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PROJECT REPORT

The history of geographical surveys in India during the British period

C. S. Meenakshi[1]

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Abstract
This study focuses on the history of Geographical surveys in India during the British period. Mainly three types of geographical surveys were conducted in British India during eighteenth and nineteenth centuries, namely the Great Trigonometrical survey, Revenue survey and Topographical survey. Origin and background of British geographical Surveys, The science of Great Trignometrical survey, experiences of surveys in different terrains and role of Indians in various surveys come under the purview of this study.

Keywords Everest · Great Arc · Great Trigonometrical Survey · Lambton · Marine survey · Observatories · Radhanath Sickdar · Revenue survey · Spirit levelling · Topographical survey

1 Introduction

The Indians had geographical knowledge even as early as vedic period. The references to geographical concepts are found in *vedās*, *purāṇās* and *itihāsās*, works of Kālidāsa, and Tamil Sangam literature. After that, many empires like Maurya, Gupta, Kusana etc. came into existence in different parts of the country. Before the arrival of the British, India was politically fragmented into about 600 kingdoms. But the village life was culturally close knit and that gave shape to the entity called India. Indians had the basic knowledge of geography but the science of cartography developed by the Europeans later on was unknown to them. The Indians had a tradition of setting on pilgrimage journeys to sacred places which involved heritage geography.

The British navigated their way to the Indian subcontinent and established three presidencies of Madras, Calcutta and Bombay during the early decades of seventeenth century to accelerate trade endeavours. The two major events turned the course of history of British in India. The first event was the Plassey war in 1757 in which the last nail was struck onto the coffers of Mughal rule in India and the second event was the death of Tipu Sultan in 1799.

These happenings were instrumental in initiating two milestone events in the history of geographical surveys in India. One of the spin-offs of these events was the formation of Survey Department—the first ever science department in India, and the other was the kick-start of Great Trigonometrical Survey (GTS) in Southern parts of India.

In 1767, the British setup a survey department that came to be known as Survey of India to coordinate the sporadic surveys and mapmaking efforts going on in various parts of India. After Tipu's death in 1799, proposal for a grand scientific geographical survey encompassing the whole country was put forward in 1800 as the British believed that the knowledge of geography of India will provide them with the lever-arm to formulate strategies to confront and defeat the opposing forces. That survey was later on named Great Trigonometrical Survey (GTS).

There was not much knowledge about the exact geography of India upto to the eighteenth century Many maps of India that had been published in Venice, Holland, France, and England were based on information collected through traders and tales of mariners and travellers. The invention of printing was a great stimulus to the study of geography, and publishing of maps. Between 1472 and 1480 seven editions of Ptolemy's maps were issued. A number of Italian and Dutch maps appeared during the following century.

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✉ C. S. Meenakshi
csmeenakshi26@gmail.com

[1] Resonance, Near Arulappad Temple, Chevarambalam, Kozhikode, Kerala 673017, India

2 Methodology

Secondary data was collected from official correspondences, records, accounts of surveys and maps of Survey of India Library, Dehradun. Relevant documents from National Archives, New Delhi, Asiatic Society, Calcutta, State Archives, Kozhikode etc. were analysed. Sites of GTS benchmarks in various parts of Kerala were visited and photographed.

3 Types of survey

The geo-surveys conducted by Survey of India are classified into: (i) Great Trigonometrical Survey (GTS), (ii) Revenue Survey and (iii) Topographical Survey.

3.1 Great Trigonometrical Survey (GTS)

According to William Lambton, there is no branch of physical science which is not affected by the three coordinates of latitude, longitude and elevation, to which the great trigonometrical operations are not of primary importance (Thullier, 1851a, b, p.525). Of all the surveys, the GTS had more to do with science. Fourteenth century was a period of renaissance in Europe. The scientific thinking and logical approaches replaced orthodox tenets and ecclesiastical canons and knowledge concepts. With the emergence of the industrial revolution in Europe during the eighteenth century, scientific pursuits gained momentum. The quest of scientific minds to find out the shape and curvature of Planet Earth resulted in terrestrial surveys combined with celestial observations. Similar such activities were going on in France, Ireland, England, and China on a smaller scale. During the same time GTS started in India, and the greatest arc of earth was measured and the curvature of its spheroid shape was computed by Col. Lambton and his team.

Apart from its scientific importance, the knowledge of the curvature of the earth facilitated navigation in a big way. For these reasons, no power was more interested in this investigation than the East India Company whose ships sailed in such large numbers that Indian Ocean was like a British lake by the end of the seventeenth century.

India was bountiful in natural resources like trees, minerals, spices, flora, fauna and other forest products. Being a tropical country it is rich in biodiversity. These resources were the main attraction that drew Europeans to India. The East India Company landed in India in 1600 with the motive of conducting trade. The company established trade centers in Surat, Masoolipatanam, Bengal etc. One of the objectives of geographical surveys was to assess the resources available in India quantitatively and qualitatively.

