The myth of river Saraswati

G. V. Padhye[1] has opened a Pandora's box by creating a new myth about the Vedic river Saraswati. According to his hypothesis, the river Saraswati is the same as river Ili in the Balkhash region of Kazakhstan. He has based his arguments on rudimentary concepts of philology and linguistics in defence of his hypothesis. Padhye has identified seven rivers of *Saptha-sindhu*, with some rivers and streams flowing into Balkhash lake. Most of his arguments are not only absurd, but also seem to be illogical. For example, by a stretch of his imagination, he opts for simple solutions. According to him, the shar grass grown in the delta of river Ili (Saraswati) gave its alternative name, Sharda. Regarding the *Sapta-sindhu*, all of them are present outside India. *Shubra-vastra* – a saree – is but a paper thin crust of ice which formed on the river surface.

It is an established fact in history that the seven rivers known as *Saptha-sindhu* in the Vedas are identifiable with seven rivers of Indian origin, viz. Indus, Jhelum, Chenab, Ravi, Sutlej, Beas and Saraswati/Yamuna. Ancient Yamuna and Sutlej were flowing together into the Arabian Sea as Saraswati river but due to neotectonic upliftment, both the rivers shifted their courses[2]. The present-day Ghaggar and its tributaries, namely Markanda, Tangri, Patiali Rao, etc. define the course of ancient Yamuna and Sutlej. A. V. Sankaran[3] has identified the course of river Saraswati with that of river Ghaggar flowing through Punjab and ending up in the Thar desert of Rajasthan. His hypothesis is based on logical arguments derived from geological and hydrogeological investigations, remote sensing studies by LANDSAT and geophysical surveys carried out in Rajasthan. Roy and Jakhar[4] have also confirmed the findings of Valdiya[2] and Sankaran[3] basing their arguments on geological evidence. Vedic Saraswati flowed in India and it had no connection with river Ili of Kazakhstan.

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Anniversary of the Bhuj earthquake: Taking stock

It is a year since the 26 January 2001 'Republic Day' earthquake hit Gujarat. It has been described as 'the deadliest intra-plate earthquake' in India's recorded history. The earthquake affected the lives of at least 15 million people, and left their homes and livestock devastated. On this anniversary, it is time to take stock of the status of pre- and post-disaster management of earthquakes in India.

'Are we now better prepared? Have we learnt lessons from past earthquakes? What are going to be our concerted plans for the future? What areas of earthquake research need to be strengthened?' These are some questions frequently asked. These need to be answered by scientists, technologists, policy planners and all arms of the Government (central and state), citizens and the media alike. The next earthquake, whenever and wherever it occurs in India, would be a test of our resolve and planning.

The seismotectonic setting of India comprises two main physiographic divisions. The first is the seismically active Himalayan region, including the adjacent northeast India. The second division is the Stable Continental Region (SCR) of the peninsular shield. Tectonic resurgence of the Mysore plateau and the surrounding regions in cratonic southern India is another subject of interest[1]. Of the major regions of earthquake occurrence in India, the most well-known (and numerous) are those of the Himalayan frontal arc. In the peninsular region of India, the earlier Latur earthquake at the centre of the Indian shield region was considered a typical SCR earthquake. Seismicity associated with the Koyna reservoir, Maharashtra is considered as one of the classic examples of earthquakes triggered by the influence of a large reservoir. And, most recently India witnessed the Bhuj earthquake in 2001. The Rann of Kutch region has suffered large and moderate earthquakes in recent history. These occurred in 1819 in the northern fringes of the Rann (a large earthquake of magnitude 7.5 that created a new tract of elevated land about 90 km long, called the Allah Bund); in 1956, in the southern part of the Rann, affecting the town of Anjar and most recently, the Bhuj earthquake. Both the 1819 and 2001 earthquakes provided ideal opportunities for researchers to study seismogenic processes in a plate-interior setting. The Bhuj earthquake generated substantial liquefaction and hydrological effects. Locals reported that the quake caused, for a short time, activation of desert rivers that had been dry for more than a century.

