Grids & Datums

Republic of INDIA

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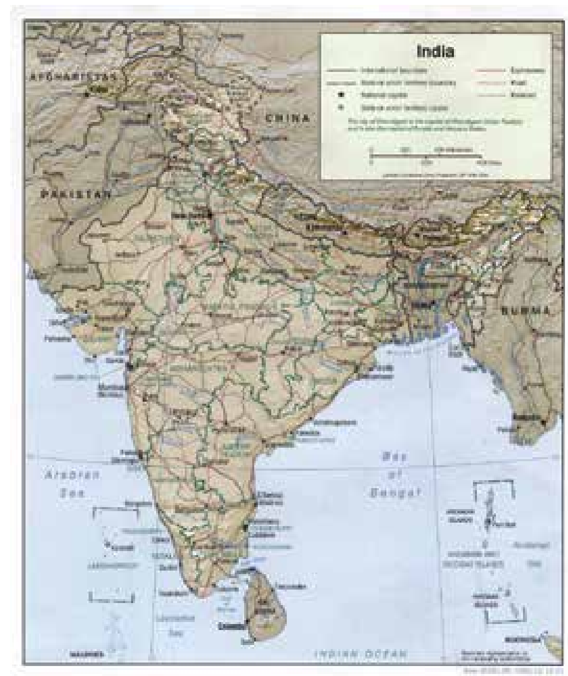
The art, culture and kingdoms of India could not have spread through centuries and countries without knowledge of its geography. In the Vedic literature of over 5000 years ago, the knowledge of land was presented in a graphical form which described the extent and shape of territories. The *Brahmand Purana* of 500 *B.C.* to 700 *A.D.* gives evidence of the art of modern map-making. The art of surveying and techniques of mensuration of areas are described in *Sulva Sutra* (science of mensuration) and in the *Arth Shastra of Chanakya* written in the 3rd century *B.C.* The golden age of Indian Renaissance in the 5th century saw the towering genius Arya Bhat who wrote *Surya Siddhant* and calculated the earth's circumference to be 25,080 miles — less than 200 miles off modern measurements of the equator. Chinese and Arab travelers and many adventurers also contributed to Indian geography. Sher Shah Suri and Todar Mai's revenue maps, based on regular land survey systems, were well known in the medieval period and continued to be in practice during the mid-eighteenth century. Even today, the six huge instruments in masonry built by Raja Sawai Jai Singh in the heart of New Delhi in 1724 attract tourists from all over the world. These were designed and built by him to study the movements of the sun, moon and planets. Such instruments were also built in Jaipur to measure, among other things, time and eclipses. Another observatory was built by him in Ujjain in 1723 to forecast eclipses and movements of the sun as well as indicate the correct time. According to records, Rajaraja I of Tanjore (985–1011 *A.D.*) carried out careful surveys of the lands and cultivation. This shows that there must have been many other surveys of which no clear records have been preserved. However, information is available of the surveys instituted by Akbar during the 16th century; measurements being made by a hempen rope which was replaced by a 'jarib' of bamboos joined by iron rings. Settlement operations included the measurement and classification of lands, and fixation of rates. Systematic surveys commenced in the 18th century.



"The Survey of India traces its birth to the appointment of Major James Rennell as Surveyor General of Bengal, by Lord Robert Clive and his council, on the first of January 1767. He placed all available surveyors under Major Rennell's orders, amongst them being the Frenchman Claud Martin, who later became famous as the founder of the La Martiniere Schools. By 1773, Rennell completed surveys of the possessions before relinquishing the post of Surveyor General in 1777. Rennell surveyed Bengal and Bihar, an area of over 1500 sq. miles, producing a continuous and uniform set of maps. The surveys, however, were far from complete or accurate in detail but were sufficient to meet the needs of the time. Rennell continued his interest in England, and his first Map of Hindustan reached India in 1783. The early history of surveys in India followed the East India Company's expanding areas of influence and conquest. The next Surveyor General, Thomas Call, like many others who followed him, undertook the task of compiling an atlas embracing the whole of India. On the initiative of John Tringle, who surveyed routes with great enthusiasm, a military 'Corps of Guides' was established. This Corps also contributed largely to the surveys of the Madras Presidency for the next 30 years. It was in 1787 that Michael Topping, a marine officer, broke away from the eternal method of Perambulator Traverse and ran a 300-mile line of triangles along the coast from Madras to Palk Strait. It was he who built a permanent astronomical observatory in Madras in 1793 and founded the first surveying school in 1794. In 1796 and 1810, the Presidencies of Bombay and Madras got their own Surveyors General with the appointment of Lt Gen. Charles Reynolds and Col. Colin Mackenzie as the respective Surveyors General. It was on the first of May 1815 that the Directors, finding it wasteful to maintain three separate and independent Surveyors General, appointed Mackenzie as the Surveyor General of India. The credit of the first surveys of the Brahmaputra in Assam in 1794, and that of the Irrawady river in Burma go to Thomas Wood. The mission also collected interesting information about people, tribes and general geography of Assam and Burma, about which nothing whatever had been known before. India was one of the earliest countries to establish a regular government survey organization and to commence systematic surveys — a few years before even the Ordnance Survey of UK.

