The W.E. Upjohn Center for the Study of Geographical Change Presents

Lectures in Geographic Change Series Fall 2010

THE GEOSPATIAL RE-DISOVERY OF INDIA

The Arthur Geddes Memorial Lecture
National Association of the Geographers, India -- November 19, 2010

From the desk of Director David G. Dickason

Mr. Chairman and NAGI Officers and Members, Geographer Colleagues, Friends. It is a very great honor and pleasure to be with you today. India is a country I love, the country in which I grew up, and in which I have carried out research. It is always a great pleasure to return to Chandigarh and to share good fellowship with colleagues at Panjab University. My presentation today is in three parts. First, introductory comments; second, focus on a key historic map of India; and third, the geospatial rediscovery of India – that is, how we may engage in India's time-space integration using geographic information systems (GIS). This forms something of an agenda for the future. Yet it also fits with the academic interests and orientation of Professor Arthur Geddes, a geographer who made India a major focus of his professional career. Although this is called the Arthur Geddes Memorial Lecture, I

Fig. 1. Aaron Arrowsmith.

wish to say that you as NAGI geographers are far more expert than I on matters pertaining to India. What I intend is to share with you some of my understanding of India based on recent research, in hopes that it may stimulate your own thinking.

Introduction. We – all of us – inhabit a multidimensional world. The world to which I refer is not that of Indic civilization nor of the West (although both are, in fact, multidimensional). I am referring to the universal world of human cognition and experience. Howard Gardiner has shown that human beings across all cultures possess multiple intelligences. [1] There are seven of them: 1) linguistic-auditory; 2) logical-mathematical; 3) visual-spatial; 4) musical; 5) bodily-kinesthetic; 6) interpersonal-social; and 7) intrapersonal-introspective/ intuitional. These intelligences are, in effect, separate languages we use and understand, but to varying degrees. They affect how we learn, what interests

Figure 2. Southern portion of Janes Rennell's Map of Hindostan (1789). Rennell shows the extent of Mysore (in blue) before the 3rd and 4th British Mysore Wars, and the "Jaghire" (in pink) surrounding Chennai/Madras administered by the EIC. By the 1820s all south India had come under EIC control or influence.

Figure 3. Detail of *The Indian Atlas* Mysore Sheet printed in 1828 showing Bengaluru/Bangalore. Notation indicates surveys were carried out by Col. Colin Mackenzie, who surveyed Mysore ca. 1795. Thus this map may have an effective date of 1795.

us, and how we function in the world. Although we employ the seven intelligences daily, we geographers probably are similar in having well developed visual-spatial intelligences. Many, if not most of us, like maps and graphics – perhaps to the point of being "mapaholics" or "cartophiliacs" (I am a map lover too). We geographers are concerned with the territorial differentiation of the earth, the earth as the home of the human species (as well as all other animate and inanimate phenomena), and find maps useful tools. So the blend of our intelligences has influenced our choice of career, and choice of specialty within geography, and our preferred tools for analysis. My talk today has a precedent that you know well -- a book by that great nationalist Jawaharlal Nehru, entitled *The Discovery of India*. [2] Nehru explored India after returning from the U.K., as did Mahatma Gandhi. During his travels, Nehru constructed his mental map of India. He came to understand that there existed basic cultural commonalities throughout India, while yet she showed regional diversity in landscape, society, and economy. Cultural continuities from the past, very much alive in the present, took precedence over the regional variety he observed. Nehru's unified mental map of India gave major impetus to India's Independence movement. A coherent mental map of India is likewise as important today for each citizen as it was for Nehru in his time. Every generation requires its own common constructs to maintain national unity. How is this accomplished? In my view, Indian geography and Indian geographers contribute to nation-building in many ways, but particularly by helping students to develop their own coherent mental maps of India.

The oft-quoted phrase "the past is a foreign country: they do things differently there," reminds us historic maps always need to be interpreted in light of their times.

Specifically, mental maps of the nation come from consulting historic maps that show the continuity of Indian society across long history. By historic maps, I do not refer to maps we make to describe the India of

1 Howard Gardiner (1983). ***Frames of Mind: The Theory of Multiple Intelligences.*** New York: Basic Books.
2 Jawaharlal K. Nehru (1956). ***The Discovery of India***. New York: John Day Company.
3 E.g., J.E. Schwartzberg, (Ed.) (1978). ***A Historical Atlas of South Asia.*** Chicago: University of Chicago Press.
4 S. Ramaswamy (2010). ***The Goddess and the Nation: Mapping Mother India*.** Durham: Duke University Press.
5 M. Monmonier (1996). ***How to Lie With Maps.*** Chicago: University of Chicago Press.
6 L.P. Hartley (1953). ***The Go-Between.*** London: Hamish Hamilton.
7 Sir L. Namier, in J.P. Kenyon (1983). ***The History Men: The Historical Profession in England Since the Renaissance***. London: Weidenfeld and Nicholson.
8 A. Arrowsmith (1822). ***Atlas of South India.*** Privately Printed.
9 Worldcat lists only six copies in libraries -- two in the U.S. and four in Europe.
10 M.H. Edney (1991). "The Atlas of India 1823-1947: The Natural History of a Topographic Map Series," ***Cartographica*** Vol. 28. P. 59-91.
11 D.M. Peers (2005). "Colonial knowledge and the military in India, 1780-1860," ***Journal of Imperial and Commonwealth History.*** Vol. 33. P. 157-180.

long ago. There are many good historical atlases; but I do not refer to them. [3] Nor do I refer to iconic map-like graphics that may have propaganda uses, or that play on the nostalgia of readers. [4] Nostalgic cartographers want us to yearn for ancient Golden Ages that were perhaps considerably less "golden" than we moderns imagine. And Monmonier has shown how easy it is to lie with maps. [5] Instead, I suggest we need to find maps created in earlier times that give insight into, and inventory of, the spatial structure and spatial relationships of society in those times. The oft-quoted phrase "the past is a foreign country: they do things differently there," reminds us historic maps always need to be interpreted in light of their times. [6] We should discover why and how they were created in order to understand what they represent. And we should recognize human beings do not distinguish the past from present and future times very reliably (regard-less whether time itself is cyclical or linear). As the historian Sir Lewis Namier observed, "One would expect people to remember the past and to imagine the future. But in fact...they imagine... [the past] in terms of their own experience, and when trying to gauge the future they cite supposed analogues from the past: till by a double process of repetition, *they imagine the past and remember the future* [italics mine]. [7] Because old historic maps are not of

Figure 4. Part of the Paris sheet of the Carte de France. Note location of the observatory (intersection of the prime meridian and prime parallel) to the immediate south of the city.

