Geological Hazard Monitoring

Geohazards may be defined as the hazards that occur primarily due to any geological event, processes, activity, condition or environment. It includes potential hazards like earthquakes, landslides, avalanches, volcanoes, tsunami etc., As the incidences and impacts of these hazards are increasing due to various factors like unplanned unscientific development, rapid urbanization leading to concentration of population and properties in confined susceptible areas due to ill land-use planning, and changing climatic conditions; there is an urgent need to improve our basic understanding of the risks posed by geo-hazards and the ability to deal with them. Furthermore, climate research indicates that one can expect more extreme weather events in the future, leading to increased flooding, landslides, avalanches, erosion, scouring, sea level rise etc., due to melting of ice, glacial retreat, uneven distribution of rains with varying intensities in different areas as well as advancement or delay in the period of rainfall that are normally seasonal in nature.

The potential impacts of such hazards tend to be ignored in today's planning of land use, development of structures, infrastructure, utilities, services and socio-economic processes. The recent extreme disasters that happened in the Country revealed gaps in the knowledge of geo-hazards available to planners, developers, financers, policy and decision makers. It is very important to understand the full spectrum of geo-hazards, including the extreme events, as a prerequisite for disaster risk management and increased resilience to these events. Any attempt to reduce the incidences and impacts of these potential disasters would require a good scientific understanding of the local hazards and the likely vulnerabilities of the elements at risk as well as enhanced capacities to avert, avoid, prevent, mitigate, resist and recover the risks within acceptable socio-economic limits.

1. Earthquakes:

Earthquakes are one of the most costliest natural hazards faced by the entire human & living kind, posing a significant risk. The risks that earthquakes pose to the society, including death, injury, and economic loss, can be greatly reduced by better planning, construction, and mitigation practices before earthquakes happen and providing critical and timely information to improve response after they occur. Earthquakes are natural hazards under which disasters are mainly caused by damage due to collapse of buildings and other man-made structures. Experience has shown that for new constructions, establishing earthquake resistant regulations and their implementation is the critical safeguard against earthquake-induced damage. Earthquake damage depends on many parameters, including intensity, duration and frequency content of ground motion, geologic and soil condition, quality of construction, etc.

The disastrous earthquake in Killari in the early hours of September 30, 1993 caused considerable damages especially in the districts of Bidar, Gulbarga and Bijapur. Other Earthquakes at Latur, Koyna, and Jabalpur are indicators of the vulnerability to earthquakes in Peninsular India. The faults, shear zones and lineaments in Karnataka are considered to be potential risk zones of the Killari type of earthquakes which also caused damages in the adjacent villages of Karnataka. The occurrence of earthquakes in Karnataka and neighbouring areas, although only of low magnitudes so far, call attention to the existence of weak zones in the State capable of storing and releasing strain energy provided by the steady northward movement of the Indian plate.

In Historical years, the earthquakes were detected from the World Wide Seismic Stations Network (WWSSN) & United States Geological Survey (USGS). However, these stations are quite distant from the Peninsular India and hence were difficult to detect earthquakes with magnitudes less than 3.0. The lower magnitude earthquakes (2.0 and below) were reported by the local communities and recorded by the BARC seismic station (specially designed array of seismometers to detect nuclear explosions) at Gauribidanur but the location of these earthquakes are incomplete and highly biased as the tremors do not occur in the vicinity of this station.

2. Causes of earthquakes:

An Earthquake is a series of underground shock waves and movements on the earth‟s surface caused by natural processes within the earth's crust. Earthquakes are caused by natural tectonic interactions within the earth's crust and it is a global phenomena. They may arise either due to the release of energy from the strained rock inside the Earth or tectonic movements or volcanic activity. The sudden release of accumulated energy or stresses in the earth or sudden movement of massive land areas on the earth's surface cause tremors, commonly called earthquakes.

Seismic Waves

Large strain energy released during an earthquake travel as seismic waves in all directions through the Earth's layers, reflecting and refracting at each interface. These waves are of two types - Body waves and Surface waves; the latter is restricted to near the Earth's surface. Body waves consist of Primary Waves (P-waves) and Secondary Waves (S-waves), and surface waves consist of Love and Rayleigh waves. Under P-waves, material particles undergo extensional and compressional strains along the direction of energy transmission, but under S- waves, oscillate at right angles to it. Love waves cause surface motions similar to that by S- waves, but with no vertical component. Rayleigh wave makes a material particles oscillate in an elliptic path in the vertical plane.

Magnitude

Magnitude is a quantitative measure of the actual size of the earthquake. Professor Charles Richter noticed that (a) at the same distance, seismograms (records of earthquake ground vibration) of larger earthquakes have a bigger wave amplitude than those of smaller earthquakes; and (b) for a given earthquake, seismograms at farther distances have a smaller wave amplitude than those at close distances. This prompted him to propose the now commonly used magnitude scale, the Richter magnitude Scale. It is obtained from the seismograms and accounts for the dependence of waveform amplitude on Epicentral distances. This scale is also called Local Magnitude scale, with other magnitude scales, like the Body Wave Magnitude, Surface Wave Magnitude and Wave Energy Magnitude. These numerical magnitude scales have no upper and lower limits; the magnitude of a very small earthquake can be zero or even negative.

Intensity

Intensity is a qualitative measure of the actual shaking at a location during an earthquake, and is assigned as Roman Capital Numerals (I till XII or even higher). There are many intensity scales. Two commonly used ones are the Modified Mercalli Intensity (MMI) Scale and the MSK Scale. Both scales are quite similar and range from I (least perceptive) to XII (most severe). The intensity scales are based on three features of shaking -perception of people and animals, performance of buildings, and changes in natural surroundings. The distribution of intensity at different places during an earthquake is shown graphically using iso-seismals, lines joining places with equal seismic intensity.