The Bhuj earthquake has generated wide attention, both national and international. Many research teams have been in the area conducting post-seismic field observations at a feverish pitch. The reason for this could be, 'the uniqueness of its tectonic regime, espe-

cially the influence of an active plate boundary on the stress field and analogies with other intra-plate earthquakes associated with ancient rift basins'. The location of the event with its occurrence in a region that is considered part of a stable continental region has added to the uniqueness. According to Rajendran *et al.*[2], although the main fault rupture did not reach the surface, the epicentral area is characterized by the development of secondary features such as flexures and folds which are related to compressional deformation, in a wide area of the Banni Plain. Besides surface deformation, the earthquake also induced widespread liquefaction, leading to ground failure, including lateral spreading.

An International Conference on Seismic Hazard with particular reference to the Bhuj Earthquake was recently held at New Delhi in October 2001. The conference aimed at providing a forum for discussing seismological, geological, geodynamic and engineering implications of the Bhuj earthquake and characterization of seismic hazard in India. Taking a cue from the topics discussed during technical sessions, we can better understand the status of earthquake research and mitigation strategies in India today.

Source parameters and damage pattern

The National Geophysical Research Institute (NGRI), Hyderabad and the India Meteorological Department (IMD) have been investigating the source mechanism of this earthquake. The source mechanism has been obtained by moment tensor inversion of regional broadband waveform data recorded at the broadband stations of the IMD in the Indian shield region. The IMD and its national seismological data centre play a pivotal role in maintaining the national seismological network and providing information on earthquakes to the Government and the media.

The Centre for Earth Science Studies (CESS), Thiruvananthapuram has carried out a comparative perspective of the 1819 and 2001 earthquakes in Gujarat. The Physical Research Laboratory (PRL) has been conducting studies in mapping of the damage pattern. These patterns show the importance of site amplification and shear waves. These inputs could be important for future microzonation studies. The Wadia Institute of Himalayan Geology (WIHG), Dehra Dun and the Geological Survey of India (GSI) have been pursuing the study of fault propagation patterns and macroseismic effects, respectively.

Seismotectonics

The GSI took up the task of drawing isoseismals over a 1.2 million km^2 area. The *Seismotectonic Atlas of India and its Environs* published by the GSI, Kolkata containing maps and notes on the seismicity and tectonics of Gujarat, is a valuable background document in this context. The Space Applications Centre (SAC, ISRO), Ahmedabad has used Indian Remote Sensing Satellites (IRS-1D and 1C) to map the major lineaments across Gujarat and for studying the differential pattern in the destruction, such as within Ahmedabad city. Remote sensing techniques have also been used by the Department of Civil Engineering, Indian Institute of Technology (IIT) Kanpur, which have shown the emergence of palaeochannels and changes on land surface after the event and the presence of shallow water tables in liquefaction sites. For the preparation of a seismotectonic hazard map, the WIHG and the Indian Institute of Remote Sensing, both at Dehra Dun, have used remote sensing and GIS techniques.

Deformation studies

The region's earthquakes have been reinvestigated using the most recent seismological tools available such as GPS-aided geodetic studies. According to V. K. Gaur, Global Positioning Satellite (GPS) geodesy offers an opportunity to define basic structural elements of important tectonic units of a country that might have high hazard potential. He further said that GPS measurements in the last six years have further refined the velocity of Indo-Eurasian convergence, giving a broad understanding of the deformation field in the continent. The mechanism of the 2001 earthquake is 'currently unresolved' according to Bendick *et al.*[3]. They are currently processing GPS data to determine coseismic changes during the earthquake. Several studies in the area of coseismic, post-seismic displacements by the Indian Institute of Geomagnetism, Mumbai, GSI, etc. are underway. Survey-mode GPS measurements have been initiated in this region only in the last few years.