The great Mathematician and Geodesist Lambton conceived the Great Trigonometrical Survey based on scientific principles by which a network of triangles would be thrown all over the country so as to provide an extensive and reliable basis for all surveys. Lambton had already acquired a good theoretical and practical knowledge of triangulation, geodesy and astronomy. He was employed as a surveyor to measure the lands of America before his military stint in India. The main purpose of GTS was to establish a network of benchmarks which would act as the foundation for all future surveys. GTS based upon correct mathematical principles, was capable of extension in every direction and formed a reliable basis for all other surveys. Also, it accomplished a desideratum still more sublime, viz., to determine by actual measurement the magnitude and figure of the earth, an object of utmost importance in the higher branches of mechanics and physical astronomy. The construction of maps requires adoption of certain methods of scale, projection, datum, symbols and orthography. All these techniques and aspects of map construction evolved and were refined over centuries (Phillimore, 1954a, b, c).

In the initial period, maps had to be sent to some private publisher in England, or copied by hand. Lithography was just gaining acceptance. It is a method of printing on stone. In 1823, a lithographic press was established in Calcutta for printing maps. Before that, engraving using copper was the method adopted for making copies of maps. In the Surveyor General's office at Calcutta, there was a drawing and compiling, a lithographic, and a photographic branch. Introduction of photozincography was a milestone event. It was effectively functioning since 1866. By means of this technique, maps were made available immediately for general use (Markham, 1878). The survey committee in 1905 made recommendations to standardise the types and scales of maps published by Survey of India.

3.1.1 The basic infrastructure and instruments developed to facilitate GTS

To facilitate geographical observations and also for the determination of terrestrial and celestial features, many systems were established, such as (i) astronomical observatories (Kochhar, 1991), (ii) magnetic observatories, (iii) tidal observatories, (iv) meteorological stations (Phillimore, 1954a, b, c, p.273), (v) means of communication (post and dak, visual & electrical telegraph) (Phillimore, 1954a, b, c, p.269), (vi) survey school at Madras, (vii) station marks and platforms, (viii) light signals, and (ix) towers (Walker, 1863, p.37).

Until the times of GTS, instruments were procured privately by the surveyors. The ordnance department

maintained small stocks of survey instruments for military surveys. But GTS required instruments of high quality, accuracy and uniformity. George Everest who joined Survey of India in 1818 as an officer and held the post of Surveyor General after that, insisted that survey instruments should be held as government property. He introduced modern equipment like the compensation bar designed by Colonel Colby of ordnance survey. It was a combination of copper and iron rods supported on brass rollers and enclosed in a wooden case. Microscopes were attached for exact measurement of length. He also introduced heliotropes and blue lights which made night survey possible. Pendulums, barometers, plane table, theodolites, compasses, sextants, chronometers, perambulators, astronomical circles, chains, compensation bars etc. are the main instruments used in surveys.

3.1.2 The macro design of GTS[1]

According to Walker (1863), initially India was divided into three macro-quadrilaterals and one triangle such as (i) North-west quadrilateral (ii) South-east quadrilateral, (iii) North-east quadrilateral, (iv) South trigon. The Meridional as well as Longitudinal series were carried out within this vast framework as a network of principal and secondary triangles. Three Great Arc series 8º–18°, 18º–24º, 24º–30º were conducted. Further 9 extension series were also completed.

3.2 Revenue survey

Taxation of lands was identified as a better source of income than profits from running a trade. To demarcate the type of lands for levying differential tax, a revenue survey was started in Bengal once the British got possession of some land there. Till then, rulers of princely states in India followed non-standardised methods to classify land for taxation. As in many other civilizations, in India too, the taxation potential of land had much to do with its productive uses. The milestone event in the course of revenue survey is the initiation of Permanent Settlement of 1793, according to which the zamindars or landholders in possession of the lands were to pay a fixed sum every year based on the estimated assessment of their holdings in the year1793, and Government renounced all further claims on the value of the crops. The drawback of the scheme was that no provision was made for future changes of ownership, or the subdivision of holdings. The whole country was surveyed at different points of time and the type of land was fixed based on which revenue was collected.

3.3 Topographical survey

Topographical survey was done mainly to mark the latitude and longitude of natural structures such as hills, mountains, rivers, plateaus, lakes, ridges, valleys, and manmade structures like buildings, roads, dams, irrigation canals etc., and to take levels of various points and contour the lands. This was started as a part of military route surveys for identifying the vantage points where the soldiers may also get food, water, safe resting place etc.. It was also required to fix points from where to start the war and where to camp during night. Mackenzie was instrumental in initiating topo-survey in Mysore. Topographical surveys are placed within the larger framework of GTS.

