The Raja Todar Mal Memorial Plenary Lecture
Indian National Cartographic Association (INCA)
October 15, 2011

The Future of Historical Cartography

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INTRODUCTION. If "history is too important to be left to the historians," as is often said, then we may say also that "maps are too important to be left to cartographers". I would like to preface my comments by saying that my INCA colleagues know vastly more about both cartography and India than I could ever know. I hope today only to stimulate renewed interest in historical cartography and to place it in the context of contemporary trends. My comments are in three parts. First, thoughts about time and historical maps. Second, reflections on how cartography (and historical cartography) is changing. Third and last, the challenges to, and opportunities for, historical cartography in the digital age.[1] As a non-cartographer, I wish to view historical cartography primarily through the lens of map content and map comparison -- in the context of contemporary geospatial concepts and methods.

1. TIME. Historical cartography deals with maps and mapmaking through time. There are two kinds of time we must recognize that humans perceive. They differ qualitatively.

Kairos Time: *Encounters with Eternity. Kairos* is a Western religious-philosophical concept with Indian equivalents. *Kairos* refers to deep spiritual or sacred time ("God's time") where people sense eternal truths.[2] Historical maps based in *kairos* time show the place of

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[1] This talk relates to South Asia, but is more general than, and views cartography 20 years later than J.E. Schwartzberg (Assoc. Ed.) and J.B. Harley and D. Woodward (Eds.) (1992). *The History of Cartography: Cartography in the Traditional Islamic and South Asian Societies*. Chicago: University of Chicago Press. pp. 579. It does not attempt to revisit the same materials as treated in so masterly a way by J. Schwartzberg. This talk also makes no effort to incorporate the many excellent previous Raja Todar Mal lectures relating to historical cartography available on the INCA website. Nor does it revisit the excellent work of S. Gole (1989). *Indian Maps and Plans: From Earliest Times to the Advent of European Surveys*. New Delhi: Manohar. pp. 207.

[2] Kairos also refers in secular terms to the "propitious" or appropriate time, a transcending time of insight, creativity, revelation or epiphany, in which humans perceive phenomena differently than usual. The role of the church in Western culture over many centuries warrants considering kairos in its sacred sense, particularly for *mappa mundi*.

Figure 1. Hereford Mappa Mundi. The most ornate T-O map, from about 1300 CE.

Figure 2. Grand Mosque at Makka. Source: Google Earth.

humans in the cosmos. Such maps termed *mappa mundi* in the West focus on an *axis mundi*, a sacred mountain or pole on which the world "revolves".[3] Figure 1. Places like Jerusalem, Makkah, Amritsar, Mt. Meru, the Altar of Heaven, and Kashi (among many others) are such foci. Sacred scriptures celebrate actions, stories, and places in *kairos* time.

Pilgrimage to sacred sites follows cosmic mental maps and pilgrims submerge in *kairos* time on their devotional journeys. A Muslim going to Mecca on the Hajj (Figure 2), a Sikh going to Amritsar (Figure 3), or a Roman Catholic *en route* to the Vatican are all immersed in *kairos* time. Their experience of the world is qualitatively different compared with other times.

Hindu tradition has a vast number of *tirthas* (or 'fords') where events in *kairos* time intersect(ed) the mundane, human world. Major Hindu temples constitute cosmic maps expressed in *kairos* time.[4] Figure 4. *Kairos* time maps are *yantras* or *mandalas,* therefore. Figure 5. They

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[3] One of the best known is the Hereford Cathedral's (U.K.) Mappa Mundi, a most ornate T-O map created before 1300 CE. It incorporates four kinds of information about the world: 1) geographical; 2) Biblical and theological; 3) Alexandrian Classical; and 4) fictional. It shows geographical change, but only theologically correct changes. For instance, the center of the map has moved from the Garden of Eden (the eastern extremity of the map) to Jerusalem where the "Christian Era" came into being. See G. Alington (1996). *The Hereford Mappa Mundi: A Medieval View of the World*. Leominster: Gracewing; P.D.A. Harvey, ed. (2006). *The Hereford World Map: Medieval World Maps and Their Context.* London: The British Library.

[4] Excellent examples are the Vaishnavite Sri Ranganathaswami Kovil at Srirangam on the Kaveri River near Tiruchirrapalli, and the Shaivite Nataraja Temple in Chidambaram, also in Tamilnadu.

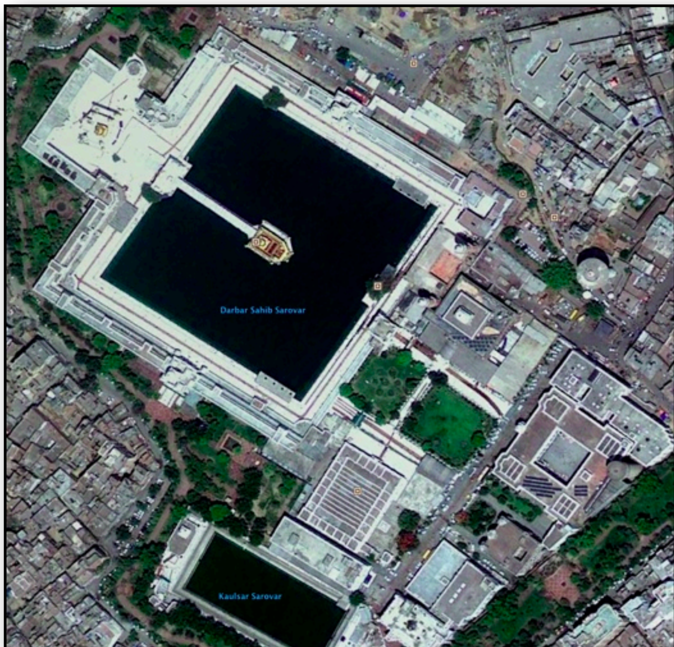

Figure 3. The Golden Temple at Amritsar. Source: Google Earth.

Figure 4. Sri Ranganathaswamy Kovil, Srirangam. On the Kaveri River near Tiruchirrapalli, Tamilnadu. Source: Google Earth.

may include whole cities like Kashi. Figure 6. And Hinduism is further unique in its flexibility of transposing space – and Kashi is mirrored at many places across India.

