Chinese Temple Networks in Southeast Asia: A WebGIS Digital Humanities Platform for the Collaborative Study of the Chinese Diaspora in Southeast Asia

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Abstract: This article introduces a digital platform for collaborative research on the Chinese diaspora in Southeast Asia, focusing on networks of Chinese temples and associations extending from Southeast China to the various port cities of Southeast Asia. The Singapore Historical Geographic Information System (SHGIS) and the Singapore Biographical Database (SBDB) are expandable WebGIS platforms gathering and linking data on cultural and religious networks across Southeast Asia. This inter-connected platform can be expanded to cover not only Singapore but all of Southeast Asia. We have added layers of data that go beyond Chinese Taoist, Buddhist, and popular god temples to also display the distributions of a wide range of other religious networks, including Christian churches, Islamic mosques, Hindu temples, and Theravadin, which are the Taiwanese, Japanese and Tibetan Buddhist monasteries found across the region. This digital platform covers a larger area than the Taiwan History and Culture in Time and Space (THCTS) historical GIS platform but is more regionally focused than the ECAI (Electronic Cultural Atlas Initiative) By incorporating Chinese inscriptions, extensive surveys of Chinese temples and associations, as well as archival and historical sources, this platform provides new materials and new perspectives on the Chinese diaspora in Southeast Asia. This paper: (1) outlines key research questions underlying these digital humanities platforms; (2) describes the overall architecture and the kinds of data included in the SHGIS and the SBDB; (3) reviews past research on historical GIS; and provides (4) a discussion of how incorporating Chinese epigraphy of Southeast Asia into these websites can help scholars trace networks across the entire region, potentially enabling comparative work on a wide range of religious networks in the region. Part 5 of the paper outlines technical aspects of the WebGIS platform.

Keywords: Chinese temples; clan and regional associations; network relations; WebGIS; collaborative digital humanities platform

1. Introduction

In 1995, in an early instance of the application of historical GIS mapping to the study of the regional cultures of China, Kenneth Dean and Zheng Zhenman (Xiamen University) explored the historical social and cultural transformations of the irrigated alluvial Putian plains of Fujian province (Dean and Zheng 2010, 2019a). The construction of a localized historical GIS for this 464 km² area with 720 villages enabled the testing of various hypotheses on the reasons for the evolution of a regional ritual alliance system with a nested hierarchy of temples from the mid-Ming onwards. The higher order temples of this ritual alliance system were also the centers for the management of the irrigation systems of the region, which had grown too complex to be efficiently managed by large lineages controlling segments of the irrigation system. The complexity of the interdependent irrigation system led to the development of ritual alliances and the formation of new rituals to mark and celebrate these alliances.

Dean and Zheng's research in Putian also revealed the important role of Chinese "overseas" in Southeast Asia who had returned to their ancestral homes after the Cultural Revolution to rebuild ancestral halls, village temples, Christian churches, and larger Buddhist monastic complexes (Dean and Zheng 2010, pp. 255–82); Dean 2010, pp. 254–75). Tracing these sponsors back to Southeast Asia revealed a complex network of diverse and overlapping lines of religious migration from the turn of the 20th century that built on earlier temple and trade networks established over hundreds of years. Spirit-medium culture is very strong in the northeast sector of the Putian irrigated plains (Jiangkou), and migrants from this region have continued its traditions of collective training of spirit mediums in temples scattered across Singapore, in the Riau islands, Sumatra, Jakarta and Surabaya in Indonesia, and in Seremban, Klang, Malacca, Muar, Johor, Sibu and Kuching in western and eastern Malaysia (Dean and Zheng 1993; Dean 2018). The Singapore Historical Geographic Information System (SHGIS) was partly designed to map the movements of different dialect groups who were often organized into communities of worship (some led by spirit mediums, others by Buddhist monks, sectarian religious leaders, Christian pastors, or clan and business leaders) into and out of Singapore and across Southeast Asia in long historical patterns of circulatory flows and re-appropriations of cultural repertoires. Dean (Dean 2011) explored the impact of ritual change and transformed gender roles for female religious members of Chinese temples in Southeast Asia back on the "home" culture in Putian, China.