Intensity scale **(It manifests the degree of damage, which gets diminished as we go away from the main shock source zone and the reverse is also true)**

Mercalli intensity scale: The scale is a seismic scale used for measuring the intensity of an earthquake.It measures the effects of an earthquake, and is distinct from the moment magnitude usually reported for an earthquake (sometimes described as the obsolete Richter magnitude), which is a measure of the energy released. The intensity of an earthquake is not totally determined by its magnitude.

The scale quantifies the effects of an earthquake on the Earth's surface, humans, objects of nature, and man-made structures on a scale from I (not felt) to XII (total destruction). Values depend upon the distance to the earthquake, with the highest intensities being around the Epicentral area. Data gathered from people who have experienced the quake are used to determine an intensity value for their location. The Mercalli (Intensity) scale originated with the widely-used simple ten-degree Rossi-Forel scale which was revised by Italian vulcanologist, Giuseppe Mercalli in 1884 and 1906.

In 1902, the ten-degree Mercalli scale was expanded to twelve degrees by Italian physicist Adolfo Cancani. It was later completely re-written by the German geophysicist August Heinrich Sieberg and became known as the Mercalli-Cancani-Sieberg (MCS) scale. The Mercalli-Cancani-Sieberg scale was later modified and published in English by Harry O. Wood and Frank Neumann in 1931 as the Mercalli-Wood-Neumann (MWN) scale. It was later improved by Charles Richter, the father of the Richter magnitude scale. The scale is known today as the Modified Mercalli scale (MM) or Modified Mercalli Intensityscale (MMI).

Modified Mercalli Intensity Scale: The lower degrees of the Modified Mercalli Intensity scale generally deal with the manner in which the earthquake is felt by people. The higher numbers of the scale are based on observed structural damage.

The following table gives Modified Mercalli scale intensities that are typically observed at locations near the epicenter of the earthquake. The correlation between magnitude and intensity is far fromtotal, depending upon several factors, including the depth of the earthquake, terrain, population density, and damage. For example, on May 19, 2011 an earthquake of magnitude 0.7 in Central California, United States 4 km deep was classified as of intensity III by the United States Geological Survey (USGS) over 100 miles (160 km) away from the epicenter (and II intensity almost 300 miles (480 km) from the epicenter), while a 4.5 magnitude quake in Salta, Argentina 164 km deep was of intensity I.

Modified Mercalli Scale		Moment Magnitude Scale
I	Detected only by sensitive instruments	1.5
II	Felt by few persons at rest, especially on upper floors; delicately suspended objects may swing	2
III	Felt noticeably indoors, but not always recognized as earthquake; standing autos rock slightly, vibration like passing truck	2.5
IV	Felt indoors by many, outdoors by few, at night some may awaken; dishes, windows, doors disturbed; motor cars rock noticeably	3
V	Felt by most people; some breakage of dishes, windows, and plaster; disturbance of tall objects	3.5 4
VI	Felt by all, many frightened and run outdoors; falling plaster and chimneys, damage small	4.5
VII	Everybody runs outdoors; damage to buildings varies depending on quality of construction; noticed by drivers of automobiles	5
VIII	Panel walls thrown out of frames; fall of walls, monuments, chimneys; sand and mud ejected; drivers of autos disturbed	5.5
IX	Buildings shifted off foundations, cracked, thrown out of plumb; ground cracked; underground pipes broken	6
X	Most masonry and frame structures destroyed; ground cracked, rails bent, landslides	6.5 7
XI	Few structures remain standing; bridges destroyed, fissures in ground, pipes broken, landslides, rails bent	7.5
XII	Damage total; waves seen on ground surface, lines of sight and level distorted, objects thrown up into air	8

3. History of Earthquakes in Karnataka:

The seismic hazard map of India was being updated by the Bureau of Indian Standards (BIS). According to this map, the State of Karnataka lies in Zones II and III. The coastal districts as well as the northern interior districts along the border with Maharashtra, lie in Zone III, where a maximum intensity of VII can be expected. The remaining districts, as well as the city of Bangalore lie in Zone II. The Bellary region, which experienced a strong earthquake in the 1840's has been downgraded to Zone II while the 1984 BIS Zoning map had placed it in Zone III. It must be noted that BIS estimates the hazard, based in part, on previous known earthquakes. Since the earthquake database in India is incomplete, especially with regards to earthquakes prior to the historical period (before 1800 A.D.), these zones offer a rough guide of the earthquake hazard in any particular region and need to be regularly updated.

Much of the seismic activity in Karnataka has been in the southern Karnataka especially in the Mysore-Bangalore region in the recent years. Historically tremors have occurred in many other parts of the state such as Bellary. Several active faults have been identified in the recent studies, in particular in the coastal plain near the towns of Bhatkal and Udupi, trending in an ESE-WNW direction. Many of these faults continue offshore into the Arabian Sea trending in the same direction. There is also no evidence of the southward continuation of the West Coast Fault in the Konkan regions of the neighbouring state of Maharashtra as previously believed. However, it must be stated that proximity to faults does not necessarily translate into a higher hazard as compared to areas located further away, as damage from earthquakes depends on numerous factors such as subsurface geology as well as adherence to the building codes. A list of historical Earthquakes in the State reported by other Agencies is given as below **Table**.