Figure 5. Portion of the London sheet, British Ordnance Survey (1801) dedicated to Lord Cornwallis. Note location of Greenwich observatory (bottom right) and Tower of London (top left)

our making, they warrant careful study. They do not come from our imaginations, and precisely for that reason they can be convincing informa-tion sources. But we may have to work hard to tease out their insights.

Figures 6-9 (left to right). Cornwallis, Mackenzie & *pandit* colleagues, Arthur Wellesley, and Lambton.

Old maps are in short supply, are increasing in monetary value rapidly, and are inaccessible to most people. So the first point I wish to make is that we need excellent digital facsimiles (that is, exact copies) of historic maps so that all may access and read. The second point, its corollary, is this. Until one has seen a proper digital map facsimile, one has not really seen the map at all. This I have only come to understand recently, and I hope this point will be exemplified in today's illustrations.

Historic Maps of India. Three years ago I went to the Library of Congress in Washington DC. It contains the world's largest map library with more than 5 million flat maps and 80,000 atlases. When I asked for 19th century ¼-inch sheets of *The Indian Atlas* the librarian could only say they had some ¼-inch maps of India. She retrieved a cart loaded with huge leather-bound volumes, each one full of maps of India at a scale of 4 miles to the inch. At the very bottom was Aaron Arrowsmith's *Atlas of South India*. [8] Here was a very important document in South Asian and world cartography, discovered by fortunate coincidence. [9]

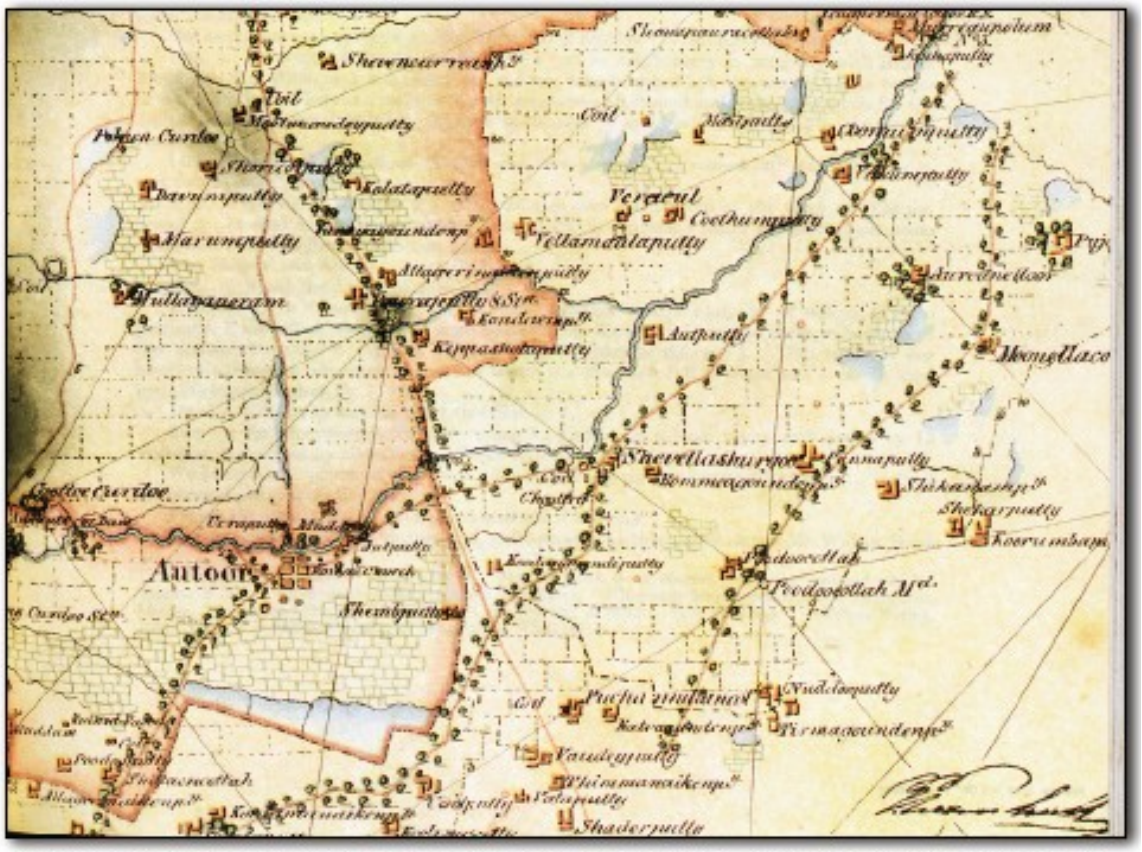

Figure 10. Portion of a fair drawn manuscript map, Dindigul District, 1815. (Arrowsmith did not have access to this map.) Note tanks (*bunds* in black, water in blue) and *ayakut* irrigated fields (outlined in green), dry cultivated fields (black dashes), tree-lined roads, other roads, settlements, and lines of triangulation. Source: Phillimore.

Importance of Arrowsmith's Atlas. Arrowsmith, a leading cartogra-

Figure 11. Lambton's trigonometric survey extending near Kanyakumari (Cape Comorin). Primary survey in bold black, and subsidiary surveys in light black. Arrowsmith tied local/regional surveys to trigonometric survey bench marks in making his atlas. Source: Phillimore.

pher of his time, conflated the first triangulated surveys of south India into one publication. Figure 1. All previous maps of India had been based on inaccurate route surveys – perhaps the best-known example being James Rennell's 1789 *Map of Hindostan*. Figure 2. Arrowsmith's maps were a great improvement. Based on field surveys made between 1795 and 1810, his 16-page atlas showed the territory gained recently by the East India Company (EIC). The atlas provided the EIC's Court of Directors their first coherent, reasonably reliable spatial visualization of south India. These maps minimized cartographic misinformation: inflated and/or fictional kingdoms were gone. Arrowsmith took a calculated risk. EIC bureaucrats "loaned" him secret manuscript maps of south India so he could make his atlas. On seeing it, the Directors commanded India be mapped according to Arrowsmith's design. The first map in this series was published in 1827, the first of many sheets called *The Indian Atlas*. [10] Figure 3. Plates were printed until 1906 when the Survey of India issued other, better map series. Arrowsmith's atlas was important because it transformed British Indian cartography from an art to a science. Most subsequent maps (until the present day) have been based on scientific measurements. In a very real sense, the modern

Figure 12. Arrowsmith atlas Madras sheet showing Lambton's original 7 mile baseline, the northern end of which is at Guindy east of St. Thomas's Mount, in the middle of the Chennai Race Course.