In the case of Putian, Fujian in China, Dean and Zheng (1993, 1995, 2010, 2019a) used historical GIS to explore the evolution of a regional ritual system tied to the management of a complex irrigation system based within a local hierarchy of temples. The key question was how did changing rituals transform local society? In the case of Singapore, the project team has used historical GIS to explore the impact of systematic urban planning on the survival of communal temples and cultural diversity. The key question is how have rituals enabled temple communities to survive and adapt? In this new age of global pandemics, this question becomes even more pressing. Many religious institutions are developing on-line rituals, leading to a de-sensorialization of ritual experience and a potential growing privatization of religious experience. To understand these future tendencies, there is need for a stronger historical understanding of the religious and ritual sphere in Singapore.

The possibility of applying historical GIS analysis to the transformations of the built environment of Singapore was also inspired by the research of Lily Kong and Brenda Yeoh. Key research questions include how, where and why so many different religious and cultural sites and organizations survive, flourish and transform within a highly secular, modern global city. Kong and Yeoh have examined the historical transformations of the religious spaces and built environment of Singapore, writing studies of temples, processions, cemeteries, and kampong village life. Kong's (Kong 1990, 2001, 2010) overview essays introduced new trends in the study of religion within geography. Kong (Kong 1993a, 1993b, 1999, 2002, 2005; Kong and Yeoh 1997) applied these theoretical advances to the study of negotiated sacred spaces, religious buildings, deathscapes, house churches, and religious and national day processions in Singapore. Yeoh's (Yeoh 1996) study of contested urban space under colonial rule discussed cemeteries and laid out the underlying dynamics of pre-independence urban transformations. More recently, Yeoh introduced the new mobility paradigm

within geography to Singapore Studies. Her work approaches mobilities as local as well as transnational, focusing in on the micro-politics of local-transnational encounters. Globalized flows, including the movements of religious practitioners, beliefs, ritual artifacts, funding, and media, are studied, not just as contemporary but also as inescapably historical. Oswin and Yeoh state, "Finally it understands places as comprised of networks of flows and thus as events rather than containers" (Oswin and Yeoh 2010, p. 170).

Arjun Appadurai's (Appadurai 1990) work on cultural, economic, and mediated flows provides additional theoretical basis for this project, as does the historical work of Charles Tilly on trade and trust networks operating across and in relation to different political and economic systems (Tilly 1990). Jose Casanova's (Casanova 2019) discussion of the long history of religious pluralism in Asia within the context of imperialism and globalization also informs this project. Anthony Reid (Reid 1988; Reid 1993), Philip Kuhn (Kuhn 2008) and Kwee Hui Kian (Kwee 2007) have outlined the historical context for the spread of Chinese networks in Southeast Asia. In this project, we are seeking the unique features of the Chinese temple and trust networks, based on both extensive historical documentation (Blussé and Chen 2003) and broad ranging ethnographic fieldwork (Tan 2015).

Based on these theoretical frameworks and empirical studies, researchers working on the SHGIS project conceive of temples and associations, villages and cemeteries as (shifting and sometimes disappearing) nodes/events within networks of flows of people, gods, ghosts, and ancestors, ritual practices, beliefs, offerings and investments. We are interested in the dense layering and entanglement of mutually interlinked networks in Singapore and throughout the Southeast Asian Chinese diaspora. Some individuals are active members of multiple associations, organized and focused on distinct levels and at different scales, from that of a village or a neighborhood, to urban, regional, national, transnational and global associations. For example, we interviewed one community leader who was an active member of 40 different associations, each operating at a different scale. He embodied a kind of associative capital, which he activated through his ability to call on and redirect flows of resources within and across different levels and kinds of networks. This interest in mobilities and flows, modes of trust and exchange, and the recursive, complex feedback effects of dense and interconnected networks, underlies the development of the digital humanities collaborative research platform introduced here. Our research seeks to understand the effects of this dense layering, and the ways in which new dimensions and flows can rapidly emerge within these networks.