Sl. No.	Date & Time	Region	Magn.	Intensity	Remarks
01.	**August 1507**	Billankote	-	III	Earliest known earthquake in Karnataka, which came on a stone inscription
02.	**1653-54**	Bijapur	-	III	
03.	**22 August 1828**	Bantwal-Mudbidri	-	VII	Epicentre East of Mangalore
04.	**12 March 1829**	Mangalore	5.7	VII	-
05.	**13 March 1829**	Bangalore	5.8	V	-
06.	**01 April 1843**	- Bellary-Kolagallu	6.0	VIII	Damage to civil structures and felt in a radius of 300 kms
07	**23 August 1858**	Bangalore	5.8	V	-
08.	**24 July 1861**	Raichur	-	V	-
09.	**13 January 1862**	Raichur	-	V	-
10.	**08 February 1900**	Coimbatore	6.0	-	Felt over a large section of south India and is the largest event during the historical period
11.	**07 January 1916**	Bangalore	5.0	V	-
12.	**12 February 1970 17:09:53 UTC**	Hassan	5.0	-	-
13.	**16 May 1972 16:36:42 UTC**	Malavalli	4.6	-	This region lies to the south of Mysore
14.	**17 May 1972 09:59:53 UTC**	Malavalli	4.5	-	This region lies to the south of Mysore
15.	**15 November 1973**	Almel-Sindgi Bijapur	4.0	V	-
16.	**12 May 1975 15:09:28 UTC**	Shivamogga	4.7	V	First known earthquake in this region. Felt in a radius of 140 kms
17.	**20 March 1984 10:45:22 UTC**	Denkanikota	4.6	VI	Felt in Bangalore and Mysore and in Tamil Nadu at Krishnagiri. Cracks were seen in plaster and utensils were overturned at these places
18.	**27 November 1984**	Masti-Berikal	4.5	-	-
19.	**03 May 1990**	Dharmasthala	4.6	-	This region lies between Mangalore and Hassan
20.	**14 November 1993**	Tallakad Kollegal	4.5	-	This region lies to the south of Mysore

Sl. No.	Date & Time	Region	Magn.	Intensity	Remarks
21.	**29 Jan 2001 02:37:47 UTC**	Bangalore	4.3	-	Caused considerable panic and minor damage to property in southern Karnataka
22.	**10 July 2002 14:09:06 UTC**	Koppal	3.5	-	Felt in some parts of the districts of Bellary, Koppal and Gadag

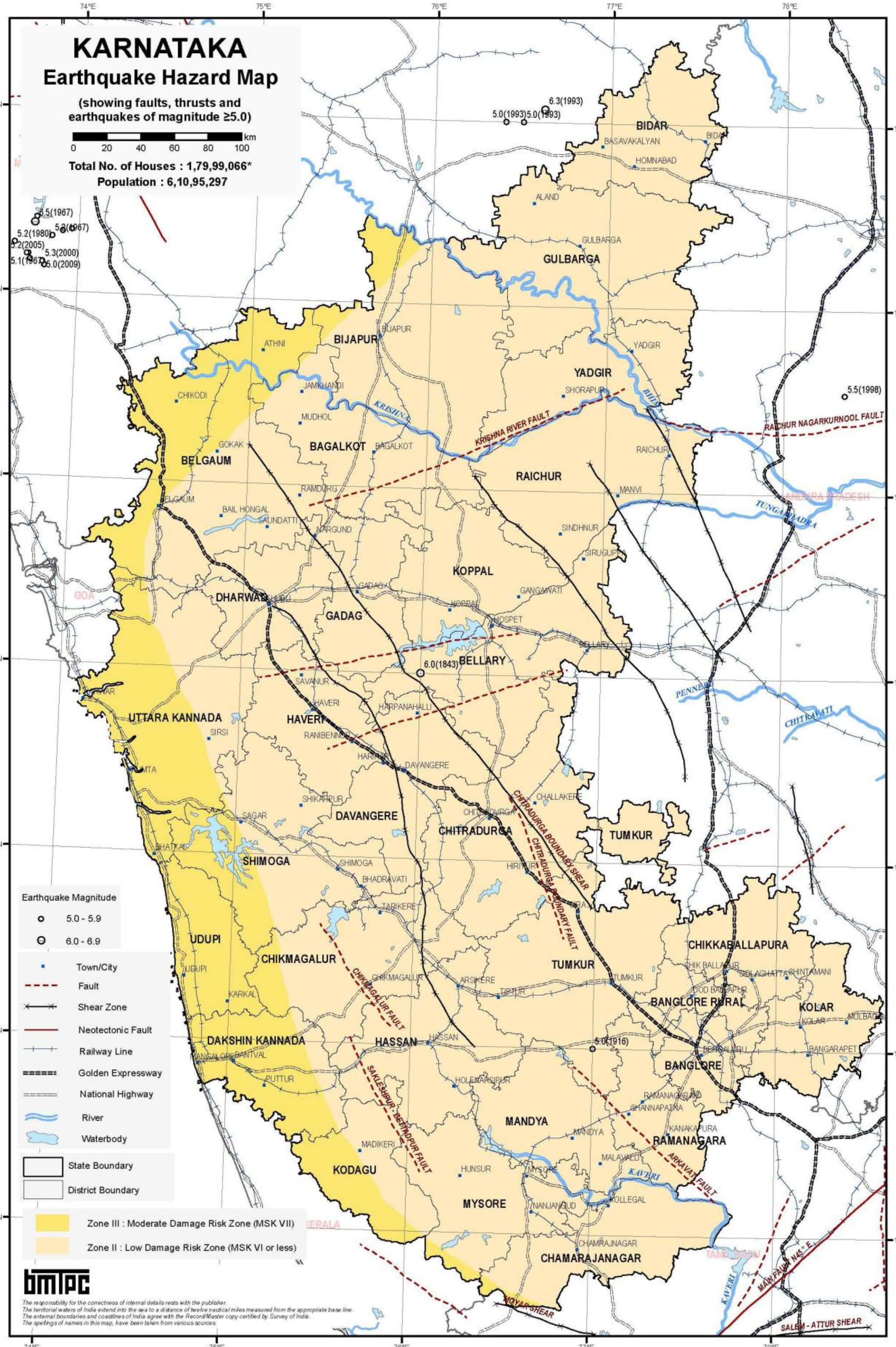
4. Seismic Zonation of India:

The importance of seismological studies lies in the fact that information generated can be used to mitigate the earthquake hazards. Preparation of Seismotectonic/seismic zonation maps is the first step in this direction. The basic data required for the preparation of these maps are:

(i) a carefully compiled earthquake catalogue incorporating details about magnitude, location of epicenter, depth of focus etc.,
(ii) delineation of seismic source zones from all possible sources like recurrence relation, tectono-geological consideration, palaeoseismicity etc.,
(iii) estimation of upper bound magnitude through statistical procedure, cumulative seismic energy release, active fault length etc., and
(iv) Attenuation of ground shaking for better results

These maps give an idea about the possibility of occurrence of earthquakes in the region and are very useful for evaluating the risk involved before designing and constructing the heavy engineering structures like dams, bridges, flyovers and large towers etc. These are also useful for planning human settlements that would remain safe during the occurrence of an earthquake. Seismic risk evaluation is also possible from these maps. Indian Meteorological Department, National Geophysical Research Institute, Department of Science & Technology, Bhabha Atomic Research Centre and Regional Research Laboratory (RRL) have established a large number of seismic monitoring network in the Country including the North East region. These stations are recording valuable seismic data, which enables to determine the location of epicenter, depth of hypocenter, energy within the focus, orientation of the geological structure that has undergone deformation and many other parameters of earthquakes.

These parameters are then utilised for preparing seismo-tectonic and seismic zoning maps. The work of seismic zoning in India was started by Indian Standard Institute (now Bureau of Indian Standards) in the year 1960 and the first map was included in the code IS: 1893-1962. A significant progress has been made since then both in seismic zoning and instrumental monitoring of seismicity. However, many questions regarding the location and nature of potential seismic zones/faults still remain unsolved and need to be addressed to in the new millennium. Seismic zonation map of a country is a guide to the seismic status of a region and its susceptibility to earthquakes. India has been divided into five zones with respect to severity of earthquakes. Of these, Zone V is seismically the most active where earthquakes of magnitude 7.0 or more could occur. Recent strong motion observations around the world have revolutionized thinking on the design of engineering structures, placing emphasis also on the characteristics of the structures themselves. It should be realized that in the case of shield type earthquakes, historic data is insufficient to define zones because recurrence intervals are much longer than the recorded human history. This may often give a false sense of security. Occurrence of the damaging earthquake at Latur, falling in Zone I is a typical example of this situation. The Karnataka state falls in the moderate risk zone (Zone III) as per the vulnerability map prepared by the Ministry of home, GoI, with a maximum magnitude of 4.9. This magnitude can affect areas in a radius of 5 to 7 kms from the epicentre. The Seismic Zonation map of Karnataka is given in below figure.



BMTPC : Vulnerability Atlas - 3rd Edition : Peer Group, MoHUA, GOI; Map is Based on digitised data of SOI; Seismic Zones of India Map IS: 1893 (Part I) - 2002, BIS; Earthquake Epicentre from IMD; Seismotectonic Atlas of India and its Environs, GSI; Houses/Population as per Census 2011; *Houses including vacant & locked houses. Disclaimer: The maps are solely for thematic presentation.

5. Permanent Seismic Monitoring Stations Network in Karnataka and its Capabilities:

Karnataka State Natural Disaster Monitoring Centre (KSNDMC) is the nodal agency in the state for monitoring of seismic activity. Scientific approaches currently adopted worldwide to enhance our resilience to the Earthquake hazard are of two types.

- The first is aimed at providing long term protection to life and property and involves estimation of the earthquake hazard in different areas of a region and its translation into engineering aspects for earthquake resistant structures and land use patterns in the area.
- The second adopted with the first is to keep a constant vigil on the evolving character of ground motion records emitted by small earthquakes from a wide area.

A tele-linked network of Seismic Stations is thus the basic equipment needed to implement rationally designed earthquake mitigation strategies. Hence, as a basic scientific infrastructure a seismic network is necessary for providing long and short term protection to its people against earthquake hazard as well as design considerations. The Killari earthquake, which happened in the neighbouring Maharashtra in the early hours of September, 1993 caused considerable damage in certain villages of Karnataka State, especially in the districts of Bidar, Gulbarga and Bijapur. This event has turned up the scientific community to think about the potential seismic hazard in the State of Karnataka.

Taking the above views into consideration, KSNDMC has set up a Solar Powered and VSAT & GPRS Enabled Permanent Seismic Monitoring Stations Network in the State of Karnataka at 14 locations including 10 Dam sites during the year 2009-2010. The present setup of Stations established are equipped with the state-of-the-art solar powered VSAT technology which includes a Broadband Seismometer, Strong Motion Accelerograph and a Digitizer synchronised with GPS along with associated accessories and VSAT Connectivity for data transmission to the Master Control Centre (MCC) at KSNDMC, Bangalore on real time basis. The Dam Sites taken up include

Almatti, Hidkal, T.B. Dam, Supa, Linganmakki, Hemavathi, K.R.S Dam, T.G. Halli and Harangi in a view towards Dam Safety in case of any Earthquake by studying the Strong motion effects near to the site.

The other land based Observatories are established at Kalaburgi, Raichur, Chitradurga & Udupi. The present setup of Stations established are equipped with the state-of-the-art Seismic equipments including a Broadband Seismometer, Strong Motion Accelerograph and a Digitizer synchronised with GPS and associated accessories along with solar power for powering the Network and VSAT for transmission of data from remote sites to the Master Control Facility (MCF) established at KSNDMC, Bengaluru on real time basis.