Cartographers of *kairos* landscapes are monks, priests, and gurus (or their interpreters).[5] *Kairos* time is eternal, and therefore it is unchanging in human terms. Study of *kairos* time maps is based primarily on devotional insight instead of cartographic interpretation. Relatively little further geographic insight can be expected from *kairos* time maps because like T-O maps, they have been with us for many centuries. They represent the eternal existing equally in the "past", "present", and "future". They are,therefore, "timeless," fixed and unchanging.[6]

Chronos Time: *Encounters with the Mundane. Chronos* time is secular time more or less as employed in modern life (albeit with differing calendars). *Chronos*, clock time, measures short time intervals like railway time and standard time. Modern cartography is based on principles of *chronos* time, from calculating longitudes to calibrating GPS. Time and space

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[5] *Kairos* time, so far as is known, has heretofore not been identified by historical cartographers or interpreters of documents such as mappa mundi. *Axis mundi* have long been identified, as has sacred and profane space. M. Eliade (1959). *The Sacred and The Profane: The Nature of Religion.* W.R. Trask (trans.) New York: Harcourt, Brace & Co. See also P. Wheatley (1971). *Pivot of the Four Quarters: A Preliminary Inquiry into the Origins and Character of the Ancient Chinese City.* Edinburgh: Edinburgh University Press. For Kashi, see D.L. Eck (1982). *Banaras: City of Light*. New York: Alfred A. Knopf. pp. 427. See also H.F. Hirt, "The Dravidian Temple Complex: A South Indian Cultural Dominant," *Bombay Geographical Magazine* (1961), p.95-103.

[6] It is not so much that *kairos* time is "changeless" as that change shown on *kairos* maps constitutes only change legitimised by the divine and/or by myth and legend (both being external to contemporary human agency).

Figure 5. Yantras of Hindu tradition, and mandalas and thangkas of Tibetan Buddhist tradition.

Figure 6. Modern Varanasi, with traditional Kashi located between the Varuna and Asi Rivers. Banaras Hindu University is visible in the geometric campus plan at bottom outside Kashi's perimeter. Hindu conceptualization allows transposition of space, so that there are many Kashis mirroring this one. Source: Google Earth.

are linked in *chronos* time – so when Wm. Lambton established the distance from Chennai to Mangalur/Mangalore by the Great Trigonometric Survey he found the distance between these places to be about 44 miles less than previously thought. Figure 7. This distance meant that these two places were more than 9 days closer for the caravans and armies of Lambton's day. *Chronos* time is also the time dimension used by Raja Todar Mal in promoting the Mughal state.

We expect many changes in *chronos* time. Places flourish and wither in *chronos* time; landscapes and settlement systems develop and are resculpted; new systems are added on top of old ones – irrigation, transportation, or legal and land revenue systems (such as developed by Raja Todar Mal). People migrate from one place to another and some places may be eclipsed by others -- for instance, Murshidabad by Kolkata/Calcutta, or Arcot by Chennai/Madras. Geographic change is basic to *chronos* time, and provides the fundamental reason for cartographers to continue making maps.

Early *chronos* maps in the West were *portolan* charts beginning in the fourteenth century (Figure 8), and nautical charts made later like Mannevillette's 1775 nautical chart of south India, Sri Lanka, and the Indian Ocean all showed compass directions for sea voyages rather than

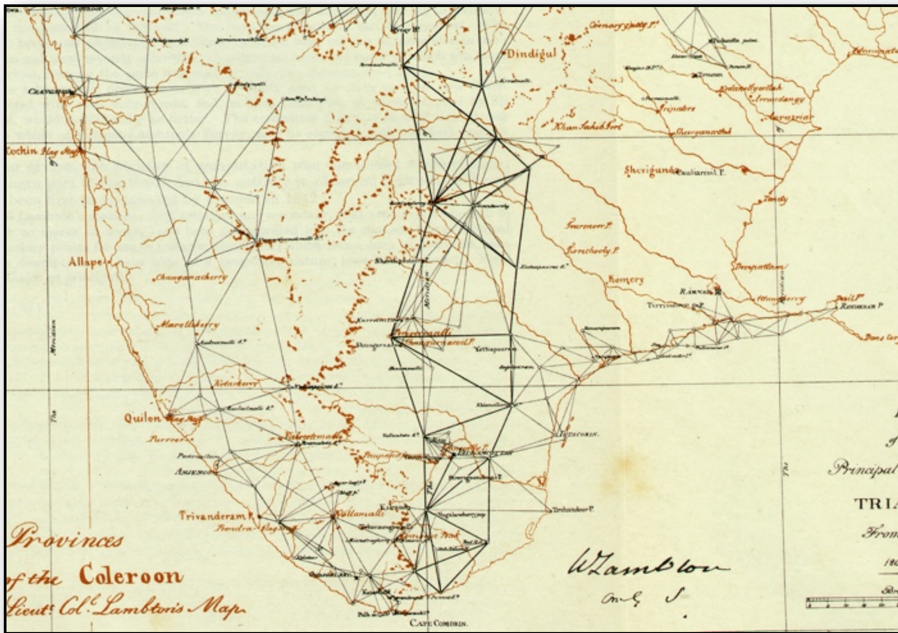

Figure 7. Southern tip of India from Kanyakumari northward to Dindigul showing triangulations of Col. Wm. Lambton of the Great Trigonometric Survey -- with secondary triangulations of others. Into these local surveys were "snapped". Arcot was 9 miles closer to "Madras" (Chennai) than previously thought. Triangulation error at Bengaluru (Bangalore) was thought to be only 7 inches!