A key element in the life of Chinese overseas was the preservation of some kind of Chinese identity, embodied in ritual forms (marriages, funerals, ancestral worship, hungry ghost festivals, feast days for the regional gods of the different dialect groups) and in the built environmental nodes/sites of activity indicated on the SHGIS maps. A wide range of strategies to preserve or re-invent "Chinese" identities developed over time in different places. Wang Gungwu (Wang 2003) explored the changing meanings of the terms for Chinese overseas (see the overview in Huang (Huang 2010)). G.W. Skinner (Skinner 1996) described the continuously self-differentiating Peranakan cultures of the region. Philip Kuhn (Kuhn 2008) focused on chain migration, economic niches, and circulations within migration patterns. Kwee Huikian (Kwee 2007) explored the role of guerrilla capitalism and Chinese temples within diasporic networks. Different kinds of temples or cemeteries or ancestral halls could be used to unify or to internally differentiate diasporic dialect groups. Many such sites were nodes linking a far-flung network back to a mother temple in China through the division of incense (fenxiang), or to a distant ancestral hall or gravesite, or to a Buddhist monastery. Return visits were paid to these sites (jinxiang) in order to renew the energy of the branch institution. However, locally invented god and goddess cults and unique ritual traditions have originated in Southeast Asia and spread across the region. We are also interested in ritual, institutional, and managerial changes introduced in Southeast Asia that were gradually absorbed back into the ever-expanding cultural repertoire of the multiple home regions of Southeast China. We seek to explore the role of traditional as well as innovative ritual traditions in these continuously evolving networks. Several essays have been published based on the SHGIS data that address these certain research questions (Dean 2011, 2015, 2016, 2018, 2019a, 2019b; Hue 2011; Hue et al. 2019).

2. Historical GIS

Digital humanities has moved from textually focused computing to embracing the full range of multimedia (Schreibman et al. 2004), and has digitally fostered the spatial humanities (i.e., the spatial turn of digital humanity) (Presner and Shepard 2016). Historical geographic information systems (GIS) echoed the spatial turn, in which computer-aided geographic data handling methodologies are applied to the spatial-oriented humanities studies pertinent to historical research (Gregory and Healey 2007; Hagge 2016; Presner and Shepard 2016). Historical GIS makes it possible to integrate a variety of formerly "incompatible" information (location-based); it structures, manages, and visualizes data in a coherent system, tracking and analyzing transformations through space and time (Gregory and Geddes 2014; Kallaher and Gamble 2017). Both space and time are important because our understanding of the world is socially constructed. Rapid changes to the built environment often distort our understanding of the life worlds of earlier times (Kallaher and Gamble 2017).

GIS, thus, allows spatial humanities researchers to make extensive use of the geographic nature of their sources, integrating them in the form of points, lines, polygons, or grid cells, with the attribute data held in conventional database form, and allowing for spatiotemporal analyses (Gregory and Healey 2007; Gregory and Geddes 2014). For instance, Cunningham (Cunningham 2014) provided insights into religion, society, and conflict in Ireland since the Great Famine, based on quantitative GIS analytic methods (e.g., spatial autocorrelation). Chloupek (Chloupek 2018) presented a GIS approach to the study of historical toponyms in Nebraska, combining critical, qualitative, cultural, and historical analysis with quantitative GIS algorithms. Stanev (Stanev 2013) developed a GIS approach to study the evolution of the railway and urban networks in the Balkans from 1870 to 2001.

Although most of the existing studies in this field are based on desktop GIS approaches, recently, interest in the digital management of geospatial humanity data on the web has increased (Brovelli et al. 2012). Many humanities researchers have embraced WebGIS approaches, either based on (1) open-source WebGIS platforms such as the Web Geoservices for Italian Cadastral Maps (Brovelli et al. 2012), or (2) commercial WebGIS platforms such as the indigenous Knowledge WebGIS for Arctic Alaska Communities (Eisner et al. 2012). WebGIS represents an advance over traditional desktop GIS due to its ease of accessibility; it enables an interactive user web interface for people to learn geospatial information (Eisner et al. 2012).

The aim of this article is to introduce our case project, the Singapore Historical GIS (SHGIS, https://shgis.nus.edu.sg) and its linked project, the Singapore Biographical Database (SBDB, https://shgis.nus.edu.sg/sbdb) in order to introduce Southeast Asian data into the field of digital humanities. The SHGIS project incorporates Chinese and English archival sources and large amounts of data on Singaporean Chinese culture gathered over the past five years into a searchable WebGIS. The SHGIS is envisioned as a long-term continuously developing research tool and an accumulating, searchable digital archive. By developing WebGIS platforms, we seek to bring the data to the public as well as to scholarly audiences. We also seek to provide means for the public to send in data to be incorporated in our SHGIS (crowd-sourcing). We intend to develop a platform for shared research into the cultural history of Singapore. Ultimately, we would like this platform to extend to cover networks inter-connecting Southeast Asian nations, and the Southeast Asia region with China and India.