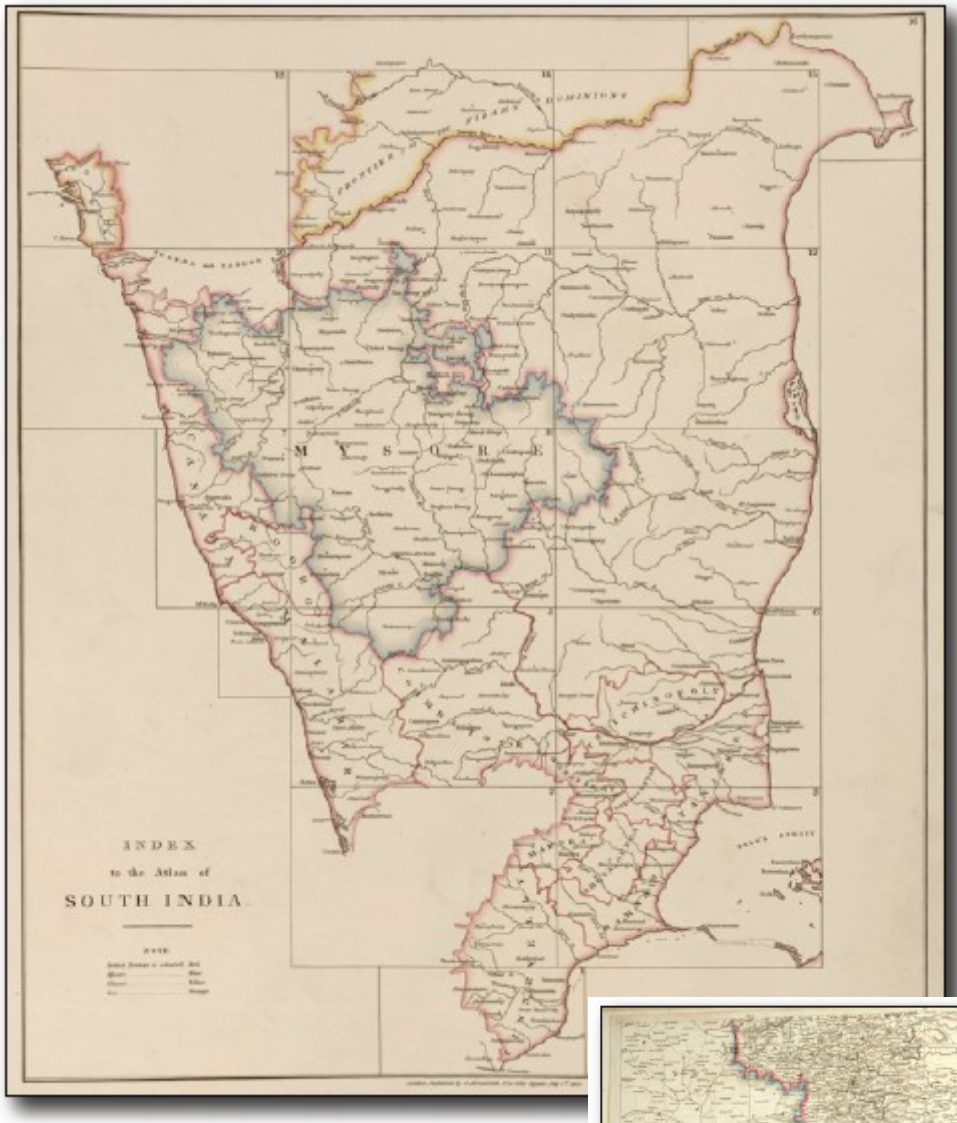

Figure 13. Index Map to Arrowsmith's atlas showing extent of coverage

mapping of India begins with Arrowsmith's atlas.

How Did This Cartographic Transformation occur? Triangulated surveys were expensive. Influential people had to be sufficiently convinced the benefits outweighed the costs so they would be willing to champion the new surveys. The templates for mapping India were Cassini's 18th century *Carte de France* and the British Ordnance Survey maps of England (Figures 4 and 5). India was the first non-European world region to be mapped in this way. The first champion of these surveys was Governor-General Cornwallis – the same man who surrendered to George Washington at Yorktown, and who was Master of Ordnance in Britain when the Ordnance Survey's new maps were being drafted. Figure 6. Governor-General Cornwallis led the Third British Mysore War. Since Haidar Ali ceded territory at the war's end, the British wanted to map the lands Haidar Ali retained and also those they had gained. The man to do this was Col. Colin Mackenzie, who possessed a passion for documenting India's antiquities and for mapping as a science. [11] Figure 7.

The second champion of these surveys was Arthur Wellesley (later Duke of Wellington), whose brother Richard was Governor-General of India during the Fourth British Mysore War (1799). Figure 8. Arthur

Figure 14. Visual content of the double elephant sized pages (27" x 40"). Note exclusive focus on mapping of land areas. Note also the curvature of the pages because sheets are in a bound volume. Imaging courtesy of the Library of Congress.

commanded an elite regiment in this war, went on to win the Battle of Waterloo against Napoleon, and became the most powerful man in the British Empire. Arthur's protege was Lt. Wm. Lambton – passionate about measuring the earth. Figure 9. Lambton began the Great Trigonometric Survey – completed after his death by Col. George Everest.

Cornwallis and Wellesley became mapping champions because the British Crown had created the office of the Governor General of India (GGI). The GGI's charge was to regain control over the EIC after the horrible post-1757 excesses. Accurate maps of India were one means of gaining control. No longer would EIC officials in India be able to deceive their superiors in England so readily, or so easily enrich themselves at the expense of the Company and the people of India. So maps were a means of dominating India, but they were also a means of controlling an EIC that had grown beyond the law.

The surveys of Mackenzie and his trainees and the triangulations of Lambton's men formed the inputs to Arrow-smith's atlas. Figures 10, 11, and 12. They generated truly "hybrid colonial knowledge." The surveys were carried out as a joint enterprise with the support and diplomacy of Indians – right down to negotiating a hoisting of a theodolite to the top of the Brahadiswara Temple *gopuram* in Thanjavur. Many surveyors were Eurasians. Mackenzie's team of *pandits* was enthusiastic in helping him explore, document and map south India.