Recent developments made in the technology of differential Synthetic Aperture Radar (SAR) interferometry have allowed the mapping of surface deformation due to an earthquake, with a resolution of $20\,m \times 20\,m$. The Department of Science and Technology (DST) has set up a Group for SAR applications in Indian case studies. Geodetic measurements and epicentral aftershock studies are currently underway. The planned SAR imagery would ultimately resolve which of the nodal planes are active during the earthquake. According to Bendick *et al.*[3], SAR imagery using recent images may distinguish between the cosiesmic strain change from this earthquake and deformation caused from previous earthquakes and interseismic movements.

The inaccessibility of a large part of the Rann of Kutch due to lack of roads, etc. is a problem faced by many researchers, including Wesnousky *et al.*[4], who visited this region for studying the surface faulting and making field observations. Repeat gravity and geomagnetic observations are also important for the study of geological changes. The Survey of India has established a network of gravity and geomagnetic stations in Gujarat. The Geodetic and Research Branch of the Survey of India has begun carrying out the study of surface deformations using geodetic and geophysical observations. The NGRI, Hyderabad has been studying the ground deformation and the causative fault of the earthquake as well as gravity gradients and trends.

Palaeoseismology is a useful method for developing earthquake chronology and also in estimating the size of past earthquakes. These provide valuable inputs to seismic hazard assessment.

Research in this area has been initiated only recently in India. Work in this field of research is presently being carried out in seven institutions in the country. Some facilities for isotope and thermoluminescence dating and Accelerator Mass Spectrometer used in paleoseismological studies, are either

available or are being established. An overview of the current status of palaeoseismology in India, states that the field is 'still in a nascent stage in the country and hence concerted efforts should be initiated to undertake extensive paleoseismic studies, with emphasis on establishing timing and recurrence period of prehistoric seismic events in the seismically active areas'[5].

Aftershock studies

There has been a paucity of local and regional instrumental recordings that could have provided the distribution of macroseismic effects and important constraints on the main shock ground motions. The IMD, however, has been undertaking the delineation of the spatial distribution of the aftershocks using data from its network and the GSI has also deployed seismographs for studying the pattern of aftershocks. Several teams have been studying the aftershocks and there is now a proposal to amalgamate all the existing data into a single database, a project in which the NGRI, Hyderabad is involved.

It is important to note that the seismic network in Gujarat was inadequate, as the region was known to be seismically active. According to information obtained from researchers, there is only one IMD station in Gujarat; the stations operated by local agencies are old and outdated. As one researcher said, 'this was a serious lack of planning – that we did not instrument this high risk area'.

Engineering aspects

Liquefaction was widespread after the event and related ground failure gave rise to sandblows, craters and lateral spreading[2]. It is the lateral spreading that mostly contributes to the failure of engineered structures. Rajendran *et al.*[2] state that 'understanding the nature of liquefaction features and their spatial distribution has important implications for earthquake hazard assessment in similar tectonic and geologic environments'. However, they add that mapping of liquefaction features in areas far from Bhuj is not complete yet. Reasons for this are the inaccessibility of the region and proximity to the international border.

The Bhuj earthquake destroyed several historic monuments in the region that date back to the 9th century AD. However, the Archaeological Survey of India is undertaking the gigantic task of restoration of several monuments in the affected area. Some of those close to restoration or those completed are the Ahmad Shah Mosque, Sidi Bashir Minars, Dwarkadhish Temple and the Zimboji Mata Temple. Rajendran *et al.*[2] feel that detailed examination of historical monuments will provide much more information on the historic seismicity of the region, useful for assessing ground motion characteristics. According to them, many of the historic structures had survived the earlier 1819 and 1956 earthquakes, but in the 2001 earthquake 'the ground shaking was apparently too severe'. Estimation of ground motion is a subject of study and research by a number of groups.

Randolph Langenbach[6] has surveyed the damage caused to historical buildings. His study revealed that traditional methods of construction fared better than reinforced concrete constructions, especially true for buildings with balconies. He said that slight differences in traditional construction design could make all the difference and also help preserve the cultural heritage in seismically active regions of the world. He said that there was a need for historical archival research, as there were a large number of old books available in palace libraries at Bhuj, Jamnagar and other places, whose contents could be used along with palaeoseismic data.