KSNDMC through its seismic monitoring network setup in the State has taken up monitoring of Local earthquakes along with Regional & Teleseismic Earthquakes. The objective of this Centre is to determine the Epicentre location (Longitude & Latitude of a region), depth and size of the local and regional earthquakes falling within the State and adjoining States respectively. These earthquake signals are extracted through the Seismogram records from the Broadband Seismometers of high sensitivity along with digital system, which registers all frequencies of significant importance. The above information thereby gathered by the Earthquake database on earthquake parameters and their effects will serve as a foundation for the basic and applied Earth Sciences research. The capabilities of the Permanent Seismic Monitoring Stations Network of Karnataka is as below:

- Appropriate choice of Seismometers & Strong Motion Accelerographs, Digital recording system, Solar Power Supply System and VSAT equipment.
- Unambiguously locating every possible earthquake with magnitudes greater than 1.0 in Karnataka & adjoining States.
- Every likely earthquake location in the State is within a distance of 100-150 kms from a minimum of 4-5 seismic stations.

- At least 3-4 of the stations record all the three components of ground motion namely, Vertical, North-South (NS) and East-West (EW).
- The epicentre of the local tremors in the State are determined with an accuracy of ± 1km and focal depth of ± 2km.
- The Scientific personnel involved in monitoring the seismic activity in the State are from professional background, i.e., from Geophysics & Geology.

Apart from monitoring, data analysis and information dissemination, the below responsibilities have also been taken up:

- Temporary installations of Seismic Instruments at tremor felt regions
- Joint Field visits to the tremor felt regions & Quarry area by subject experts
- Workshops at tremor felt regions
- Mass Awareness / Community Awareness Programmes
- Measurement & monitoring of Groundwater temperatures in open wells & Bore wells at tremor felt regions
- Providing presentations on Earthquakes and Quarrying activity to the local community
- Providing presentations to the Dam Authorities on the working procedure of the PSMS Network as and when required

6. Agencies responsible for monitoring Earthquake activity in the State:

A. Karnataka State Natural Disaster Monitoring Centre (KSNDMC), An Autonomous Organisation of Revenue Department (Disaster Management), Govt. of Karnataka & Nodal Agency of the Government of Karnataka for monitoring earthquake activity in the State

B. National Center for Seismology (NCS), Ministry of Earth Sciences, Govt. of India, the Nodal Agency of the Government of India for monitoring earthquake activity in the Country as a whole

- ❖ KSNDMC has established a network of 14 VSAT enabled Permanent Seismic Monitoring Stations during 2009 and was operational till 2021. The above network was strengthened during 2021 establishing SIX (06) Seismic Monitoring Stations along with additional TWO (02) already operational since 2016 totalling the network strength to EIGHT (08) as below:

Sl. No.	Name of the Observatory	Location of the Observatory
01.	Almatti Dam	Vijayapura
02.	Hidkal Dam	Belagavi
03.	Thalakalale Dam	Shivamogga
04.	Hemavathi Dam	Hassan
05.	T G Halli Dam	Bengaluru
06.	Jogimatti forest guest house	Chitradurga
07.	Sub-regional Science Centre	Raichuru
08.	Zonal Agricultural & Horticultural Research Station	Udupi

- ❖ NCS has approached KSNDMC for establishing FIVE (05) Seismic Monitoring Stations in the already existing Observatories of KSNDMC and during, 2021, Govt. of Karnataka has established 05 Seismic Monitoring Stations at Kalaburagi, Supa dam, Tunghabadra dam, KRS dam & Harangi dam as below:

Sl. No.	Name of the Observatory	Location of the Observatory
01.	Sharana Sirasagi	Kalaburagi
02.	Tunghabadra Dam	Ballari
03.	Supa Dam	Uttara Kannada
04.	K.R.S Dam	Mandya
05.	Harangi Dam	Kodagu

7. Dissemination of Earthquake Information:

- The Earthquake activity is monitored through the real time seismic data received to KSNDMC from remote Observatories across the State
- The data from the nearby Observatory is fetched and the Phases (P, S, Surface & Coda waves) are marked initially
- The Earthquake Parameters (Epicentre location, Magnitude, Depth & Intensity) are measured
- The District & local administration is informed of the Earthquake occurrence along with the local Dam Authorities
- KSNDMC will, if required take up Community awareness programmes based on the repeated occurrence of earthquakes and also establish a temporary seismic monitoring station in the vicinity to closely monitor the local seismicity

The Earthquake Parameters shall be disseminated within 30 minutes of occurrence of a local tremor, sample as below:

Epicentre: 1.8 kms SW of M D Hatti, Takkalaki GP, Tikota Taluk, Vijayapura District
Magnitude: 2.9
Date: 24.02.2023
Time: 10:32:14 PM
Co-ordinates: Lat: 16.8826° N; Long: 75.5358° E
Depth: 05 Km

In addition, a note on the Earthquake recorded and reported by the KSNDMC Network is communicated with the Office of Deputy Commissioner, Tahsildars, Dam Authorities for dam inspection. A sample of the same is given herewith.