Spirit-levelling operation of the survey was employed to connect together all the different lines of levels executed in this country which will then be reduced to the Mean Sea Level as their common datum. Without the epistemological base laid by these surveys, many of the wars would not have been won by the British. Also they would not have been able to collect land revenue in a systematic way although they had identified land as a better source of revenue than trade, especially when the company was facing tight competition from other European companies such as the French East India Company. These surveys helped the British gain an edge over the French, Dutch and Portuguese. From a scientific point of view, the GTS, which lasted for more than fifty years, was the greatest geodetic computation ever made and it is considered to be one of the sterling achievements in the field of science comparable with man's moon-landing.

4 Coastal, marine and river surveys

Many attempts were made to study the coasts of India. The first knowledge came from the early navigators from Arabs, Portugese, Dutch, French and English. Early mariners observed their position at sea and off the coast taking latitudes by sextant or Astrolabe, following point to point along the coasts by compass bearings and estimating their longitudes. Marine survey department was established in Bengal in the year 1809. Until that time, Surveyor General was responsible for various coastal surveys, and for the collection and custody of marine charts. River surveys to ascertain the course of rivers were also conducted. The merchants trading with India were interested mainly in the

[1] Synopses of the final results of the whole of the operations including the secondary as well as the principal triangulation had been published in "Synopses of the results of the operations of the Great Trigonometrical Survey of India – volume XXVII". Description and co-ordinates of the Principal and secondary stations and other fixed points of ***The Madras Longitudinal Series*** or ***Series G of the Southern TRIGON*** was prepared in the O/o Trigonometrical Branch, Survey of India. Colonel G Strahen, RE, Deputy Surveyor General in charge, published under the orders of Colonel H R Thullier, RE, SG of India Dehradun, printed at the O/o Trigonometrical branch, SoI, B V Hughes,1892.

coastal areas of India as they had to anchor the ships along the Indian coast. Often the ships of East India Company got lost along the Coromandel coast and Ganges delta. The coasts of India were surveyed in detail by the British so as to facilitate navigation and trade thereon.

In terms of terrains, India can be divided into seven categories such as the Himalayan mountain region, Plateaus, Planes, Eastern and Western Ghats, Deserts and Coastal regions. Various geographical surveys were carried out in all these seven regions. The technology and the socio-political approach employed in each region varied.

5 Role of Indians in surveys

Indians were taking part in the survey process- both physically and intellectually –at multiple levels and different ways. The village men took part in various physical activities and performed manual jobs like clearing the forests, paving the path, guiding the routes, carrying loads, delivering food and water, lifting the signal lamps and staff (measuring scale), passing the messages, erecting the tents as also acting as security guards.

The surveyors had to depend on the natives to sustain their life. On the other hand, for the common people a new livelihood—hitherto not available—got opened up.There were lot of people who were doing all sort of odd jobs relating to the survey. Many of such local workers brought their elder children and grand children to the survey camps. The members of the same family worked as labourers, masons, tree cutters, flag bearers, forest clearers etc.for generations in the survey camps.

It was not easy for the europeans to carry out a very tedious and complex geographical survey in a country where the routes, languages and even the attire were unfamiliar and unknown. So, inorder to complete such a complicated task, the intellectual involvement/ partnership of the natives was essential. Indians were put into use as translators of the local language and dialects to English, and the transcriptors of the reports & observations. In those times when the equipments like photostat machines were not in vogue, Indians were used for making handwritten copies of survey documents. Many able Indians were involved in survey related tasks as intellectual partners viz. writers of the reports to be submitted to the authorities, accountants proficient in mathematical calculations, draftsmen, cartographers, artists for drawing sketches, the data collectors, surveyors for measuring lands and fields etc. Names of many Indians get specific mention in the reports and diary notes of the surveyors, the prominent being that of Radhanath Sickdar, Syed Mohsin Hussain, and Nayan Singh. The most important among them is that of Radhanath Sikdar who contributed significantly through vital inputs and important mathematical calculations to arrive at the height of Mount Everest.

6 The results and achievements of geographical surveys

The vast geographical surveys, that took place in India during the British period, laid the basis for a scientific geo-data collection in India. This venture, which attempted to measure more than twelve times the area of Great Britain and cost the British more than fourteen lakh pounds, enabled us to take long strides in geodesy and geography. It's an awe-inspiring feat even when we look at it from today's age of satellite imaging, Geo Information Systems (GIS), and Global Positioning System (GPS). Technological advancements in data collection have not rendered the old ones redundant. In fact, the digital revolution holds those analogue records dear, for they speak volumes on the kaleidoscopic spatial and temporal pattern changes that take place in this part of the continent. Even today, we refer to those topographical sheets prepared by the British (some toposheets have been revised later by GoI) for determining levels, plotting contours, and for planning development works. The revenue survey maps still form the basis of the planning works of our revenue and agricultural departments.