What happened to buildings? The main shock had a focal depth of about 23 km. The earthquake destroyed buildings of all types, whether built from stone, timber or reinforced concrete. For buildings of more recent origin, considerable variation in damage was observed. Poor-quality construction led to some multi-storey concrete buildings completely collapsing in moderately shaken regions, while other structures remained intact[7]. Several teams have been investigating the reason for failure of buildings. One key feature to provide earthquake resistance is by imparting ductility to out-of-plane movement of walls and for this the Department of Civil Engineering, Indian Institute of Science, Bangalore has developed a type of reinforcement called 'containment reinforcement'.

The port of Kandla was severely damaged by liquefaction and related ground failures, although numerous engineered structures, such as oil tanks, survived the earthquake. Research teams from Roorkee and Delhi studied the cause of failure in oil pipelines and jetties. The performance of elevated water tanks in the earthquake was part of a study conducted by the Department of Earthquake Engineering, IIT, Roorkee. Research for the seismic design of elevated water tanks, liquid storage tanks and bridges, etc. has been done by the Department of Civil Engineering, IIT, Kanpur. They have also published a proposed draft of changes and the present shortcomings in the Indian seismic code (IS: 1893–1984) on building systems[8].

According to A. S. Arya, IIT, Roorkee, the 2001 earthquake had natural origins, but a man-made disaster. He pointed out that India is one of the pioneering countries in formulating Standard Codes and Guidelines for safer constructions for reinforced concrete structures, bricks, concrete blocks, etc. India had even developed guidelines for low strength masonry buildings made from random rubble stone and brick, laid in mud mortar. Guidelines exist for earthquake-resistant construction of rural buildings. In spite of this, the tragedy in the earthquake region could be attributed to 'non-implementation of the various Indian standards during the last 40 years, although appropriate codes and guidelines became available', he said.

Arya's observations acquire more strength as one recognizes that the Kutch region lies in Zone V, the zone of highest seismic potential in the Seismic Zonation Map of India, prepared by the Bureau of Indian Standards (BIS). The seismic hazard map of the Indian region indicates a 10% probability that ground acceleration in the Kutch region will exceed 0.25 times the gravitational acceleration in a period of 50 years[9]. The paper adds that the damage potential could be reduced by strict implementation of building codes, retrofitting of important buildings particularly in Zones IV and V, popularization of simple, inexpensive methods to strengthen old buildings, and rural dwellings, and microzonation studies (as undertaken by

the Government of India for Jabalpur and New Delhi) to prepare risk maps of important cities.

There have also been damages to water resources projects in Gujarat. The Gujarat Engineering Research Institute, Vadodara and the Narmada Water Resources and Water Supply Department have started restoration work of dams, etc. The geotechnical aspects of damaged earth dams have been investigated by the Department of Civil Engineering, IIT, New Delhi with suitable corrective measures.

Predictability of earthquakes

Earth scientists remain divided on the possibility of prediction. There is no method for accurately predicting the size, time and location of an earthquake, enabling evacuation (that is short-term prediction). Efforts to understand earthquake processes must go on (thereby increasing our ability to predict). The emphasis must be on how to minimize the hazard. The bottom line is – earthquakes will continue to occur, but how much destruction it will inflict on a society is a reflection of its ability or the lack of it, to take proper steps to mitigate the damages.

Kusala Rajendran, CESS, Thiruvananthapuram said that 'a very important point that we must remember in earthquake studies is that most scientists have given up on predicting earthquakes, so as to give a warning and do evacuation. The issue is not about predicting earthquakes, but about predicting ground motion and about predicting how a particular structure will respond to the anticipated ground shaking. The studies therefore should address: (i) identification of potential faults, (ii) work out their behaviour and recurrence patterns, more precisely work out the maximum expected magnitude (based on the length of faults, past earthquakes, etc.) and then comes the crucial part of predicting ground motion and behaviour of structures. Clearly, it is important to note at this juncture that prediction is still not a realizable goal'.