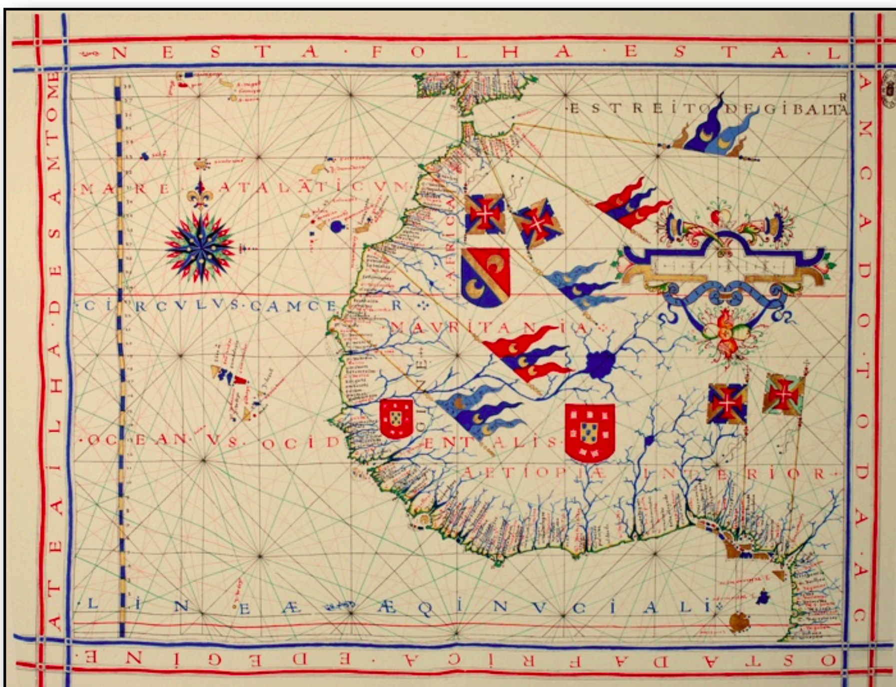

Figure 8. A portolan-like chart of the 17th century. Compass directions are given clearly over the Atlantic Ocean, with greater detail for coastal areas than inland. Whether this chart was based on a map projection, as we understand them today, is unknown.

information about landward hinterlands. Figure 9.

The Nature of Time & Temporal Maps. Cartographers don't have to think as philosophers and physicists do about whether time is linear, circular, or goes in cycles – whether *kairos* time is "real" and *chronos* time is "illusory", or whether both are "real".[7] (Hindu philosophic schools of thought can accommodate almost any conceptualization of time!) But as humans we all live in the "present" (although we like say that some of us live more in the "past", or more in the "future", than others). We perceive the need for maps of the "present" (the "now") and we make new maps now for use in the "future" (the "nows" yet to come). We make new maps when we perceive existing maps are no longer adequate – when the "present" of past times (the "thens") seems different enough from our own "present" to justify the cost and effort of a new map.

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[7] B. Greene (2004). *Fabric of the Cosmos: Space, Time, and The Texture of Reality*. New York: Vintage Books.

Figure 9. Mannevillette's 1775 nautical chart of south India. Compass direction based. Known seaports are listed with no data on Indian or Sri Lankan hinterlands.

Thus, every map of the world set in *chronos* time is actually "historic", and even contemporary maps should be the concern of historical cartographers. So, historical cartography includes almost all other varieties of cartography because we all live inside the *chronos* "time-space envelope". Historical cartography is not defined by the mildewed smell or the spotted look of old maps, or even by the medium (stone, wood, vellum, palm leaves, paper, mylar) on which the maps were rendered. Only in popular thinking does the age of a map make it "historic". Historical cartography as an academic field was created by highly trained, future-oriented mappers who probably were not very impressed by the historicity of their work as they were doing it. So the idea that historical cartography is past-oriented is a myth. Wm. Faulkner reminds us "the past is never dead; it is not even past".[8] Maps of "then" are available to us in the "now" and it is for us cartographers and geographers to comprehend the change these maps show as we plan for the "nows" to come. Maps surviving from pre-digital ages were the spatial databases of their time. When we compare maps of different times, we discover that maps created long ago are actually embedded in more recent maps. (But we can only know this by studying them.)

We must exercise care when interpreting maps of the past, however. Maps as temporal snapshots do not reveal dynamic landscape processes. We should also remember that people in past *chronos* times did not necessarily think as we do today. So we must interpret their maps

[8] W. Faulkner (1951). ***Requiem for a Nun.*** New York: Random House.

consistent with their views and translate their views into our times; otherwise, we may commit fundamental temporal fallacies and thereby draw false conclusions.

2. CHANGING CARTOGRAPHY. Arthur Robinson, that dominant figure of twentieth century cartography, developed and disseminated a "one-way" "Cartographic Transformation Model" that sieved the "real world" through the cartographer's science, art, perception and mentality into maps consumed by map readers.[9] Figure 10. This was, of course, what cartographers had been doing all along (more or less). None had noted their schematic work flow. Robinson emphasized map users in the cartographic communication process rather than maps as product. The model gave the impression cartography was changing slowly. The geographer Peter Haggett has called this stage of cartography/geography the "ROMS" stage – "Read-Only MapS" (i.e., readers could not change the printed map).[10] This model was perfectly suited to the age of paper maps. Cartographers interpreted available data about the world, organized it into map form, and published it in printed form for readers.

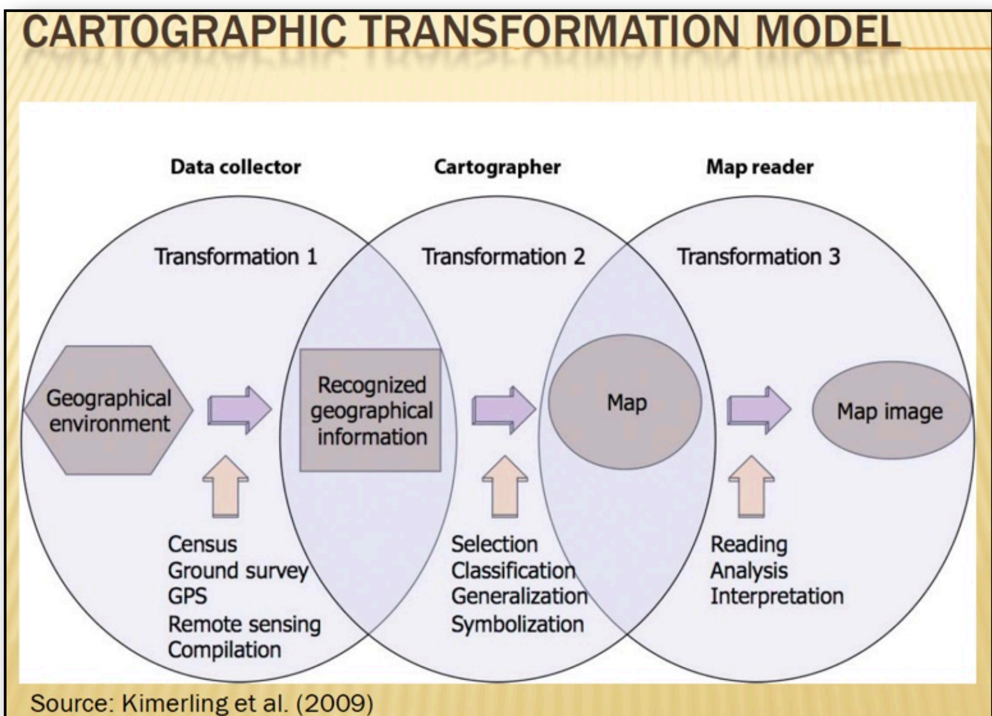

Figure 10. The Robinson-Petchenik Model that distinguishes between cartography and map makers, and the map users-map readers.