A Note on the Earthquake recorded by KSNDMC on 24.02.2023

An Earthquake of Magnitude 2.9 is recorded by the KSNDMC Network in Vijayapura district with the following parameters:

Earthquake details & inferences from the Analysis:

Epicentre: 1.8 kms SW of M D Hatti, Takkalaki GP, Tikota Taluk, Vijayapura District

Magnitude: 2.9

Date: 24.02.2023

Time: 10:32:14 PM

Co-ordinates: Lat: 16.8826° N; Long: 75.5358° E

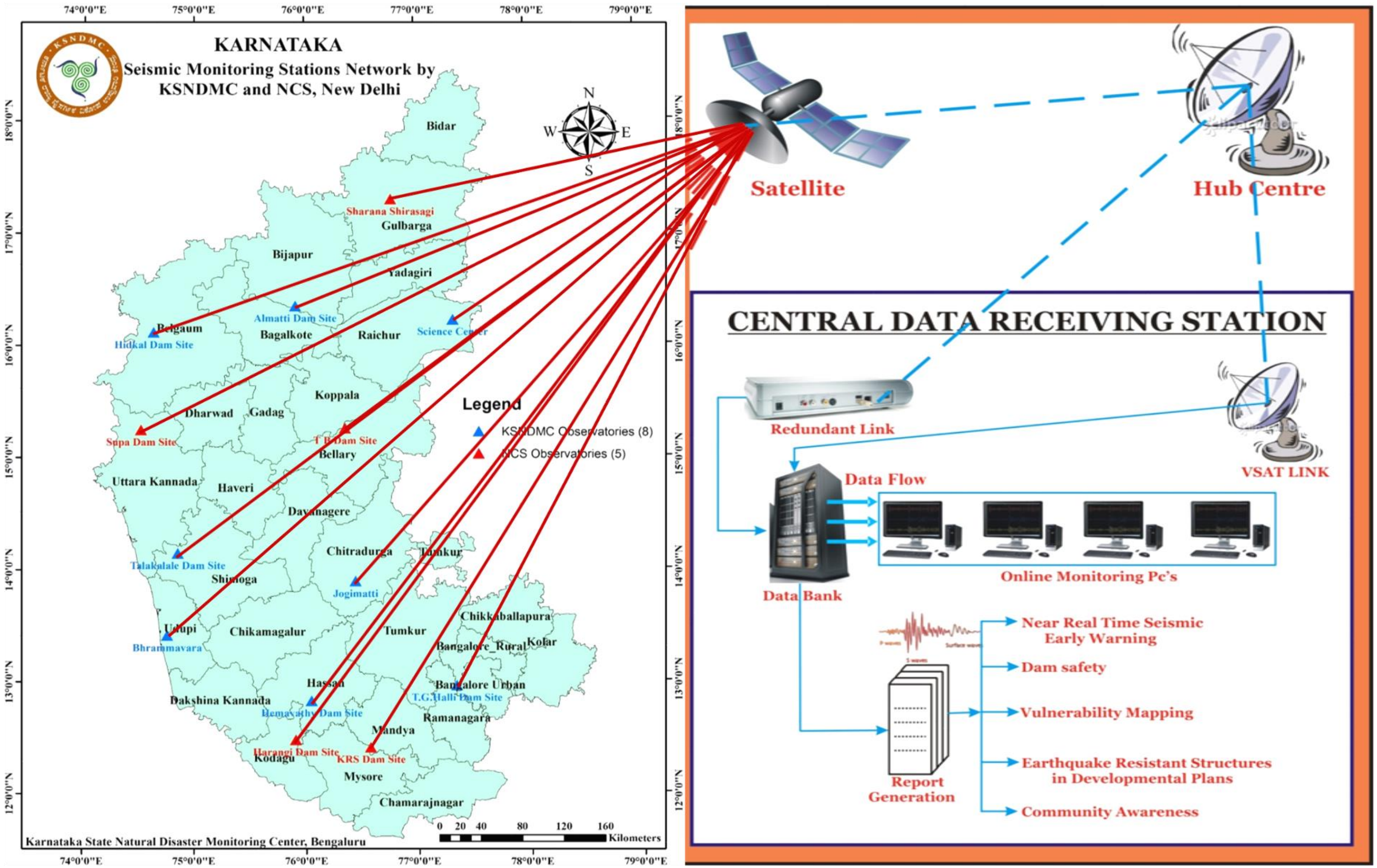
Depth: 5 Km

Further, the Earthquake epicentred at "**1.8 kms SW of M D Hatti, Takkalaki GP, Tikota Taluk, Vijayapura District**" has the following distances from the Epicentre:

- *2.4 kms W of Takkalaki GP, Tikota Taluk, Vijayapura*
- *4.8 kms NE of Tikota Taluk, Vijayapura*
- *20.7 kms WNW of Vijayapura City, Vijayapura*

As per the Seismic Intensity map of the above Earthquake from the Epicentre, the intensity observed is low and the tremor might be felt up to a radial distance of 40-50 kms from the epicentre. This type of earthquake would not create any harm to the local community as the intensity observed is low, though there might be local vibrations felt. The epicentre falls in Seismic Zone III and the region is void of any structural discontinuities as per the Tectonic map. The community need not panic as the magnitude & intensity observed are low.

Director, KSNDMC



KARNATAKA
Seismic Monitoring Stations Network by
KSNDMC and NCS, New Delhi
Legend
KSNDMC Observatories (8)
NCS Observatories (5)
Sharana Shirasagi
Almatti Dam Site
Science Center
Hidkal Dam Site
Supa Dam Site
T B Dam Site
Talakalale Dam Site
Jogimatti
Bhrammavara
Hemavathy Dam Site
T.G.Halli Dam Site
Harangi Dam Site
KRS Dam Site
Bidar
Gulbarga
Bijapur
Yadagiri
Belgaum
Bagalkote
Raichur
Koppala
Dharwad
Gadag
Bellary
Uttara Kannada
Haveri
Davanagere
Chitradurga
Tumkur
Shimoga
Udupi
Chikamagalur
Chikkaballapura
Bangalore_Rural
Kolar
Hassan
Bangalore Urban
Dakshina Kannada
Ramanagara
Mandya
Kodagu
Mysore
Chamarajnagar
0 20 40 80 120 160 Kilometers
Karnataka State Natural Disaster Monitoring Center, Bengaluru
Satellite
Hub Centre
CENTRAL DATA RECEIVING STATION
Redundant Link
VSAT LINK
Data Flow
Data Bank
Online Monitoring Pc's
Near Real Time Seismic Early Warning
Dam safety
Vulnerability Mapping
Earthquake Resistant Structures in Developmental Plans
Community Awareness
Report Generation