The Atlas. Arrowsmith's atlas displays most of Dravidian India from

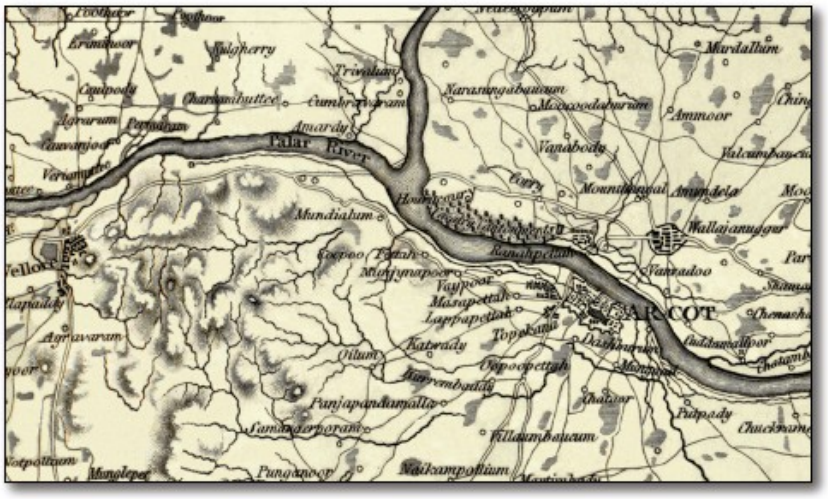

Figure 15. Well developed settlement and transport networks exemplified in Arcot-Vellore axis (incl. Walajanagar and Ranipettai) along Palar River.

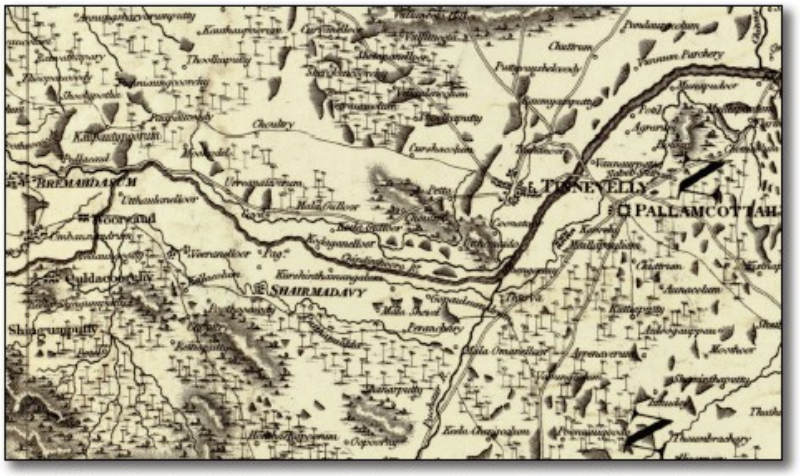

Figure 16. Five tier settlement hierarchy by combination of symbology and typography. Two rural land cover types -- 'Other' forest (bottom left corner) and Palm trees (bottom center).

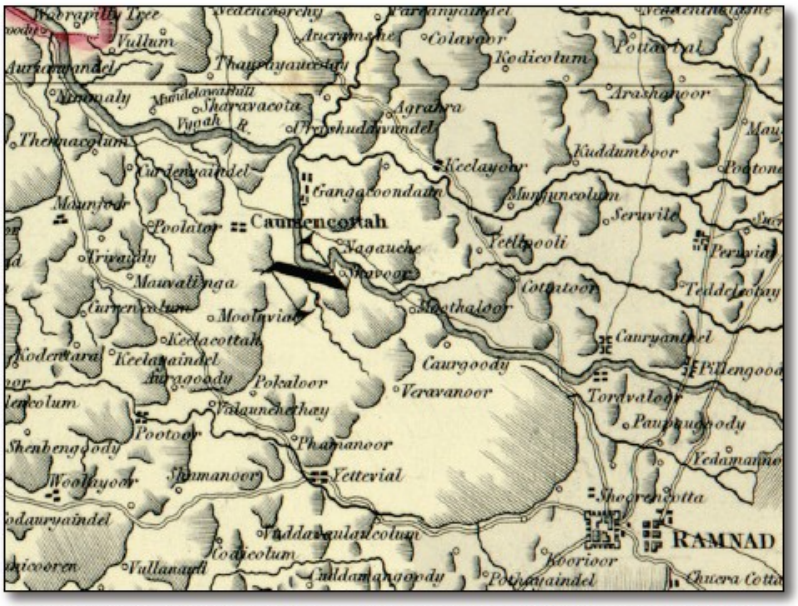

Figure 17. Rain-harvesting *tanks* on the lower Vaigai River. Some are fed by channels cascading tank to tank.

Figure 18. The Kaveri River at Tiruchirapalli/Trichinopoly and the "Grand Annicut" diverting water between the Kaveri and the Coleroon. Regularly irrigated lands are shown in gray.

Kanyakumari to the Krishna River. Figure 13. On the west, it included Portuguese Goa. On the east it included Pondichery and Tranquebar. It excluded today's Kerala, Tamilnadu's Dindigul District, Sri Lanka and also much of Hyderabad state. Arrowsmith created his own projection for the atlas. The large sheets form tiles that display south India seamlessly when placed side by side. [12]

We are only now interpreting these maps. Already certain things are clear. First, the atlas focuses only on the land area of peninsular India, although more trade moved over coastal waters than overland. Thus, the maps were of military-strategic significance to the EIC. Figure 14. Second, the maps display a fully articulated urban system and highway network. Figure 15. Clearly the British Raj reinforced the structure and spatial relations of pre-existing settlements. Thus, south India's cultures, institutions, leaders, and villagers had already sculpted the landscapes of the south into patterns broadly similar to those of the present. This does not imply a static system, for each generation reworks entirely the landscape it occupies according to the contexts, standards, and opportunities of its day.