This constituted a "democratizing" trend in itself. The map now no longer was owned by the king, his generals, or members of the political-military-religious elite because it was printed in many copies. Before the age of printed

[9] A.H. Robinson and B. Petchenik (1976). *The nature of maps: Essays toward an understanding of maps and mapping*. Chicago: University of Chicago Press.
[10] P. Haggett (1996), "Geographical Futures: Some Personal Speculations," in I. Douglas, R. Huggett, and M. Robinson (eds.), *Companion Encyclopedia of Geography: The Environment and Humankind*. London: Routledge. p. 963-974. His interpretation was based on that of M. Monmonier earlier.

maps, whoever controlled the only copy of a map had a significant advantage. In the printed map age, anyone with enough money or influence could access it.

In eighteenth century India, all maps were drawn one copy at a time for the East India Company (EIC). The few EIC maps that were printed constituted exceptions to general practice. (James Rennell's *Atlas of Bengal* (1779) and *Map of Hindoostan* (1782) are some of the best known of these exceptions.) When EIC Directors in London requested a map, twelve to fourteen months were required to make it, and then it had to be sent to England – so the total time was nearly two years between a map's request and its delivery in London. Figure 11. The map was expensive. It benefited very few.

Cartographers did not know how many copies of printed maps would sell because demand for printed maps was "latent", or hidden. The printing of maps transformed cartography into a business. Previously cartographers required patrons (like artists, poets and musicians) for their one-of-a-kind works. Now they gained some independence selling

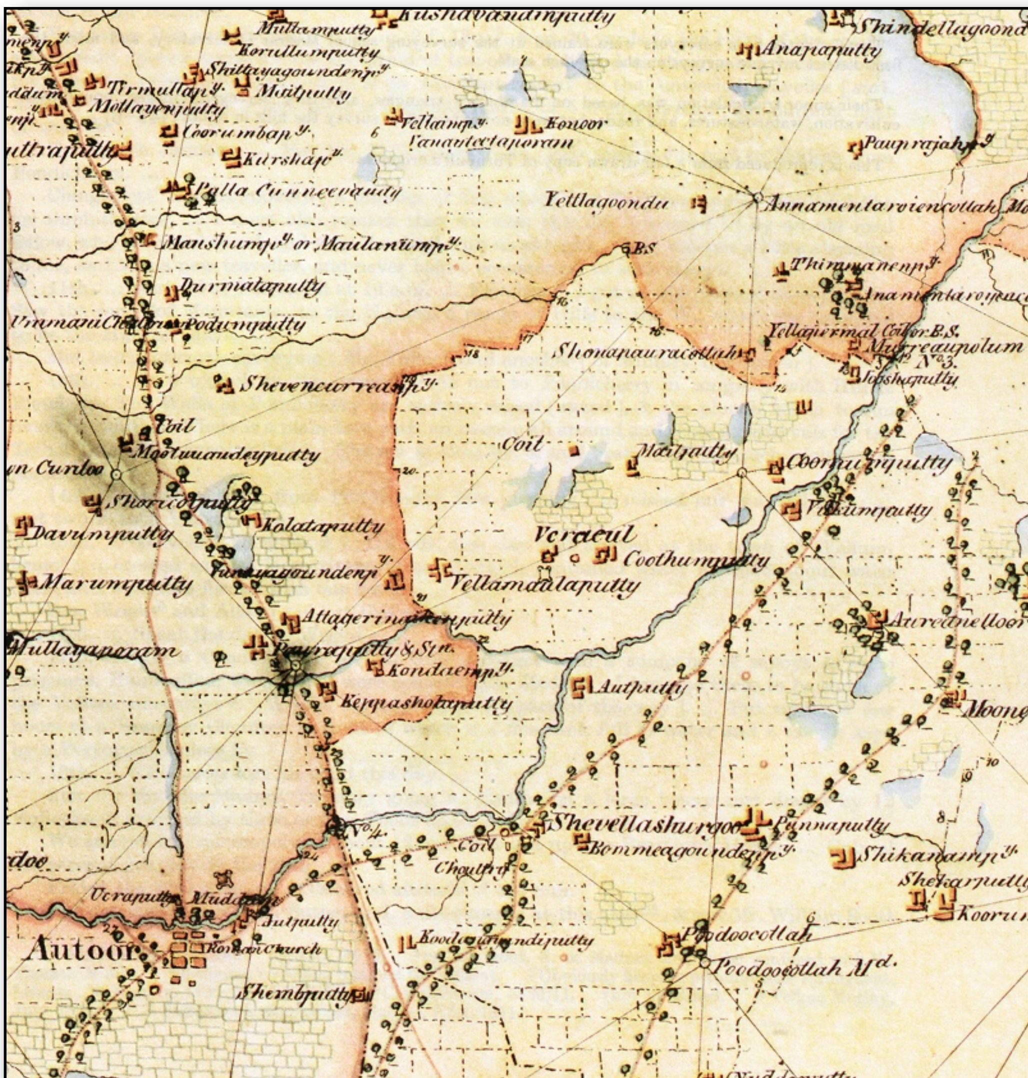

Figure 11. A "Fair Drawn" (i.e., finished) Manuscript Map of part of Dindigul District (1815). This map was not available to Arrowsmith for his Atlas of South India. Note drainage, triangulation lines, tree-shaded roads, tanks (light blue), irrigated rice fields (in green), and dry cultivated fields (black dashed lines), and villages small and large. Orthography is, of course, "colonial phonetic". Source: Phillimore.

Figure 12. Letts' Atlas of India i(1883) 12 plates were hand-tinted versions of SDUK (Society for the Diffusion of Useful Knowledge) maps issued between 1828 and 1842 with railway and telegraph lines overprinted very approximately.

printed maps to buyers. Map-makers competed fiercely in the seventeenth and eighteenth centuries – and often plagiarized each other (no copyright laws then existed). Profits became increasingly important because accuracy (beyond a minimum) was expensive and reduced profits. Some inaccurate maps of India were reprinted for more than fifty years. Perhaps most famous was the twelve-sheet Society for the Diffusion of Useful Knowledge map of India. Figure 12.