3. SHGIS

3.1. Data Preparation

It has been long been recognized that the most time-consuming and costly phase of a GIS project is the building up of the dedicated database (Ducruet and Beauguitte 2014; Gregory and Healey 2007). This is true with regard to both the data collection and the technical process of database development. In this SHGIS project, Chinese and English archival sources and large amounts of data on Singaporean Chinese culture gathered in our fieldwork over the past ten years were incorporated into our PostgreSQL database.

From 2010–2015, Dean and Hue (2017) gathered early Chinese inscriptions found in temples and huiguan (associations) in Singapore with the support of a Canadian Social Science and Humanities Research Council (SSHRC) Insight Grant. After Dean moved to the National University of Singapore in 2015, , he formed the research team made up of the co-authors of this paper, and applied for a Singapore Ministry of Education (MOE) Tier 2 research grant. The research team hired undergraduate and graduate student research assistants to collect and process data. We began the process of building up a historical GIS of Singapore by developing an ArcGIS website with contemporary base maps, and adding in dozens of historical maps from 1822 to 2019 that had been geo-referenced by the NUS Geography Department under the direction of Associate Professor Feng Chen-Chieh. Later, we added other maps, including Street Directory Maps from the 1950s onwards, as well as aerial photography of Singapore from 1950–1954, geo-referenced by the Singapore Land Authority. These map layers are super-imposable, enabling users to explore the complete transformation of the built environment of Singapore over time.

From 2016–2018, the research team gathered multiple kinds of cultural-historical data, including the current and former locations of over 800 Chinese temples, 250 Chinese associations (including regional native-place associations, clan associations, and trade associations), former locations of over 550 Chinese schools, 200 kampong villages, and 180 cemeteries, as well as over 600 Christian churches, 100 mosques, and 25 Indian temples across Singapore island.

The research team developed surveys and interview questionnaires, and visited hundreds of temples and huiguan to collect data. Associate Professor Arthur Tay (Electrical and Computer Engineering, NUS) and his research team developed a mobile phone application based on the iPhone operating system (iOS), designed to collect organized attribute information and photographs about Singaporean Chinese institutions (e.g., the Chinese temples and huiguan).

This information had to be geo-referenced in order to be included in a GIS database. This project utilized the OneMap geocoding service named "Search" (https://docs.onemap.sg/#introduction) which is a localized geocoding service suited for addresses in Singapore. It enables researchers to search for address data, and returns both latitude, longitude and x, y coordinates of the searched location.[1]

In 2018, 2019 and 2020, teams of NUS students enrolled in the GE1005 Everyday Life of Chinese Singaporeans class carried out research visits to over 250 temples and associations. They used the iPhone app to directly upload their photographs and basic questionnaire data to our Web Server. They also prepared reports on each site. Thus, the SHGIS gradually expanded its coverage, and for each of these points linked classified photo albums (jpg) and detailed written reports (pdf) are available. Users can search for a specific temple by name or search the name of a deity (showing all those temples where the deity is the main god). For some temples, we have added 3D visualizations with cultural information embedded within the image (Mah et al. 2019).

Beginning in 2017, our research team created additional map layers by digitizing polygons from a series of historical maps showing the historical expansion of the boundaries of Housing Development Board (HDB) residential apartment complexes that house over 80% of Singaporeans, from the first flats built by the Singapore Improvement Trust (SIT) in the late 1950s, to the most recent HDBs still under construction in 2020. The spread of the HDB led to the elimination of the over 200 kampong villages that had once covered Singapore, and this in turn led to the forced movement of their village temples. One unique aspect of Singapore's rapid urban development plan (since independence in 1965) is that the vast majority of the religious buildings and Chinese associations of Singapore have only 30 year leases from the government. Most temples have thus had to move, sometimes multiple times, to make way for urban development. Many village temples were swept up in this process. Currently, over 320 temples share space with one another in 68 "United Temples" (Hue 2011). Each freestanding independent temple is reduced to an altar table set against a wall in a larger, shared space.