The maps show a somewhat irregular 5-fold settlement hierarchy (by typography and symbolization). [13] Figure 16. The extent to which Brahmin informant/translators con-

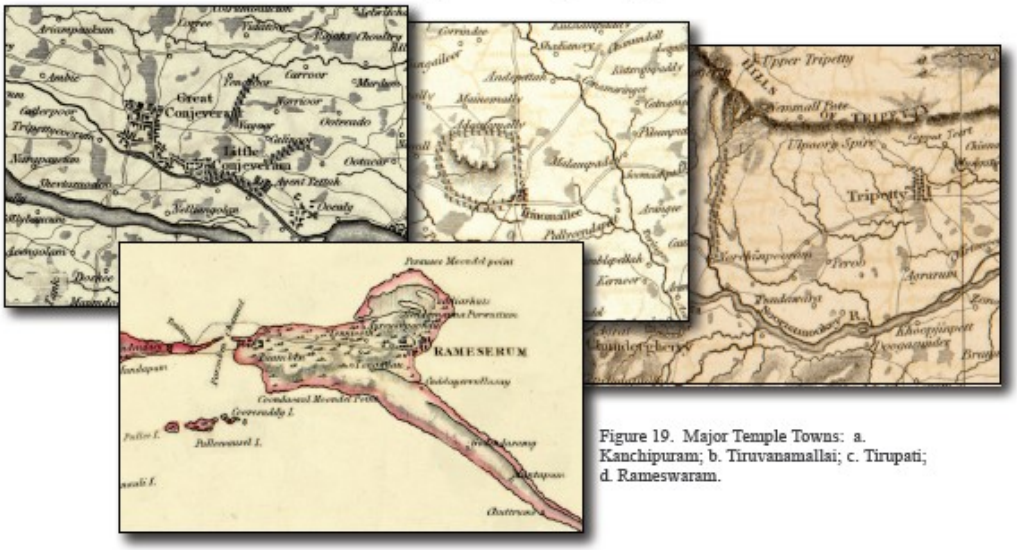

Figure 19. Major Temple Towns: a. Kanchipuram; b. Tiruvanamallai; c. Tirupati; d. Rameswaram.

12 Arrowsmith also made the last route survey map of India in 9 sheets (1816, revised in 1820), scale 16 miles to the inch. A map at 4 miles to the inch seemed perhaps a sufficiently detailed scale, and simplified his computations too.
13 Urban historians have done exciting work on individual cities and the structure of Indian urbanization in earlier times, although they seem not to have investigated the spatial relations of cities. See J. Heitzman (2001). "Urbanization in Southern India, 900-1900." In S. Rajagopal (ed.). ***Kaveri: Studies in Epigraphy, Archeology, and History***. Chennai: Panpattu Veliyiittakam. p. 299-330.
14 R. Thakur (1994). "Urban hierarchies, typologies and classification in early medieval India: c. 750-1200". ***Urban History***. Vol. 21, Pt. 1. p. 61-76
15 J. DeLoches (1993). ***Transport and Communications in India Prior to Steam Locomotion***. Delhi: Oxford University Press. Vol. 1: Land Transport.
16 Spatial analysis of the transport network is planned. See R. Abler, J. Adams, and P. Gould (1970). ***Spatial Organization: The Geographer's View of the World***. Englewood Cliffs, NJ: Prentice-Hall.
17 D. Ludden (2002). "Spectres of Agrarian Territory in Southern India." ***Indian Economic and Social History Review***. Vol. 39. p. 233-257. See also D. Ludden (2003). "Maps in the Mind and the Mobility of Asia." ***Journal of Asian Studies***. Vol. 62. p. 1057-1078.
18 C.R. Markham (1878). ***A Memoir on The Indian Surveys.*** 2nd ed. London: W.H. Allan & Co.
19 There are smaller problems too. Walker, who took over after Arrowsmith died, mistakenly created the Indian Atlas sheets at a somewhat smaller scale than 1:253,440. He also changed the map projection so that sheets no longer tiled together. See Markham.
20 S.G. Burrard (1903). "On the Values of Longitude Employed in Maps of the Survey of India." Professional Papers. Series 7. Calcutta: Survey of India. P. 6.

Figure 20. Transparent Overlay of National Atlas of India Population Distribution plate on Arrowsmith Chennai/ Madras plate showing Kanchipuram. Kanchipuram's 1951 population (proportionate circle, purple) and rural settlements (agricultural in green, non-agricultural in red dots according to settlement size) is shown. The significant concentration of non-agricultural villages immediately east of Kanchipuram may be a continuing manifestation of silk weaving -- whether by continuing production in 1951 or by residence of silk weaving occupational castes.

structed this hierarchy we do not know – but there are many *agraharams*, *Brahmadesams*, *choultries* and *chattrams* indicating Brahmin-related settlements and pilgrim rest houses (aside from major towns with famous temples and their associated Brahmin dominated zones). [13] Rural settlements are indicated through four land cover types – two of forest cover (palms and "other") and two related to agriculture (showing seasonal reservoirs, "tanks", and *ayakut,* wet-rice irrigated, lands). Figure 17. Other lands must have been under wet-rice cultivation also. Figure 18. But perhaps they were not regularly irrigated, or Arrowsmith omitted them because they crowded the printed page. Prominent were major temple towns – such as Tirupati, Kanchipuram, Tiruvannamallai, Madurai, Tiruchendur, Rameswaram and others. Figure 19a-d. That there was a "central place"-like pattern based on religious importance, or sanctity, is quite possible. To religious centers came many pilgrims, who in turn brought their temple donations and their spending money. Pilgrimage was a religious and a recreational activity – so commerce and manufacture also found a niche in these towns. Places such as Kanchipuram became major manufacturing centers (for silk). Figure 20.