The Pursuit of Accuracy. Cartographers knew the benefits of accurate maps. James Rennell, "father" of the Survey of India (formally established only after the *British Raj* took over from the EIC after 1858), did not believe the accuracy gains of new survey techniques warranted replacing his maps based on route surveys.[11] Figure 13. Historical cartography's story is about the struggles of geodesy (calculating the earth's

Figure 13. J. Rennell's ***Hindoostan***. (1782). Based on route map surveys. His geographical memoir describes how he inferred city locations, and how he drew this map. He did not favor trigonometric surveys replacing his work. One of the relatively few maps of India printed in the 18th century.

[11] Rennell had been named Surveyor General of Bengal by the EIC, and Bengal was the first among equals of the Presidencies of the EIC -- but there was no formal institution called the Survey of India until later.

ellipsoid and measuring magnetic anomalies), astronomy and horology (calculating correct longitudes), applied trigonometry (accurate angular surveys) and valiant human endeavor (death rates among field survey teams were high) to create more accurate maps. These expensive activities were state/EIC funded. The search for map accuracy brought mapmaking again under the supervision and control of the state. More accurate maps were so much better that map-makers without state support could not compete.

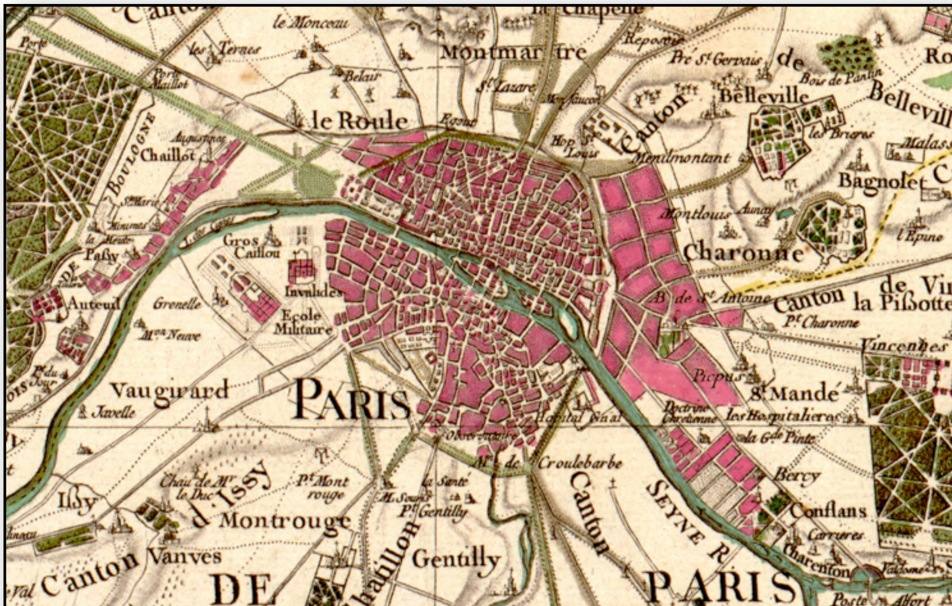

Figure 14. Sheet One of the Carte de France, showing the observatory to the south of Paris on which the coordinate system for France was based. (Library of Congress)

The first of these whole-country, large-scale accurate maps was the Cassini family's *Carte de France*. Figure 14. The second was the British Ordnance Survey. Figure 15. Other European states also carried out systematic triangulated surveys – although none truly understood geodesy then. After these efforts came the triangulated surveys of India sponsored by the EIC. To the Trigonometric Survey benchmarks across India, local surveys could be referenced.

The project triggering this change was Aaron Arrowsmith's *Atlas of South India* (1822).[12] Figure 16. For the first time the EIC Directors had an atlas printed at a common scale and projection (4 mi. to 1 in., or 1:253,440). This atlas showed what was possible for India, even though Arrowsmith had to omit information from some of the larger scale maps he used. Figure 17. Specific demand for more accurate maps developed immediately. Large-scale mapping in

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12 A. Arrowsmith (1822). *Atlas of South India*. Privately Printed. For a more extensive discussion of this atlas, its importance, and contents, see D.G. Dickason (2010), "The Geospatial Re-Discovery of India", The Arthur Geddes Memorial Lecture, 32nd NAGI Conference, Chandigarh, November 2010. Available online at: <http: www.wmich.edu/ucgc/>.

Figure 15. Part of London in the 1st edition of the British Ordnance Survey of England (1801). (Bottom r.) the Greenwich observatory. At left on the Thames R. is the Tower of London.

India began during the 1820s and continues to the present. By the start of the twentieth century, no major region of the world was more extensively mapped than undivided India![13] Figure 18. The first of these major projects was called *The Indian Atlas*, and by 1881 most of undivided India had been mapped (excluding portions of Rajasthan/Rajputana). Figure 19.

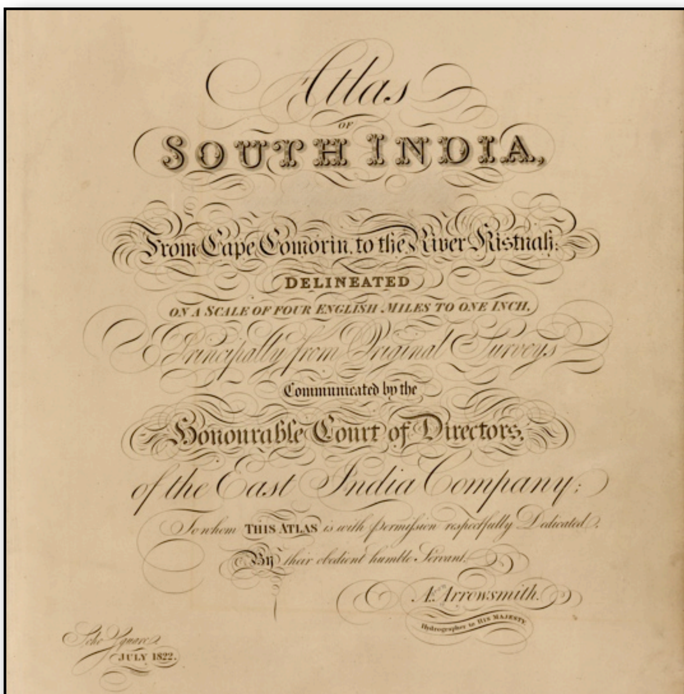

Figure 16. Only six copies of this atlas survive in public repositories. It was not a commercial publication. It stimulated revolutionary change in mapping

Problems, Problems. There were many challenges. **First**, Aaron Arrowsmith died and his vision for mapping India was lost. John Walker, a competitor, took on this work. **Second**, the Great Trigonometric Survey started in 1801 under Wm. Lambton was completed by George Everest after Lambton's death. Everest discovered Lambton's measurements were not sufficiently exact. He resurveyed south India. Not enough was then known about geodesy to make accurate field measurements. The Survey of India in 1903 noted that Kalianpur's coordinates, Everest's base for mapping India, were inexplicably wrong. Whether this was computational error or sabotage (or both), we will never

[13] J.G. Bartholomew (1890). "The Mapping of the World," *Scottish Geographical Magazine*, Vol. 6, p. 293-305. Bartholomew's map is reproduced in Collier.