GTS involved field measurements and observations, and complex and elaborate calculations. The field measurements and observations were subject to man-made and instrument-related errors and also to some mysterious and complicated natural forces like gravity and magnetism, optical aberrations like terrestrial and celestial refraction, parallax etc. These factors had to be taken into account in mathematical calculations.

Great Arc is one of the main features of GTS. The Great Arc passes through 77° 41 of East Longitude from Cape Camorin to Banog at the foot of the Himalayas between parallels of 8 and 30 approximately. The length of the Great Arc is 2400 km approximately. The area comprised by the Great Arc operations till 1848, principal and seccondary aggregates to 56,997 square miles (Thullier, 1851a, b, p.530). The grand total triangulated area from commencement till 1848, principal and secondary aggregates to 477,044 square miles (Thullier, 1851a, b, p.533).

The Great Trigonometrical survey could achieve the following scientific, commercial and the administrative objectives.

The scientific objectives accomplished were (i) GTS served as the base survey for all other surveys like revenue and topo (ii) The latitude and longitude of every point in the subcontinent were determined (iii) Bench Marks were established all through the country (iv) The shape and eccentricity of earth was determined (v) GTS resulted in serendipitous

discoveries regarding gravity of earth—One of the assumptions on which Newton's theorems are formulated is that Earth is of uniform density. But this assumption was proved wrong in the course of GTS (Phillimore, 1950).

The commercial objectives were (i) fixing anchorable ports along the Indian coast (ii) determining the correct direction of sail of trade ships (iii) Exploration of natural resources and (iv) Locating lat-long of shore points for navigation were fulfilled.

Administrative goals included (i) to establish a communication link between Coromandel and Arabian coasts (ii) to assess land ceded, invaded and the land taken over in wars (iii) marking vantage points and frontiers and territories (iv) planning strategies for warfare and (v) to establish a framework to support topographical and revenue surveys were also attained.

7 Conclusion

Geography is a subject in which both natural science and social science meet harmoniously. All countries developed their own systems of measuring and plotting the land—be it for the measurement of features of earth, as in geodesy, or be it for the assessment of extent and nature of parcels of land for revenue purposes, or be it for marking natural and man-made structures as in topographical surveys. India, which was a conglomeration of about 600 big and small kingdoms, too had its own methods of comprehending and documentation of geography. Geography finds place in literature right from vedic period, and pilgrimages give a geographical dimension to the religious practices prevalent in India.

Geographical surveys and cartography have been evolving through ages. Rennaissance (14–17 th CE) and industrial revolution (18th CE) gave a big boost to scientific and technological movements world over. Geodesy and Cartography also benefitted a lot from these scientific advancements. The Britis used this scientific and technological development as a tool for invasion, and exploitation of resources and developed colonies in various parts of the globe including India. Knowing the physical and cultural features of this country was essential for them to formulate invasion strategies. Also, it was important to put every physical nuances in picture form. All these activities took place at a time when conveyance and communication was not as easy as they are now. The authorities sitting in their office in London needed to have more of some real representations of India than the abstract ideas collected through fascinating stories and half-true heresay. That is the larger context leading to conducting of geographical surveys in India. Great Trigonometrical Survey acted as a broad scientific framework within which other surveys like revenue and topographical surveys took place. By means of these surveys, the British could achieve the scientific objective of determining the geodetic features, political goal of invasion and commercial purpose of resource exploitation, smooth navigation and profitable trade.

This paper depicts the various aspects of geographical surveys conducted by the British in India during Eighteenth and Ninteenth centuries. The scientific, political, social and cultural facets of survey activities have been discussed with special focus on the scientific aspect. The evolution and progress of surveys have been described. The scientific aspects form an important part. The diverse geographical landscapes and cultural mindscapes of India find special mention in this study. The physical and intellectual contributions of Indians are also elaborated.

On leaving India, the British left us with a priceless legacy of a reasonably well-surveyed country. Many developing countries have been handicapped because of lack of proper map cover. But as far as India is concerned, at the time of independence, The *Survey of India* was in possession of a wide range of maps prepared during the British period. The department is continuing its survey and cartographic journey with the help of new techniques like Imaging with the help of satellites and drones, Airborne Laser Terrain Mapping, Mobile mapping, and Geographic Information System (GIS). As stated in their logo, *Survey of India* is surveying and mapping this subcontinent *Asethu Himachalam*, that is from Kanyakumari to Himalayas.

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Data availability Data of the article 'The history of geographical surveys in India during the British period' is available in Survey of India library, Dehradun.

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