"It was very fortunate that a man of the genius and resolution of Lambton was in the subcontinent to lay the foundation of the 'Great Trignometrical Survey of India' a few years before similar projects were undertaken by France and England. In November 1799, he put forward his proposal for a Mathematical and Geographical Survey that should extend right across the Peninsula from sea to sea, controlled by astronomical observations carried out on scientific principles, capable of extension in any direction and to any distance. He started his work from Madras where, in early 1802, he measured the famous base line at Saint Thomas' Mount as a start for his triangulation, north and south through Carnatic India and across the Peninsula, with his famous 36-inch great theodolite. He completed a meridional arc from Cuddalore to Madras observing latitude at both ends and obtaining a value for the length of a degree that was essential for his scientific work. By 1815, he had nearly covered the whole Peninsula south of the river *Kistna* (Krishna) with a network of triangulations braced by main cross belts. To him goes the distinction of measuring the longest geodetic arc closest to the equator, from Cape Comorin to the 18° parallel.

THE USE OF LAPLACE STATIONS HAD NOT YET BEEN ADOPTED BY THE SURVEY OF INDIA; CONSEQUENTLY ERRORS IN AZIMUTH AND POSITION WERE INTRODUCED. THESE ERRORS ARE PARTICULARLY EVIDENT IN THE TRIANGULATION SERIES OF SOUTHERN INDIA. THE 1880 ADJUSTMENT HAS HOWEVER, REMAINED THE BASIS OF ALL INDIAN TRIANGULATION AND MAPPING. THEREFORE THERE IS NO SUCH THING AS AN "INDIAN DATUM;" IT IS ONLY AN ADJUSTMENT! (JMN, 21 JUNE 1997)

"In 1806, a subaltern came to India at the tender age of sixteen. He was none other than Lieutenant George Everest. He joined Lambton in 1818. Lambton died at work on 20 January 1823 at Hinganghat at the age of 70. General Walker recognizing his work wrote in 1870, 'of all Col. Lambton's contributions to geodesy, the most important are his measurements of meridional arcs, the results of which have been employed up to the present time in combination with those of other parts of the globe, in all investigations of the figure of the earth.' Lambton's mantle fell on the worthy shoulders of George Everest. Everest felt the need for basing the surveys on a rigid reference framework. This raised the problem of finding a suitable reference spheroid to fit the shape of the earth's gravity equi-potential surface for India and the adjacent countries. Everest realized that the Indian subcontinent was too large for basing surveys on an osculating sphere, let alone a tangent or secant plane. Everest therefore, started his control work from Kalianpur in Madhya Pradesh, more or less in the centre of India. Here he made astronomical observations and treated the astronomical latitude, longitude and the plumbline at that place as error-free. With Kalianpur as the center, he conceived covering the length and breadth of India by a gridiron of triangular chains, as opposed to the network of triangles conceived by Lambton. He brought to surveying greater accuracy and rigorous observational procedures besides devising and refining the instruments. He introduced the observation of astronomical azimuths from pairs of circumpolar stars, ray traces for long lines, *etc*. His redesigned 36-inch great theodolite is famous today. He replaced the chain with Colby's base-line apparatus and 10-foot compensation bars, with which he measured various bases. He completed the great meridional arc from Cape Comorin to Banog in the first Himalaya near Mussoorie, a length of 2400 km. Everest made the government agree to the revision of Lambton's work, based on more accurate instruments and the procedures as laid down by him. Later, in 1830, he was appointed as the Surveyor General of India but, much against the wishes of the then government, he continued to devote much time to the Great Meridional Arc. This was completed by him in 1841 and he utilized the last 2 years of his service in its computations and adjustments. The work and norms laid down by Everest have stood the test of time. The Everest spheroid, evolved by him in the year 1830, is not only still being used by India but also by Pakistan, Nepal, Burma, Sri Lanka, Bangladesh, Bhutan and other south-east Asian countries.

"We can only grasp the significance of his monumental work if we can visualize India of the early nineteenth century

— without communications and full of jungles, wild animals, robbers and disease. The average length of a side of the triangulation was about 31 miles, the maximum being about 62 miles. One cannot imagine how such long-distance observations were planned, laid down on the ground, line of sight cleared of all trees and sometimes even houses, and how big rivers and swamps were crossed. Everest, devoted to his work, did all this despite his partial paralysis and bad health. Based on his conceptualization, the gridiron network today covers the entire country and forms a solid foundation for accurate surveys and mapping for defense, development and efficient administration. It was with the help of this gridiron network that the highest peak of the world was observed and discovered in 1852 and its height declared as 29,002 ft. - *i.e.* about 8840 meters. After fresh observations and computations, the Survey of India declared its height in 1954 as 8848 meters. In 1975, the Chinese put a metallic beacon on Everest and observed it from 9 stations. They also carried out sufficient astronomical and gravimetrical measurements, the coefficient of refraction was reliably determined and the final result of the determination was declared as 8848.13 ± 0.35 meters. Sir Thomas Holdick concluded in the Standard of January 24, 1905 that 'It was officers of the Survey of India who placed his name just near the stars, than that of any other lover of eternal glory of the mountains and let it stay in witness to the faithful work not of one man but scores of men.' Everest was the first from amongst the eight Surveyors General of India to be knighted" (*Survey of India Through the Ages, by Lt. General S. M. Chadha, delivered at the Royal Geographical Society on 8 November 1990, on the eve of Sir George Everest Bicentenary celebration by the Surveyor General of India*).