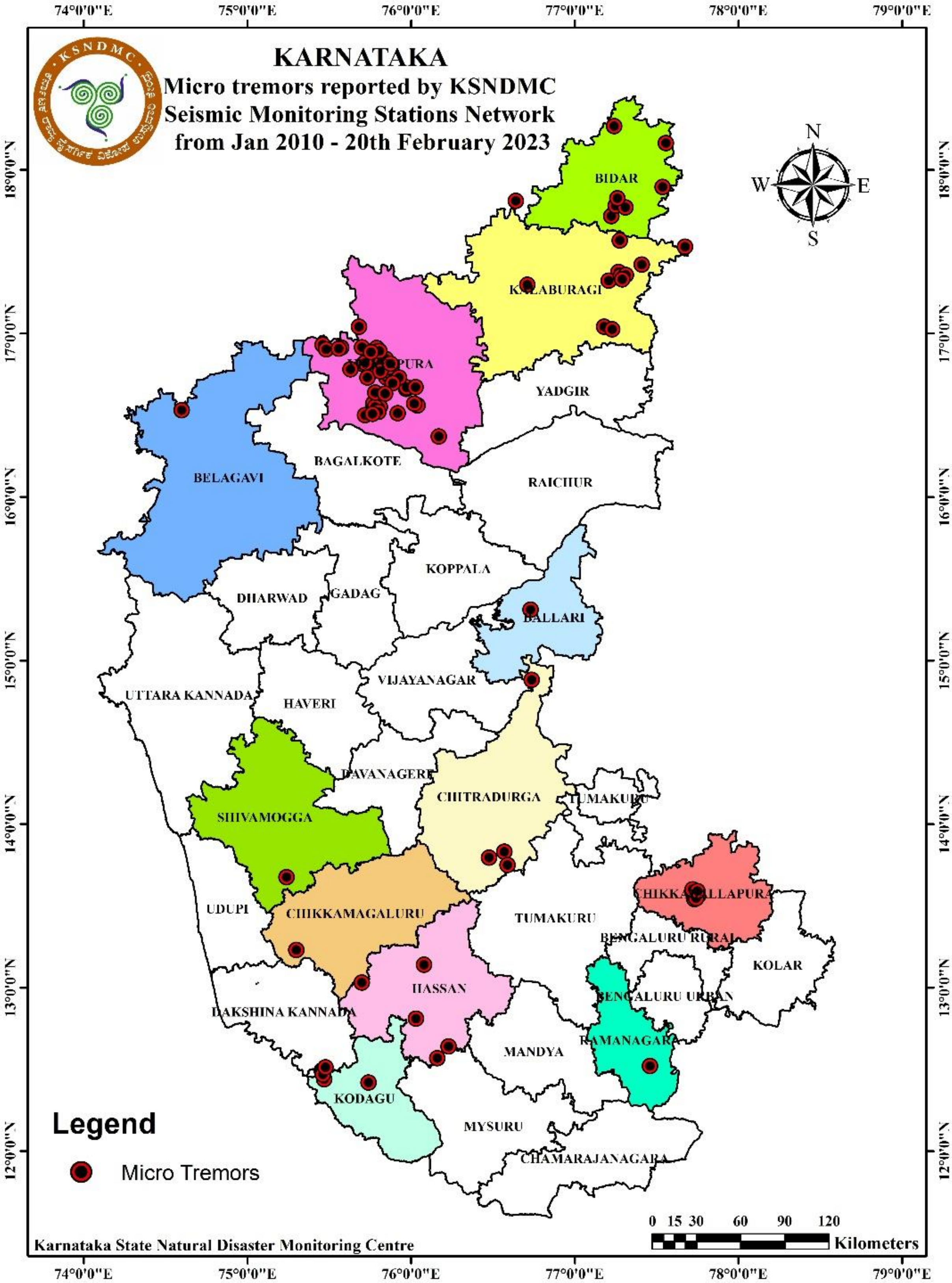
8. Present Seismicity in Karnataka:

Information Dissemination: The analysed earthquake event is disseminated to the officials of District, Taluk and Gramapanchayath, Dam Authorities through SMS initially. Later a Technical Report will be disseminated detailing the geology of the area where the tremor was felt, presenting the recorded seismograms with mark of primary & secondary waves, mapping the faults, major & minor lineaments in the area, if any, Do's & Don't's during an earthquake and safety measures to the local community.

The processed information from the above stations is also being made available to the users through the Centre's web portal at www.ksndmc.org and through e-mails. This Centre through KSNDMC Daily Reports provides Daily Earthquake information on Local, Regional & Teleseismic Earthquakes to the CM's Office and offices of other Line Departments. The total list of Earthquakes reported by the KSNDMC Network of Seismic Monitoring Stations, district-wise is given below for reference:

Sl. No.	Name of the District	Number of Events
01.	Vijayapura	66
02.	Kalaburagi	12
03.	Bidar	09
04.	Chikkaballapura	06
05.	Chikkamagaluru	03
06.	Chitradurga	10
07.	Hassan	03
08.	Kodagu	08
09.	Belagavi	01
10.	Ramanagara	01
11.	Shivamogga	01
12.	Bellari	01
13.	Border Districts in Karnataka	02
14.	States adjoining Karnataka	02
Total		**125**

A Map of 125 Local Earthquakes reported by the KSNDMC Network in Karnataka since the inception of the Network is given below with a magnitude ranges between 1.2 & – 4.4.



