managed by a composite team of officials from central

Government as well as state Governments (rotation basis). Participation of state Government officials will not only help in improving coordination between central and state agencies but also induce reciprocal capacity building and reap long term benefits. (Dave R K, 2009)

Government of India, as the unifying agency for all states and union territories, would require focusing on "continued innovation" to keep pace with the dynamics of both technologies as well as service demands in disaster management and continuity of Governance (COG).

Resource scarce third world countries have no option except to design their disaster management system centered on the principals of "sharing", to achieve sustainability objectives, by leveraging modern Information and Communication Technology.

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Dr R K Dave is a strategist and expert on ICT, emergency and disaster management. He has also specialized in spectrum management and eGovernance. He is in the field of ICT for more than 35 years and has worked in various capacities with central as well state Governments and international agencies. Few of his major accomplishments include implementation of - Monitoring earth Station (Government of India), GMDSS policy (WPC, DOT, GoI),Communication and canal automation, Sardar Sarover Narmada Project, GSWAN (Gujarat), SWAN Policy (GoI), Broadband Policy (GoI),International Information Highway (ADB project),SCADA system for GIFT city, Gujarat, ICT infrastructure project for disaster management (Gujarat). Dr Dave holds Bachelor of Engineering (Electronics & Communication), M.B.A., M.S.H.S. (Emergency management) and Ph.D. (Emergency and disaster management). He is currently heading ICT infrastructure development project for State Network of EOC(s) in Gujarat State, which is under advance stage.