Slightly more than one-third the size of the U.S., India is bordered by Bangladesh (4,053 km) (*PE&RS*, March 2008), Bhutan (605 km), Burma (1,463 km) (*PE&RS*, September 2013), China (3,380 km) (*PE&RS*, May 2000), Nepal (1,690 km) (*PE&RS*, June 20138), and Pakistan (2,912 km) (*PE&RS*, July 2009). The lowest point is the Indian Ocean (0 m), and the highest point is Kānchenjunga (8,598 m) *(World Factbook, 2014)*.

"The bulk of the geodetic triangulation in India was carried out with large theodolites between 1802 and 1882. Its simultaneous adjustment involved a decade's labor. In the 20th century, very little was done in the way of geodetic triangulation – only a few outlying series in Baluchistan and Burma having been observed. The presence of Military Survey Companies in the different theaters during WWII and in the period immediately following it enabled important gaps between the triangulation of India and its neighboring countries like Iraq, Iran, Siam and Malaya to be filled. A continuous chain of triangulation now exists from Syria to Malaya" *(Geodetic Work in India – War and Post-War, B.L.Gulatee, Empire Survey Review, No. 77, Vol. X, 1950)*.

The origin of the Indian Adjustment of 1916 is at station Kalianpur (Strong Base) where: Φ_o = 24° 07' 11.26" N, Λ_o = 77º 39' 17.57" East of Greenwich, α_o = 190º 27' 05.10" from Kalianpur to Surantal, and the ellipsoid of reference is the Everest 1830 *(India)* where: a = 6,377,301.243 m, $1/f$ = 300.8017 *(UK Military Survey, 1982)*. The adjustment depended on baselines evenly distributed throughout India. The use of LaPlace stations had not yet been adopted by the Survey of India; consequently errors in azimuth and position were introduced. These errors are particularly evident in the triangulation series of southern India. The 1880 adjustment has however, remained the basis of all Indian triangulation and mapping. Therefore there is no such thing as an "Indian Datum;" it is only an adjustment! *(JMN, 21 June 1997)*

In 1924 the "Minute Mesh" was introduced. This is a reference system consisting of meridians and parallels at one minute intervals: descriptive references are given by a convenient system of lettering, and all survey computations are done in spherical terms in the usual way" *(Geodetic Report, Survey of India, CPT. G. Bomford, R.E., 1930)*. "As the result of a decision arrived at the artillery survey conference held at Akora on 12th January 1926, two forms and a set of tables were prepared for the conversion of the spherical co-ordinates to rectangular, and *vice versa*, on Lambert's conical orthomorphic projection. This projection is also known as Lambert's second projection with two standard parallels" *(Geodetic Report, Survey of India, CPT. G. Bomford, R.E., 1928)*.

Seven separate India Zones were created in 1926 by the Survey of India, all seven having the same scale factor at origin (m_o) = 823/824 = 0.998786408, the same False Easting = 3,000,000 Indian Yards, and the same False Northing = 1,000,000 Indian Yards. The following parameters differ: Zone I has φ_o = 32º 30' N & λ_o = 68º E; Zone IIA has φ_o = 26º N & λ_o = 74º E; Zone IIB has φ_o = 26º N & λ_o = 90º E; Zone IIIA has φ_o = 19º N & λ_o = 80º E, Zone IIIB has φ_o = 19º N & λ_o = 100º E, Zone IVA has φ_o = 12º N & λ_o = 80º E, and Zone IVB has φ_o = 12 N & λ_o = 104º E. As a hint for the readers that need the actual two standard parallels for each of the above India Zones expressed with the British Method of defining Lambert parameters; for India Zone I, the equivalent standard parallels are 35º 18' 50.3486" N and 29º 39' 18.7703" N. The requisite equations to solve for the other India Zones are in Chapter 3 of the Manual of Photogrammetry, editions 5 and 6.

Because there is no unified datum in existence for the sub-continent of India, there is a significant difference in transformation parameters from Indian 1916 to WGS84 from region to region. The Survey of India is slowly releasing geodetic and cartographic data to the general public after maintaining a significant degree of secrecy for centuries. Curiously, the India Lambert Zones are for restricted military use, and civilian applications in GIS for India seem to prefer the U.S. military's Universal Transverse Mercator Grid System.