Figure 17. Scope of the Atlas of South India. It included territory immediately surrounding Mysore/Karnataka, excepting Mahratta lands.

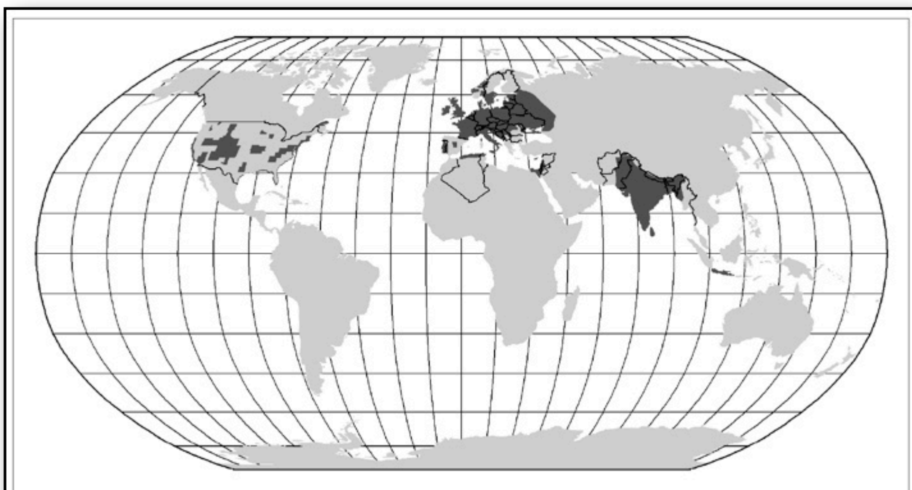

Figure 18. Regions of the world mapped by trigonometric surveys before 1900. Source: Bartholomew.

know. But George Everest was a tyrannical employer. **Third**, the original coordinate base for *The Indian Atlas* was the Madras Observatory in Chennai. The coordinates of the Observatory were recalculated more than a dozen times in the nineteenth century, and only early in the twentieth century were computations considered accurate. Markham said that if the coordinates of India's maps were wrong, the entire British mapping effort in India would have been wasted.[14] The W.E. Upjohn Center has shown the inaccuracy of the original coordinates can be corrected, although not easily. Figure 20. **Fourth**, John Walker personally managed *The Indian Atlas* until 1869. Not until Atlas maps were made in India was it known that Walker established the scale of his maps incorrectly (they are actually slightly smaller scale than 4 miles to the inch). No one knew he changed the map projection so *Indian Atlas* maps would not tile seamlessly. Further, he arranged the map sheets to cover as much water and as little land area as possible because he was paid for each completed map sheet. Moreover, some map sheets he compiled came from field surveys more

[14] C.W. Markham (1878). *A Memoir on The Indian Surveys*. London: W.H. Allen & Co. See also: C.E.D. Black (1891), *A Memoir on the Indian Surveys: 1875-1890*. London: W.H. Allen & Co., and R.H. Phillimore (1945ff.) *Historical Records of the Survey of India*. Dehra Dun: Survey of India. 4 vols.

than thirty years old. For instance, Sheet 1 (Karnataka/ Mysore showing Bengaluru, also known as Bangalore) published in 1828 noted C. Mackenzie as surveyor; but Mackenzie surveyed Mysore about 1795 and did not resurvey it again. Figure 21. Metadata for the manuscript maps Walker used to make the *Indian Atlas* does not survive. The maps sent to Walker were not indexed. Not surprisingly, the Survey of India stopped publishing the *Indian Atlas* in 1905 and began again to map India more accurately.

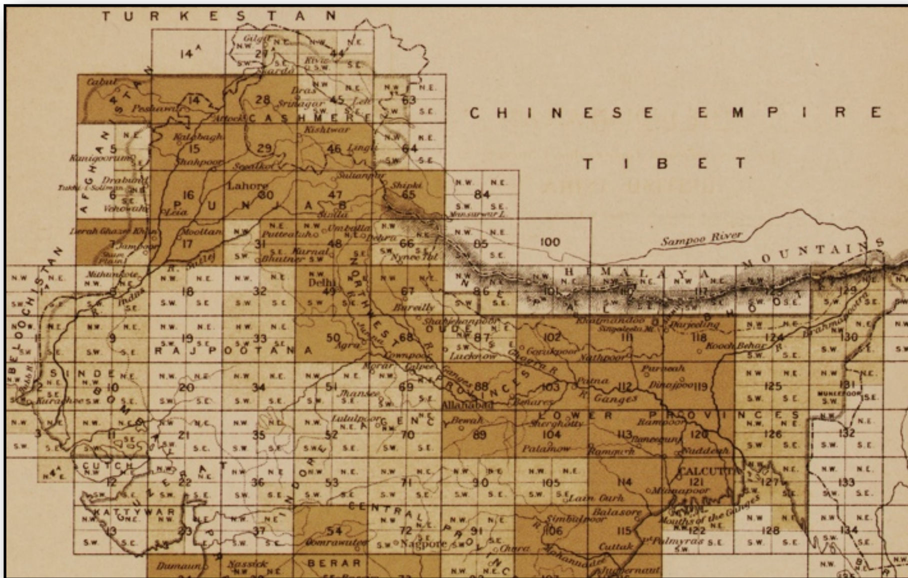

Figure 19. Indian Atlas sheets completed for north India by 1881. (All south India had been completed. Brown color means sheet issued as one sheet. Khaki color means sheet issued as quarter sheets. Other color means not yet mapped. Index map created for 1881 International Geographic

Figure 20. Arrowsmith's Madras sheet corrected to modern coordinates so that it overlays Google Earth's coordinates correctly. Given the 1822 sheet is 4 miles to the inch, there is quite a clear correspondence to modern features -- i.e., tanks, rivers, coast line, Fort St. George.

Digital Cartography. One hundred years later Google Earth was released. (Computer-based cartography had begun about 1970.) The full geospatial revolution began during the 1990s having begun in the 1960s. (Google Earth is therefore a metaphor for the digitalization of cartography.) Figure 22.