9. Community Awareness Programmes taken up:

Karnataka State Natural Disaster Monitoring Centre (KSNDMC) & Karnataka State Disaster Management Authority (KSDMA), Govt. of Karnataka in the process of monitoring and management of earthquakes in Karnataka has taken up the following works as a part of Capacity Building and measures on building Confidence to the local community. The Capacity Building Programmes taken up jointly by KSNDMC & KSDMA, Govt. of Karnataka in management of Earthquakes at the grass root level of community is shown as below Table.

Sl. No.	Date	Name of the District	Taluk	Remarks
1	08.12.2009 & 09.12.2009	Haveri	Byadagi	Awareness to the local community & temporary installation of Seismic Instruments
2	26.04.2010	Vijayapura	Basavana Bagewadi	Awareness to the local community & temporary installation of Seismic Instruments
3	04.05.2010	Vijayapura	Kalgurki	Joint Field visit by KSNDMC & GSI
4	14.02.2011	Vijayapura	Basavana Bagewadi	Workshop by KSNDMC, BARC, NGRI, C-MMACS and NIRM
5	07.01.2011	Chikkamagalur	Kadur	Awareness to the local community on quarrying activity & temporary installation of Seismic Instruments
6	29.09.2011	Chikkamagalur	Kadur	Field visit at quarry activity area with DC, DMG and other departments
7	17.08.2012	Hassan	Arkalgud	Field Survey Post Tremor
8	09.04.2013	Chitradurga	Hiriyur	Temporary installation of seismic equipment's
9	13.04.2013	Chitradurga	Hiriyur	Ground water temperature measurements
10	24.11.2013	Vijayapura	Vijayapura	Filed visit & Temporary installation of the Seismic instruments at tremor felt area
11	02.12.2013	Chitradurga	Hosadurga	Reconnaissance Survey at Micro Tremor Felt Villages
12	04.12.2013	Vijayapura	Vijayapura	Community Awareness program

Sl. No.	Date	Name of the District	Taluk	Remarks
13	25.01.2014	Bangalore	Bangalore North	Survey on Building cracks at Deputy Commissioner of Police North Reserve
14	23.10.2014	Vijayapura	Vijayapura	Awareness to the local community & temporary installation of Seismic Instruments
15	06.05.2015 & 07.05.2015	Madikeri	Kushalnagar	Working procedure of Seismic instruments to the Dam Officials
16	13.06.2015	Tumkur	Gubbi	Awareness to the local community & media on false alarm earthquake
17	01.07.2015	Tumkur	Gubbi	Field survey & installation of temporary station
18	30.10.2015	Kalaburgi	Chincholi	Scientific field investigation of tremor felt regions
19	06.11.2015	Kalaburgi	Chincholi	Temporary installation of Seismic instruments
20	01.01.2016	Tumkur	Gubbi	Land subsidence studies due to increasing of Ground water
21	14.10.2016	Kalaburgi	Chincholi	Community Awareness programme
22	11.11.2016	Kalaburgi	Chincholi	Workshop by KSNDMC, GSI and Bangalore University
23	20.04.2017	Ramanagara	Ramanagara	Scientific field investigation of tremor felt regions
24	14.08.2018	Chikkamagalur	Koppa	Reconnaissance Survey at Tremor felt regions
25	05.09.2018 & 06.09.2018	Chikkamagalur	Koppa	Temporary installation of seismic instruments
26	19.02.19	Shivamogga	Thirthahalli	Reconnaissance Survey at Tremor felt regions
27	11.03.2020	Kalaburgi	Chincholi	Survey related to mysterious sound followed by minor vibrations & Community Awareness programme
28	03.11.2020 & 04.11.2020	Vijayapura	Vijayapura	Survey related to mysterious sound followed by minor vibrations & Community Awareness programme
29	11.02.2021	Shivamogga	Shivamogga	Visited the Quarry area where the Gelatin sticks have exploded

Sl. No.	Date	Name of the District	Taluk	Remarks
30	28.09.2021	Humnabad	Bidar	Survey related to mysterious sound followed by minor vibration at Hunasanal & Shamatabad villages
31	13.10.2021	Kalagi & Chincholi	Kalaburagi & Vijayapura	Survey and mass awareness programme related to mysterious sound followed by minor vibrations at Korvi, Hosalli & Gadikeshwar villages
32	17.10.2021 till 20.10.2021	Chincholi & Basavana Bagewadi	Kalaburagi & Vijayapura	Community Awareness program by Hon'ble Minister for Revenue at Gadikeshwar village and Temporary installation of seismic equipments by NGRI
33	08.11.2021 & 09.11.2021	Kalaburagi	Kalaburagi	Two-day workshop to study the Tremors in Kalaburagi, Vijayapura & Bidar districts
34	11.11.2021	Chinthamani	Chikkaballapura	Survey & community awareness programme related to mysterious sound followed by minor vibrations at Mittahalli village
35	24.12.2021	Chikkaballapura	Chikkaballapura	Survey & community awareness programme related to mysterious sound followed by minor vibrations at Bandahalli, Mandikal and Bhogaparthi villages
36	01.08.2022	Chikkaballapura	Chikkaballapura	Community Awareness program by Hon'ble Minister for Health & Medical Education at Bandahalli village
37	03.02.2022	Chikkaballapura	Chikkaballapura	Field investigations at Bandahalli, Mandikal and Bhogaparthi villages & Community awareness programme by a technical central team of NIRM scientists