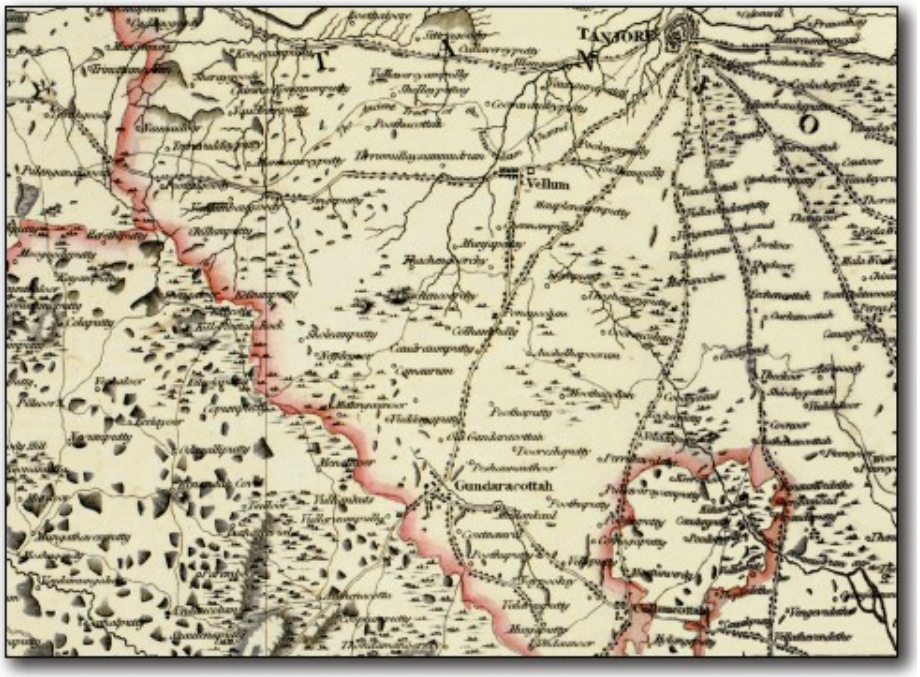

Figure 21. Radiating out from Thanjavur (top right) are tree-lined roads denoted by tree icons either side of the roadway. As roads crossed the border into Pudukottai state (bottom left) many became secondary in status (denoted by parallel lines), and farther to the southwest tertiary roads are shown as single lines.

Figure 22 a and b. Spectral Geographies: a. Arrowsmith's Depiction of the Wall Dividing Kerala from Tamilnadu. Despite commonalities such as pilgrim circuits linking east and west, a wall divided these two regions. b. Google Earth shows the alignment of the wall to the present day. Vattakkottai (fort) still very much exists, and the southern part of the wall has been converted to roadways.

Presumably, the demand for luxury textiles was great there, and the "market" came to the merchants in this age of high freight trans-port costs. This is analogous to pilgrimage to cathedral towns in pre-industrial Europe. As temples towns grew important and needed secular authorities to assure the safety of their donated assets, there seems to have arisen in post-medieval times a "twin-city" effect – for instance, Tirunelveli-Palayamkottai, Rameswaram-Ramanatha-puram, Shri-rangam-Tiruchirapalli, Kanchipuram-Arcot, and Tirupati-Chandragiri, among others. In the cases of Tirupati and Kanchipram, Madras/Chennai displaced their secular twins after they came under English influence.

There were other temple towns without secular twins – for instance, Madurai and Kumbakonam. Each had different origins. [14] And Tirunelveli-Palayamkottai had a third pole, Melpalayam – where Arab Muslim traders engaged in international trade.

The atlas shows a fully articulated road network, with a three-fold hierarchy. Figure 21. The main highways were shaded by trees, providing natural air-conditioning to travelers. Tree-lined roads were rare in north India at this time. We are told that the precedent for tree-lined roads was established by the 17th century Nayak queen of Madurai, Mangammal. [15] There appear to be thousands of kilometers of tree-shaded roads at this time in south India. Second tier roads were indicated by parallel lines, and third tier (local roads) by a single line. Importance and centrality of a

Figure 22c. Spectral Geographies: Northern Segment of the Wall. The line running south to north west of Aralvamozhi/Aramboly and east of Vadakoor represents what is left of the wall in its northern extremity, as shown by Google Earth.

place is denoted by the number and importance of roads intersecting it. Finally, rivers and terrain show clearly on these maps. [16]

The EIC never intended to create a benchmark to show what south India looked like before the modern age. But to us moderns that is exactly what it did. These maps give us visual spatial expression of south India before the age of telegraph and railway, before modern comercialization and industrialization. They provide evidence that south India was fully constructed before ever John Company or the British Raj appeared. Because the pace of change in those times was slow, the structure and spatial relations of south India as shown in these maps may also reflect broadly south India as it existed at the end of the medieval era. Ludden refers to this as the revelation of "spectral geographies", when current conditions provide clues to geographical conditions of earlier times. [17] Figure 22a-c. This atlas is, therefore, useful in comparing south India