Disaster response in India

An institutional mechanism exists for the management of natural disasters in the country, including earthquakes. There is the National Crisis Management Committee, headed by the Cabinet Secretary and the Crisis Management Group under the Chairmanship of the Central Relief Commissioner. The nodal department for the coordination of all activities relating to management is the Department of Agriculture and Cooperation. A Krishi Control Room functions to monitor the situation. At the state level, an interministerial committee functions under the Chairmanship of the Chief Secretary and the nodal officer is the Relief Commissioner. In the context of the Bhuj earthquake, a National Committee on Disaster Management (NCDM) has been constituted under the Chairmanship of the Prime Minister, having representatives of both national and state level political parties. Its mandate is to suggest necessary institutional and legislative measures for effective long-term strategy, in order to deal with major natural calamities in the future.

After the earthquake, help came from several national and international agencies. The United Nations system, multilateral and bilateral agencies, NGOs and the corporate sector came forward to participate in relief and reconstruction activities. However, one year on, it is the need of the hour to focus on integrating disaster management with development planning efforts. Speedy response to a disaster situation is important and this is only possible if there is thorough preparedness. Multi-hazard response plans, from the country down to the community level have to be prepared and updated frequently. Personnel for search and rescue teams should be trained and provided with the right equipment. For this, organizational restructuring, appropriate legislation and human resource development in the context of crisis management has to be done.

In spite of all the research and technological development in earthquake studies and the disaster management response put in place, as described above, still many questions remain unanswered. Issues that have been recognized or are yet to be considered, including some recommendations made at the New Delhi conference are as follows:

(1) Information on slip parameters and distribution, deformation and surface changes prior to earthquakes is still ambiguous. It is important to resolve why this large earthquake was associated with a short rupture length. The other important issue is to understand where the future earthquakes are likely to strike; (2) Recognition of the importance of making all relevant data from decades prior to the event available to the scientific community and issuing a CD-ROM with digital seismic, geodetic and geologic data; (3) Monitoring of earthquakes in Gujarat should be continued, to catch the next nasty earthquake; (4) New approaches like palaeoseismology are required for quantification of hazard and for modelling the rupture process. Mapping of palaeoliquefaction features throughout the Rann of Kutch and developing recurrence statistics are needed. There is a requirement for studies of analogous deep events like stress diffusion or Coulomb failure, such as in earthquakes of 1897 and 1819 and gathering seismic reflection profiles, as deep structure is currently unknown; (5) Building codes for earthquake-resistant structures need to be stringently implemented; (6) Exploring new avenues for outreach – for educating the public and urban policy planners, etc.

Recently, V. S. Ramamurthy, Secretary, DST, Government of India was asked to comment on the status of earthquake research in the country. What he stated is like a blueprint of an action plan for improved understanding of earthquakes. Firstly, geophysical studies had to be conducted to determine the location of active faults, which number at least about 300 in the country. Then, sources have to be identified and efforts have to be made for predicting earthquakes based on their past history. In methods of prediction, a lot more work was necessary, which called for higher investment, especially in areas of fundamental earthquake research. Then, it was important to know how earthquakes propagate. Although epicentres could be away from human habitation, the effect of the earthquake on cities had to be assessed, such as that of the Bhuj earthquake on Ahmedabad city, nearly 300 km away. The issue here is in understanding the site-specific effects.