Undeniably, Google Earth represented a flooding tsunami-like change for cartography. Google combined somewhat mechanistic map design with comprehensive coverage of satellite

Figure 21. The first Indian Atlas sheet published in 1828 shows Bangalore (Bengaluru), whose territory is defined by the line of trees and vegetation around the city. This map was probably surveyed about 1795 by Mackenzie.

images and digital maps, and an interactive gazetteer. In the six years since introduction, Google has also introduced other software so that individual users can customize Google Earth to their needs and preferences. Google Earth, with more than 500 million users, continues to grow in popularity. Google Earth's widespread acceptance shows a huge demand to see the world in map-like ways -- a latent demand until Google Earth's release. The cartographic communication model now focuses on digital spatial databases that can be manipulated by users, many of whom have little cartographic training. The map user is often the map maker.

Figure 22. Opening view of Google Earth. Intuitive controls allow easy view of any part of the earth.

The digital age offers no hope of putting the "genie" (the *djinn*) "back in the bottle". We must live in the digital age. But the digital geospatial age makes it possible to revisit Raja Todar Mal's vision of managing India's land resources. In realizing his vision, geospatial technology and digital cartography could become an exploding career field in India for decades to come.

3. DIGITAL HISTORICAL CARTOGRAPHY. Puristic historical cartographers continue to study the history of cartography and maps, and to "deconstruct" maps of earlier times. That is, they study maps as instruments of power and domination, and of ethnocentric, class, gender or bureaucratic bias.[15] A small band of outstanding scholars continues this tradition. It promises, however, to remain a rather small group with somewhat esoteric, non-digital focus.

But historical cartographers face a major new dilemma. Much map information today is being "born digital". That is, many maps are no longer produced to be issued as paper maps. They are issued in digital form. No integrated clearinghouse, indexing, or metadata system exists. This is a big problem with no solution in sight, and is the librarian/information scientists challenge. Many innovative maps may disappear even more quickly than their printed brethren, as people who query for maps encounter "Error 404" pages.

Historical cartographers also have, for the most part, not tried to study geographical change. (Admittedly, the study of geographic change was a task of "Himalayan" difficulty in the age of the paper map.) This part of historical cartography has been ceded to others who study "global change" or "human dimensions of global change". Because most global change scholars are not familiar with historic maps, this opportunity holds great promise.[16] If little change can be assayed, it is because the past is embedded in the present. For instance, "path dependence" shows in not only in road patterns but in other features as well. Figure 23. To know this, historic maps must be geospatially enabled; they must become digitally "re-born". (This is to say that people, institutions, and funding must be allocated to convert paper maps into digital form.) This is particularly important because so much geographic change has occurred over the last 200

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[15] J.B. Harley and D. Woodward, eds. (1992ff). *The History of Cartography*. 6 vols. Chicago: University of Chicago Press. See also M.H. Edney (1997). *Mapping an Empire: The Geographical Construction of British India, 1765-1843.* Chicago: University of Chicago Press; and J.W. Crampton (2010). *Mapping: A Critical Introduction to Cartography and GIS.* Chichester: Wiley-Blackwell.

[16] In the past, regional geographers did much of this work. See O.H.K. Spate and A.T.A. Learmonth (1967). *India and Pakistan: A General and Regional Geography*. London: Methuen & Co., Ltd. See also A. Geddes (1982). *Man and Land in South Asia*. A.T.A. Learmonth, A.M. Learmonth, C.D. Deshpande, and L.S. Bhat (eds.) New Delhi: Concept Publishing Company. Study of geographical change is much more feasible when geo-referenced digital maps can be overlaid.

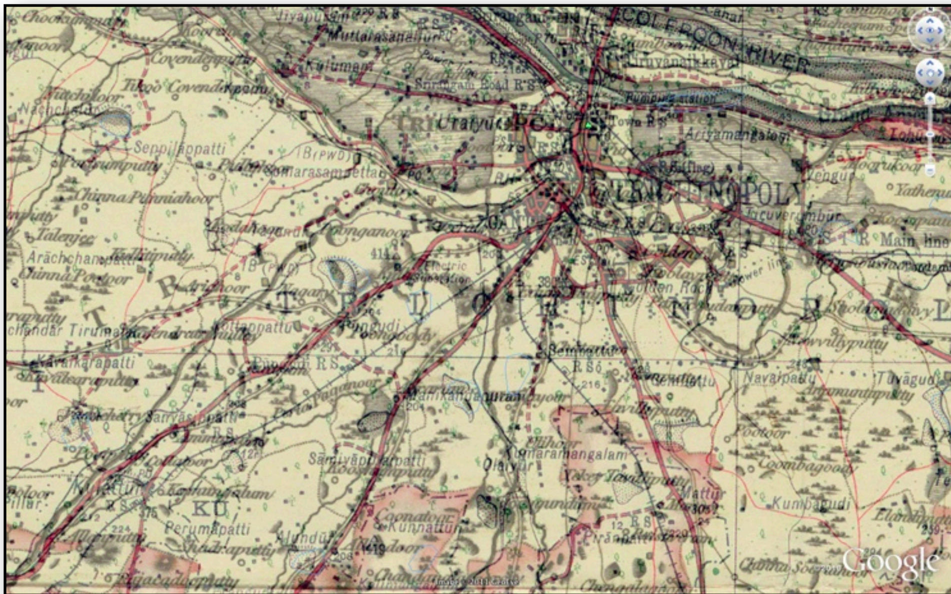

Figure 23. 1947 Survey of India map overlaid over Arrowsmith's 1822 map of Tiruchirappalli, Tamilnadu region. Main roads extending south from the city follow surprisingly similar corridors. Such change, or lack thereof, is part of the R&D effort of The W.E. Upjohn Center for the Study of Geographical Change.

years during the "Anthropocene" Age -- the era that coincides almost perfectly the age of accurate map-making. We must try to generate a 200-year perspective, not just a 20-year perspective (based on satellite images) to understand our changing world. India has a rich collection of *chronos* maps that can be used for this purpose.