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[1]　There are a variety of geocoding services such as Google's geocoding API (https://developers.google.com/maps/documentation/geocoding/start) and Esri's geocoding with ArcGIS (https://developers.arcgis.com/features/geocoding/). OneMap is based on Singapore's postal code in which each building has a unique postal code.

Over the past five years, we have added data to the SHGIS covering many different kinds of themes. One map function shows the multiple relocations of several hundred Chinese temples over the past 50 years. The annual cycle of the performance of rituals at different temples across the island over the course of each year is mapped on another layer, using a moving timeline (as shown below). A recently (2020) added set of data downloaded from the Commission for Charities (COC) provides an overview of the annual income and expenditures of several hundred churches, temples and mosques across Singapore (over 2 billion SGD in 2019). A map layer displaying this data provides a birds-eye view of the economic geography of religious activity. Another map layer (developed in 2018) uses heat maps to show the movement in the 1980s and 1990s of many regional, clan and trade associations from the "Chinatown" area into the Geylang area of Singapore, which is somewhat notorious as a red-light district. Behind these moves are features of the local land rental system, as one could get 90-year leases in Geylang. Other map layers (2018) show the distribution of spirit medium altars in HDB apartments and in private homes. We estimate that several hundred mediums go into trances on a daily basis across Singapore. The spirit medium altars on this map layer represent only those private altars that have publicized their locations.[2] Hundreds more do not want to appear on maps, as their activities are part of a gray zone of tolerated but not fully legalized religious activity. This is true for many other semi-recognized religious groups, including, for instance, hundreds of household altars of syncretic sectarian religious groups such as the Yiguandao, based in Taiwan. The same ambiguity extends to religious altars or temples located within factories, car-parks, and mixed-usage buildings across Singapore. The SHGIS can (and should) only capture part of the rich detail of Singaporean religious life.

3.2. System Architecture

The system architecture of the SHGIS WebGIS is outlined in Figures 1 and 2. In brief, the backend (the server side) is composed of an ArcGIS Server and an IIS Web Server running on the Windows Server 2012 R2 operating system.[3] Compared to other opensource operating systems such as Linux, Windows operating system tends to be more user-friendly to humanists in general (Abhilash and Vasthav 2015). The ArcGIS Server hosts the Geoweb services published through ArcMap, based on geographic data stored in a PostgreSQL database. The combination of PostgreSQL and its PostGIS extension establishes a Data Base Management System (DBMS) that allows interactions between the database and GIS software (Andris 2016). The IIS Web Server hosts the web applications and website framework developed based on WordPress, PHP and a MySQL database. The ArcGIS Server and the IIS Web Server are integrated by an ArcGIS Web Adaptor. The frontend (the client side), including the Geoweb applications and the SHGIS webpages, are developed using HTML, JavaScript, and CSS.

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[2]   Data drawn from lists of spirit medium altars published by the Taoist Association of Singapore. We are not aware of any increased vulnerability of the owners of these altars from publicly listing their addresses, or from our including these points on the SHGIS.