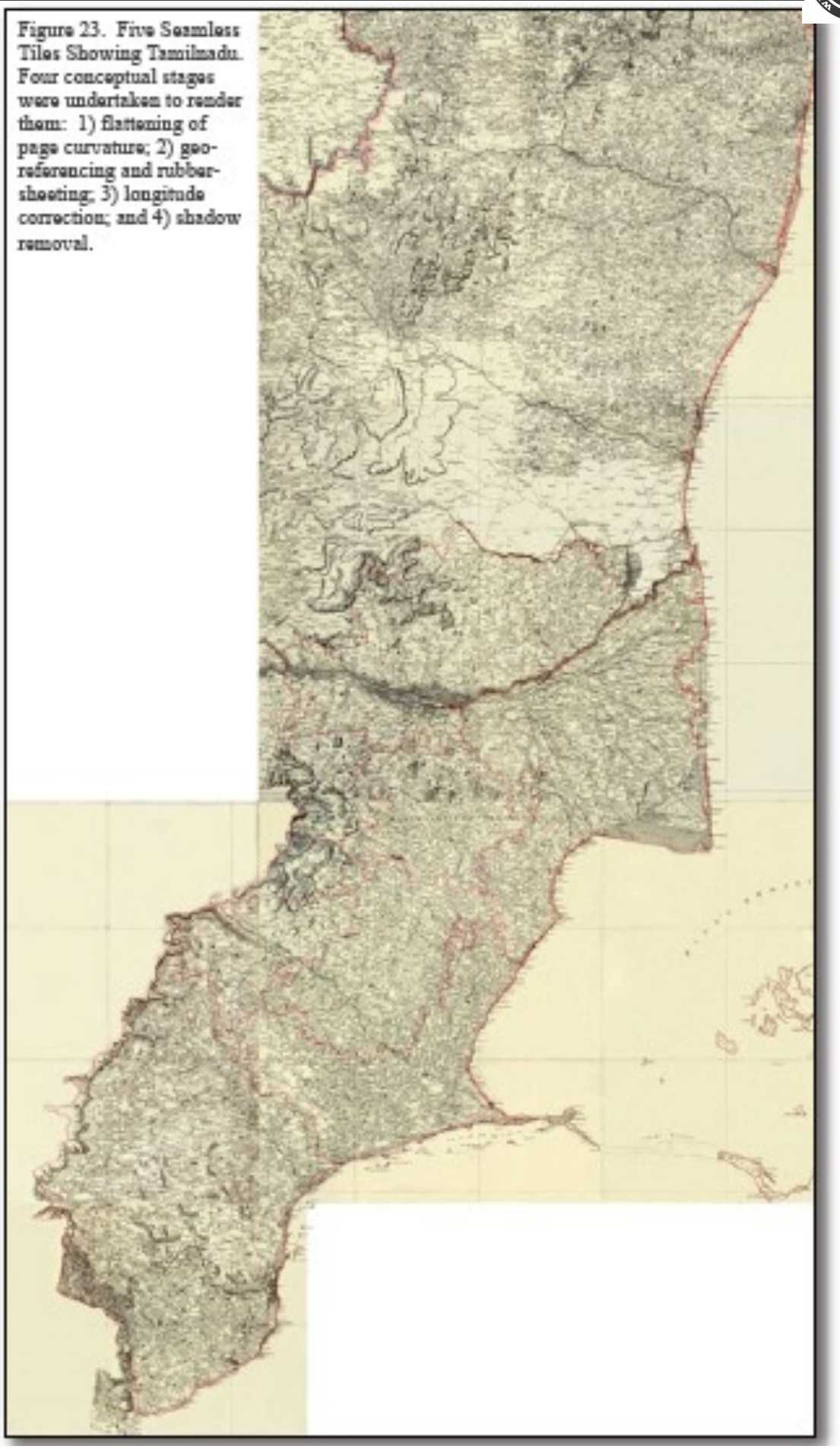

Figure 23. Five Seamless Tiles Showing Tamilnadu. Four conceptual stages were undertaken to render them: 1) flattening of page curvature; 2) georeferencing and rubbersheeting; 3) longitude correction; and 4) shadow removal.

Figure 24. Indian Atlas Sheet 28 (Portion). This hand colored sheet shows in light blue the glaciers and ice fields mapped by Col. Godwin-Austen during field surveys about 1860. (A dissected map sheet.)

of two centuries ago with south India now, and also perhaps with the south India of four centuries ago. Much more work is required to validate this hunch.

Geospatially Re-Discovering India. Individual maps and atlases are one thing. How can we integrate them across time and space? That is the challenge in rediscovering India geospatially. Maps and other archival data sources are the pre-digital spatial databases of their time. By integrating diverse visual-spatial data and lexical-numerical data, we can use GIS systems to query, analyze, relate, and integrate information that could never be used in this way previously – to learn new things, and to renew respect for those who have preceded us. For historic maps, the first challenge is coordinate control. Each map must be georeferenced to standard, authoritative coordinates. Only then can maps of different scales and projections can be compared reliably. This is easy to say, but more difficult to do. Arrow-smith's first "modern" maps of south India ought to be georeferencible and made comparable to later maps. There is one major problem. These maps were made in an age when it was still difficult to calculate longitude accurately. The Madras observatory was established in 1794. Its longitude was recomputed 14 times by 1905, because calcu-

21 I.N. Gregory and P.S. Ell (2007). Historical GIS: Technologies, Methodologies and Scholarship. London: Cambridge University Press.
22 A prototype for an Historical Atlas of South India (covering the state of Puddukottai only) has been created recently, and extends from very early times up to ca. 1600.
23 R.H. Phillimore (1950). Historical Records of the Survey of India. Dehra Dun: Survey of India. 4 vols.
24 I do not propose for India anything I would not suggest for the United States. At The W.E. Upjohn Center we are engaged in an "Authoritative U.S. Topographic Maps Initiative". Not only are we digitizing and georeferencing (with metadata) all topographic maps produced by all U.S. government agencies, we have just completed the first 60,000 of these ultra-accurate digital maps for GIS use.
25 W. Shakespeare (1611). The Tempest.
26 Professor Michael Bishop, personal communication.
27 M. Monmonier (2008). Coast Lines: How Mapmakers Frame the World and Chart Environmental Change. Chicago: University of Chicago Press.
28 A. Geddes (1960). "The Alluvial Morphology of the Indo-Gangetic Plain: Its Mapping and Geographical Significance". Transactions and Papers (Institute of British Geographers). Vol. 28. p. 253-276.
29 A. Geddes (1937). "The Population of Bengal, Its Distribution and Changes: A Contribution to Geographical Method." The Geographical Journal. Vol. 39. p. 344-361. This work was followed by a more comprehensive all- India review in A. Geddes (1942). "The Population of India: Variability of Change as a Regional Demographic Index." Geographical Review. Vol. 32. P. 562-573.
30 R. Bryson and D.A. Baerreis (1967). "Possibilities of Major Climatic Modification and Their Implications: Northwest India, A Case for Study." Bulletin of the American Meteorological Society. Vol. 48. P. 136-142.
31 O.H.K. Spate (1956). India and Pakistan: A General and Regional Geography. London: Methuen & Co..
32 A. Geddes (1982). Man and Land in South Asia. New Delhi: Indian Council of Social Science Research. Published posthumously and edited by: A.T.A. Learmonth, A.M. Learmonth, C.D. Deshpande, and L.S. Bhat.
33 P. Haggett (1996). "Geographical Futures: Some Personal Speculations." In I. Douglas, R. Huggett, and M. Robinson, Companion Encyclopedia of Geography: The Environment and Humankind. London: Routledge. p. 965-973
34 M. Monmonier (1985). Technological Trends in Cartography. Minneapolis: University of Minnesota Press.
35 J.B. Harley, quoted in J.W. Crampton (2010). Mapping: A Critical Introduction to Cartography and GIS. Chichester, UK: John Wiley & Sons.
36 T.S. Eliot (1942). Little Gidding. http://www.tristan.icom43.net/quartets/gidding.html

Figure 25. Indian Atlas Kashmir Sheet 28 (Part). The Vale of Kashmir shows only one large lake (Wular) on this sheet published in 1867. This mapping is to be compared to Figure 27.

lated values were always suspect. The values Lambton used were wrong. And Markham noted that if the longitudes of British maps of India in the 19th century were wrong, the entire mapping effort would have been wasted. [18] This is likely the main reason these maps have been forgotten. [19]

This is the GIS digital age, though. With patience these maps can be repurposed and combined analytically with other information. This is exactly what we have done in The W.E. Upjohn Center through a combination of geo-referencing and "rubber-sheeting". In the process we have also rediscovered what the Survey of India discovered more than a century ago – specifically that Col. George Everest's computations contained an inexplicable error of about 7.14 seconds of longitude. [20] Figure 23. When corrected for this, there is excellent correspondence with Google Earth. Correcting for longitudinal error is

Figure 26. Resurvey of the Vale of Kashmir in 1911-12 showed lakes adjacent to Srinagar. Was the cause heightened flow of glacial meltwaters, drainage of wetlands in the Vale, or a combination of these and other factors?