Ramamurthy said that more research was needed to study the character and

velocity of how seismic waves propagate and how they get attenuated or amplified depending on the nature of rocks and soils. Microzonation, of vulnerable cities and urban centres had to be carried out but that 'we were a long way off still'. Use of appropriate building codes needed to be made mandatory for future structures. Present structures had to be revisited from the point of view of earthquake-resistant design. More thought needs to be put into 'how do we strengthen existing buildings?' He said that there was now a realization that we need to invest more before earthquakes occur. This is more effective in getting the most out of investments made and also, we must wisely make decisions on where and how to invest. There had to be more research in areas such as relief measures, i.e. how to dismantle the debris created after a devastating earthquake. There were several areas in science and technology (S&T) of earthquakes that needed improvement. Although this process has begun, we need a quantum jump, keeping in mind sensitivities and matching it with public good. When queried on the subject of foreigners conducting research in India, he said science is for everyone, only it must be known to the Ministry (S&T) as to who was conducting research and where it was being conducted. On the subject of data sharing, he said data were already available on the Web. Data, he said, were of three types: free, on demand and sensitive. A process was being evolved to streamline this according to requirements. Another area that needs to be strengthened is the design and development of instrumentation in the field of earthquake research.

The DST in full recognition 'for the need for seismologists, geologists and engineers to work hand-in-hand with administrators and planners to develop a proper strategy for risk evaluation and mitigation in such regions of higher seismic risk' has taken up the challenge. According to G. D. Gupta, Adviser and Head, Seismology Division, DST, a proposal is being evolved, subject to further approval by the government, for setting up of an Institute of Seismology in consultation with the Gujarat government. Being conceived as a 'technology front' institute, it would further the understanding of the Kutch region. Also, it could cater to local needs, using the latest technology available. This knowledge and confidence could then be translated elsewhere and help in devising future strategy. Further, in the pipeline is a plan to monitor surface deformation using GPS/SAR interferometry to capture fine-scale movements of geodynamic origin and understand how deformations are taking place on a millimetre scale. In recent years, advances have been made in data capturing, remote sensing with automated data centres and a good number of digital broadband stations supplying high quality data have been established, he said. However, Gupta felt that research efforts in the areas of numerical modelling and simulation experimental studies were still lacking. There existed a spirit of data sharing with several groups coming together for tackling vital areas in earthquake research. However, more needs to be done for human resource development in the earth sciences, he added.

H. K. Gupta, Secretary, Department of Ocean Development (formerly Director, NGRI, Hyderabad) while speaking at the New Delhi conference pointed out that the number of lives lost due to earthquakes in developing countries was much larger than those in developed countries. The level of investment in earthquake-related studies, however, was quite the opposite. Gupta said that a higher quantum of investment was necessary. In a paper published recently, the authors have said that 'Time and again it has been demonstrated that not earthquakes, but buildings kill people[10]'. It suggested the following:

(1) Implementation of building codes of the Bureau of Indian Standards (BIS) must be made mandatory; (2) Retrofit important buildings situated in Zone IV and V of the zonation map; (3) Seventy per cent of Indians live in rural areas, in houses and dwellings without any engineering design principles in place. Methods are available to strengthen their dwellings by some simple, very inexpensive approaches. These should be popularized; (4) Microzonation of important cities of the country is a must.

Earthquake forecast is not possible as of now. H. K. Gupta said that it was very important to know what kind of ground accelerations are expected due to earthquakes in a region. He pointed out that a programme was taken up by the United Nations to prepare a Global Seismic Hazard Assessment Map. This map has been prepared by scientists from organizations all over the world, including NGRI, between 1992 and 1999. It gives basic information of the expected peak ground accelerations over the next 50 years and is available on the website. He said that it is very important to convert this map into a seismic risk map of the country that would require microzonation studies.

Gupta felt that research in the earthquake field had to be well supported by 'application' of research efforts. He said there is an oft-repeated query of 'what is S&T doing for the citizen?' An answer for this is that 'S&T cannot deliver unless there is in place a good implementation mechanism'.

'What we missed out in Bhuj was strong motion data. What we also did not know or pay attention to was the site effects, both near and far. We knew from the1819 earthquake that Kutch is susceptible to liquefaction. But we did not care much about it while building Bhuj. This is the lesson that we must not forget. Delhi, Mumbai and many more cities in India are perhaps sleeping in the shadow of a possible, distant earthquake. The point is that if we were careful enough, so many houses would not have collapsed, not to the extent of crushing people beneath. That is the lesson that we learned the hard way, and we must not err again', said Kusala Rajendran[11].