[3]   The integration of GIS and the web makes data sharing much easier and allows for the incorporation of multimedia data (e.g., images, documents, and video). The selection between opensource GIS and commercial GIS affects the specific process of WebGIS development and its outcomes. We greatly appreciate the value of free and opensource options. However, as a small team of humanists working on the exploratory phase of the SHGIS, our project lacked a team of developers who are not only highly technically savvy and independent but also familiar with the context of Singaporean Chinese culture. Since documentation and support for opensource solutions are often lacking compared with commercial solutions, a complete development based on the former can be more expensive than the latter. Therefore, this project chose to leverage on commercial GIS solutions instead of opensource solutions. Nevertheless, we look forward to the continued improvement of opensource software such as QGIS, as this could help with issues of long-term preservation. We would like to note that the historical maps, as well as the feature layers (i.e., the point, polygon, and polyline layers) in our platform are enabled with OGC (Open Geospatial Consortium) capabilities. Experienced users can download this data. We are continuously expanding and correcting the data, and plan to announce a SHGIS 2.0 in January 2021.
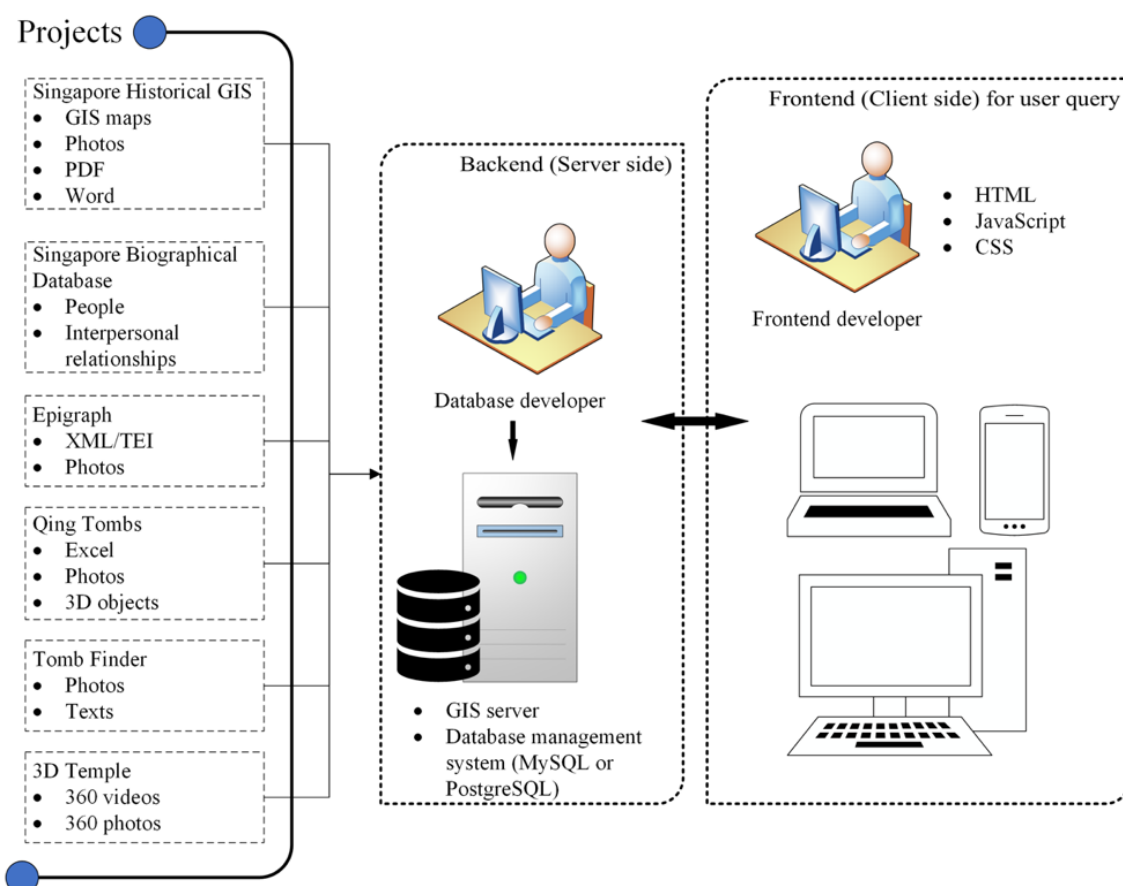
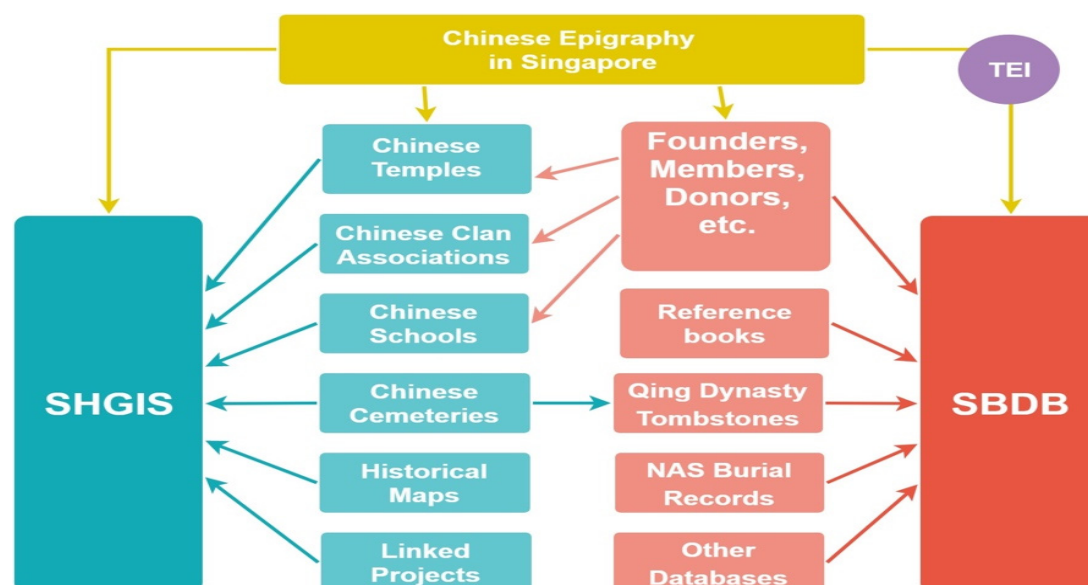**Figure 1.** System architecture of the SHGIS WebGIS.