Figure 27. Haramukh Glacier: Scale 1:63,360. Survey of India Map Sheet 43-J 15 (Part), 1915. Note the many terms giving evidence of prior more extensive glaciation in this area.

not easy, but other problems are actually more difficult.

Libraries – repositories of many historic maps – follow imaging rules and protocols developed for digitizing books. When scanning, they do not like to flatten book pages for fear of crushing the spine of the book. For text imaging this is no problem. Maps, being visual-spatial scientific documents, are quite different, however. The problem is that each scanned page now contains new sources of error composed of variable resolution (that also affect focus and lighting). Before geo-referencing, each map must be re-projected onto a virtual flat page, and only then can the virtual page be assigned coordinates. This is a time-consuming and expensive extra step. New standards for imaging maps contained in bound volumes must be developed in dialogue with our librarian colleagues. Otherwise, integration of historic maps in GIS will occur much more slowly than desired.

The great promise of geospatially-based work is that there are now a number of national historical GIS projects (NHGIS) in the U.S., Britain, China and elsewhere. [21] In each there is an increasing capability to inventory, track, and model change across time and space. If there is not an NHGIS of India, geographers, historians and others should band together to realistically envision one. [22] Of high priority is the proper digitization and geo-referen-cing of historic maps.

Essential to any effort are the historic maps of the Survey of India. The Survey is a most professional organization and has been so for a long time. [23] The Survey of India's are some of the most accurate, beautiful, and detailed maps ever made. They are a delight to the eye. The Survey's maps, together with information from the predigital databases of the respective surveys of India (archeological, anthropological, geological, botanical, and the census of India) and with the maps of the National Atlas and Thematic Mapping Organization (NATMO), should be digitally preserved for use in an NHGIS of India. [24] More than this, historic manuscript maps of India, from which the printed maps were created, should be digitally preserved also. Markham tells us many manuscript maps were destroyed in the early 1870s before the Survey of India was formally estab-

lished. But early manuscript maps are thought to survive in the British Library, the National Archives of India, the Tamilnadu State Archives, and in the Survey of India. Priceless and irreplaceable, they are India's cultural patrimony from the British Raj.

As William Shakespeare said long ago, "What's past is prologue."[25] Not only do we study the past to understand it better, we study the past to understand the present and to project the future. Many issues in our global future depend on data about and from India. Intensely debated studies of global climate change, sea level rise, and human dimensions of global change lie before us. Indian data, based specifically on historic Survey of India maps, are essential to these efforts. Let me cite just a few examples.

Global climate change is now being studied by many. A leading climate-earth systems scientist, who studies Himalayan glaciation, recently told me that his climate change detection analyses are limited because historic satellite imagery provides a perspective of only a few decades. [26] He needs a deeper time frame for his studies. I showed him the following maps: 1) an Indian Atlas sheet showing glaciers in Kashmir as mapped personally by Godwin-Austen about 1860; and 2) selected Survey of India sheets showing the Haramukh Glacier in Kashmir created between WWI and WWII. Figures 24, 25, 26, and 27. He immediately expressed how useful these maps could be in studies of global climate change. These maps also show the maximum altitude of tree growth, another biogeographic indicator of climate variation.

Second, global rise in sea level is subject of great importance. The devastating 2004 Asian tsunami is a clear indicator that temporary surges in sea level, though rare, require careful emergency planning using maps of the first (normal high water), second (low-tide water), third (storm surge) and fourth (future sea level) coastlines. [27] Sea level rise issues are important to India's coastal zones and the Ganga-Brahmaputra delta. Historic maps could assist analysis greatly. Geddes' careful work on Bengal's population growth and change could form an integral feature of studies in this genre. [28] Moreover, Geddes' methods for spatially interpolating

Figure 28. Yamuna/Jumna River Badlands Southeast of Agra. Note "Broken Ground" notation and stippling indicating badland erosion. Source: U.S. Army Map Service 1:250,000 map sheet.

population data relative to land use and land character should not be ignored. [29]

Third, cultural desertification is a practical issue in India. If Bryson's analysis is still largely correct, the Thar Desert has developed and expanded spatially because of human overuse of a short-grass steppe biome.[30] And his claim that desertification can be reversed (without need of cooperation by/with Pakistan) is also interesting. Historic maps of this region could provide useful benchmarks to track both the historic advance of the desert, and its retrogression because of reclamation efforts.

Historic maps could give insight on other topics such as studies of the badlands of the Chambal-Yamuna rivers region. [31] Figures 28 and 29. Geddes' outstanding work on the Gangetic Plain fits here exactly. [32] His intimate knowledge and drawings, many of which were never published because they were oversized and in color, could be integrated into future studies.

Figure 29. The same badlands as shown on preceding map. The Yamuna River region east of Agra and southwest of Firozabad.

Conclusion. Peter Haggett has noted presciently that, besides change occurring in the world around us, there have been major changes occurring within the discipline of geography. [33] The first of the disciplinary changes he noted was in mapping – with a switch from "ROMS" to "RAMS." "Read only" maps (ROMS) – i.e., pre-digital printed and manuscript maps – were/are progressively giving way to "random access" maps (RAMS) – i.e., digital maps created from computerized GIS databases. [34] This trend has only accelerated since Haggett's article. Geospatial geography is becoming ever more vital and central among the academic disciplines.

By converting historic maps of India, such as Arrowsmith's (and the *Indian Atlas* and Survey of India maps that followed) into RAMS, we are actually *en route* to understanding India anew through studies that integrate time with space. This is important not only because J.B. Harley has said quite simply and insightfully, "The [historic] map ... restores time to memory," but also because in doing this we will be able to remember the past more clearly, study the present more crisply, and imagine the future more effectively. [35] And we will do it using our multiple intelligences – visual-spatial, linguistic, logical-mathematical…. In this, we may be able to say with the poet T.S. Eliot,

> "We shall not cease from exploration
> And the end of all our exploring
> Will be to arrive where we started
> And know the place for the first time." [36]

We are in process of re-discovering India in this generation in new and interesting ways. It is an exciting time to be a geographer in this great nation of India!

Thank you for your kind attention. Namaskaar!