At The W.E. Upjohn Center we have developed a new hyper-accurate digital topographic map that is also of publication-quality.[17] We have completed full coverage of the United States. These maps are designed to be used overlaid on other images, aerial photos, or maps so that it is easy to detect change visually.[18] This is our "Authoritative U.S. Topos©" initiative. We want to include in this collection all topographic maps of the U.S. ever issued, going back to the time of George Washington and Thomas Jefferson -- that is, back to the time of the first accurate trigonometric surveys. What we have started for the U.S. we can also do for India.[19] There is equal need for an "Authoritative India Topos©" initiative to preserve in digital, geospatial form

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[17] The W.E. Upjohn Center has invoked the most geometrically accurate imaging of large format documents (i.e., maps) worldwide. For instance, a 1:63,360 scale map imaged with its equipment will capture every detail on the map through true optical imaging, and each feature will have a maximimum digital positional error of 6 inches on the ground for maps of 1 in. = 1 mile scale. Thus, imaging of maps introduces no significant error in the imaging process. There is no other system worldwide that does this. Moreover, The W.E. Upjohn Center has invoked post-imaging processes that, entirely lossless, improve upon the archival quality image and yet compress the image more than 95%. Geo-referencing RMS error is generally ≤2 pixels.

[18] The W.E. Upjohn Center may be accessed through its website at the following URL: http://www.wmich.edu/ucgc/.

[19] The W.E. Upjohn Center is happy to work jointly with any agency (within the United States or abroad) to preserve immaculately its cartographic cultural heritage and to mobilize this heritage for use as part of any national spatial data infrastructure. Although sheet-fed imaging technologies have improved greatly in the last two decades, they do not meet 21st century geospatial accuracy requirements. Moreover, no other agency has developed the post-imaging procedures that make The W.E. Upjohn Center's products so accurate and so easy to use. In short, all non-W.E. Upjohn Center map imaging methods are "good enough" methods that will, in time, require re-imaging and/or re-processing of maps to 21st century accuracy standards. This was the intent of our benefactors, Mary U. and Edwin E. Meader, and this is the vision we have made real.

Figure 24. Sheet 28 of the Indian Atlas (1857). Srinagar is at bottom right and Wular Lake at top left. Haramukh Glacier is at top right. Scale: 4 miles to the inch.

all topographic maps of India, including *Indian Atlas* and earlier manuscript maps.[20] Figures 24 & 25.

Finally, historic maps are being created now by people who are not primarily map users. Data for *chronos* time maps can be collected through "crowd-sourcing", also known as volunteered geographic information (VGI). To do this is fairly easy and low-cost. Informants use their GPS-enabled mobile phones to add data to a spatial database. One illustration: mapping India's third coastline – that is, the limit of the sea surge (the 2004 tsunami) above high tide level. Coastal residents certainly remember how far the ocean poured over their lands. The collective effect of hundreds of thousands of telephone calls made at the landward edge of the tsunami can define the greatest extent of sea encroachment on India's coast in the last two centuries. India's National Disaster Management Authority may develop other disaster management plans using crowd-sourced information on floods, earthquakes, and epidemics.[21]

CONCLUSION. Cartography continues to evolve in both expected and unexpected ways. Although some dimensions of traditional historical cartography continue into the twenty-first century, much of historical cartography will be increasingly affected by digitalization. More

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[20] National Archives of India (1986). *Catalogue of the Printed & Published Maps: Parts I & II.* New Delhi: Government of India, 1986. _____(1975). *Catalogue of the Historical Maps of the Survey of India: 1700-1900*. New Delhi: National Archives of India, 1975. _____ (1975). *Catalogue of the MRIO Miscellaneous Maps of the Survey of India*. New Delhi: Government of India, 1982. _____ (1984). *Catalogue of the Forest Maps of the Survey of India*. New Delhi: Government of India, 1984. Secretary of State for India in Council (1878). *A Catalogue of the Manuscript and Printed Reports, Field Books, Memoirs, Maps, Etc. of the Indian Surveys Deposited in The Map Room of the India Office*. London: Wm. H. Allen, 1878. _____ (1870). *A Catalogue of Maps of the British Possessions in India and Other Parts of Asia*. London: Wm. H. Allen, 1870.

[21] A. Kapur (2010). *Vulnerable India: A Geographical Study of Disasters.* Shimla: Indian Institute of Advanced Study, provides an excellent small-scale overview of the recent incidence of natural hazards in India. VGI would add accurate local information that, when aggregated across the nation, would provide large-scale accuracy for viewing and analysis.

Figure 25. Vale of Kashmir (1911). New lakes exist around Srinagar, with extensive wetlands. Haramukh Glacier has expanded. By 2011 Wular Lake (top left) had almost disappeared. Scale: 1 inch to the mile.

than preserving historic maps, historical cartography will "curate" (i.e., organize) these documents digitally. Many of the uses for historic maps continue. The ways we analyze historic maps will be almost entirely mediated by geospatial technology. This will happen in India as INCA, NAGI, and related professional societies and Government of India agencies like the Survey of India, the Indian Hydrographic Office, and the National Archives of India adopt the vision of hyper-accurately digitalizing map resources. INCA and NAGI can provide the leadership to make a future for India consistent with Raja Todar Mal's vision centuries ago. In so doing, each can jointly claim modern day "Navaratna" status, and cartography/geospatial technology/geography together can become one of the thematic "Nine Jewels" of this great nation

Namaskaar! Thank you for your kind attention.[22]

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[22] David G. Dickason is Professor of Geography & Director of The W.E. Upjohn Center for the Study of Geographical Change at Western Michigan University (WMU). He received the following degrees: B.A. (College of Wooster), M.A. (Pittsburgh), and Ph.D. (Indiana). He also did post-graduate language studies at the University of Chicago and University of California-Berkeley. He chaired the University's Asian Studies Program (1974-80), directed its Malaysian community college (1995-97), and chaired WMU's Department of Geography (2000-06). He has taught in five university units (Geography, Asian Studies, Environmental Studies, General Studies, and WMU-Sunway College, Malaysia). He edited *The East Lakes Geographer*. He developed interactive computer mapping software (1981-85) and introduced GIS to Western Michigan University and west Michigan in 1988. He co-founded WMU's Computer Mapping Laboratory in 1980 and its Regional GEM Center in 1989. He founded the GIS Research Center in 1992 and The W.E. Upjohn Center in 2005. He has produced more than 100 publications and technical reports. He has received more than $7.5 million in grants, contracts and awards from the following agencies: National Science Foundation, American Council of Learned Societies, American Academy for the Advancement of Science, U.S. Fulbright Program, American Institute of Indian Studies, U.S. Environmental Protection Agency, U.S. Army Corps of Engineers, Ford Foundation, W.K. Kellogg Foundation, Kalamazoo Community Foundation, Michigan Department of Environmental Quality, Western Michigan University, Lucia Harrison Fund, municipal and local governments, and private donors.

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