When asked about the role of Technology Information Forecasting Assessment Council (TIFAC) in rehabilitation work, Y. S. Rajan, its Executive Director, expressed satisfaction. The response from the small- and medium-scale industries made it possible to deliver the necessary goods to the affected region. Nearly 392 shelters, 128 toilets, 15 shops, one post office and 25 classrooms were set up and more orders were placed with the same companies. Similarly, more orders were placed with the industry that had initially helped in fitting about 250 people with endoskeletal composite artificial limbs. Due to the scale of the disaster, the whole process of technology development, production and delivery had to be compressed in terms of time. There was a close working relationship between the industries concerned, aca-

demics and consultants that helped speed up the process. He said that the companies were part of TIFAC's Advanced Composite Mission, which primarily supplied railway requirements, etc. and the items provided by them were in fact not part of their main product line. However, the companies rose to the occasion and delivered the first lot of items in 45 days. Recognizing a deficiency in availability of heavy equipment for moving debris, etc. the Bharat Earth Movers Limited, Bangalore had stepped in to help. Ongoing work in this regard was progressing well, he added. Having shown the way, it was now for others to take it up from there, he said. But it was TIFAC's large existing network between local NGOs and local industries that had contributed to the effectiveness of the operations.

From this it is clear that the country needs to go full-steam ahead on the proper implementation of all that S&T can offer in the area of earth sciences. Be it results from basic research or research in the engineering sciences. Those seismically active areas in the country, where we know well in advance of the possible risks, should be focused upon. The attitude of 'letting it be' till a dangerous situation arises, would be catastrophic. Finally, one question posed could not get a definitive answer. This was regarding how many villages had been actually rebuilt after the earthquake.

Recently, it has become known that the BIS is going to take up a review of the National Building Code. This has been necessitated by technological advancements that have been made since the existing code was formulated about two decades ago. The exercise is to be completed in about two years and would incorporate alternative technologies, and a system of integrated approval from pollution control boards, Urban Arts Commission and local bodies for building, etc., i.e. all techno-legal requirements would be brought within the code. The revised code would give added focus on safety and preventive measures. This would give a basis for not only reconstructing Bhuj, but also in the design of new structures in the country.

Bachi Singh Rawat, Hon'ble Minister of State for Science and Technology said on the occasion of the New Delhi conference that 'we realize that there is still a lot to be done towards the immediate goal of preparedness'. This speaks volumes about the present situation.

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Genomics and evolution*

The availability of human genome data has sparked-off a great deal of interest and discussion about the new science of genomics (and more recently, proteomics). This discussion has also resonated in the Indian scientific community. There is a tremendous amount of genetic information now available for many species, including humans, and an obvious challenge is to make 'sense' of this information (in other words, to convert this information into knowledge). One is reminded of Eliot's eloquent lament, 'where is the knowledge we have lost in information', and it is certainly to be hoped that this will not be the fate of the information that sequencing efforts yield. In fact, one could practically define genomics as being an attempt to convert sequence data into genetic knowledge.

In general, the methodologies and conceptualizations used to generate information need not necessarily be the same as those needed to convert the information into knowledge. In the case of genetic sequence data, in particular, the conceptual framework in which these data need to be interpreted is to be found in evolutionary rather than molecular genetics. It is equally true that the technologies of genomics, which come from the realm of molecular rather than evolutionary genetics, are very useful tools with which one can address many extremely important questions in evolution. This interdependence of genomics and evolution has clearly been recognized in many scientific communities worldwide, and there have been many international meetings on evolutionary genomics in the past year or so. In the Indian context, however, this interdependence does not appear to have been explicitly articulated, whereas, for example, the need for integrating information technology and genomics has been well recognized. I find it particularly distressing that this is the case, because if

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