Figure 2. Interlinking sources and databases for the SGHIS and SBDB.

3.3. WebGIS Visualizations

The SHGIS WebGIS applications were developed based on ArcGIS API for JavaScript (https://developers.arcgis.com/javascript/). The point data displaying the locations of the Singaporean (and Southeast Asian) cultural sites is published through ArcMap as web feature

services and is included in the WebGIS application as feature layers.[4] The web feature services allow users to query the attributes associated with the point data on the maps. In addition, detailed documentation about the Chinese temples and associations in Singapore is linked to the point data in PDF format for users to acquire more sociocultural knowledge. Photographs of the temples were collected through a set of iPhone Apps (Chinese Temple App, Huiguan App), using Apple's Testflight, as mentioned above. The photographs were compiled and are displayed on the website using photo albums developed based on UberGallery (a PHP-based photo gallery) (https://www.ubergallery.net/). The albums are also linked to the point data of the temples shown on the WebGIS platform.

As mentioned above, 31 web map services of Singapore historical maps (ranging from 1828 to 2010) were obtained from the NUS Department of Geography to provide historical contexts for the feature layers. They are included in the WebGIS application as TileLayers which allows us to work with cached map services exposed by the ArcGIS Server REST API and add them to a map as tile layers. A cached service accesses tiles from a cache instead of dynamically rendering images, which enables tiled layers to render faster than MapImageLayers and thus avoid overloading issues. These historical maps can be used as base maps, showing the historical spatial contexts surrounding the selected Singaporean cultural sites.

SHGIS includes two types of WebGIS applications: (1) static maps and (2) time-aware maps. The former visualizes the data layer by layer. Each layer (i.e., one of the feature or map services mentioned above) represents a collection of points of interest (e.g., the temples) or a map (e.g., a historical map). Users can search the locations of specific points (e.g., the location of a temple) from the maps, which are developed based on the Search widget of ArcGIS API for JavaScript (https://developers.arcgis.com/javascript/latest/api-reference/esri-widgets-Search.html).

The latter time-aware maps visualize the location changes of the points of interest over time. These maps were developed based on the TimeSlider widget of ArcGIS API for JavaScript (https://developers.arcgis.com/javascript/3/jsapi/timeslider-amd.html).

3.4. Static Maps

Figure 3 illustrates a WebGIS application showing a static map. More maps (e.g., the distribution of Chinese schools in Singapore) can be found in the SHGIS website (https://shgis.nus.edu.sg). Three feature layers about Chinese Temples and clan associations in Singapore are turned on as an example. A popup box is enabled to show the detailed attributes of one of the temples. The base map is a web map service of the Singapore 2010 map enabled with Open Geospatial Consortium (OGC) capabilities. The popup box provides a hyperlink directing to a PDF report that introduces detailed information about the temple and a hyperlink directing to an album that shows the temple photographs, as shown in Figure 4.

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[4] We believe the parallel publication of open standards-based services (OGC) in addition to ESRI's proprietary services increases the potential impact and reusability of the published data.
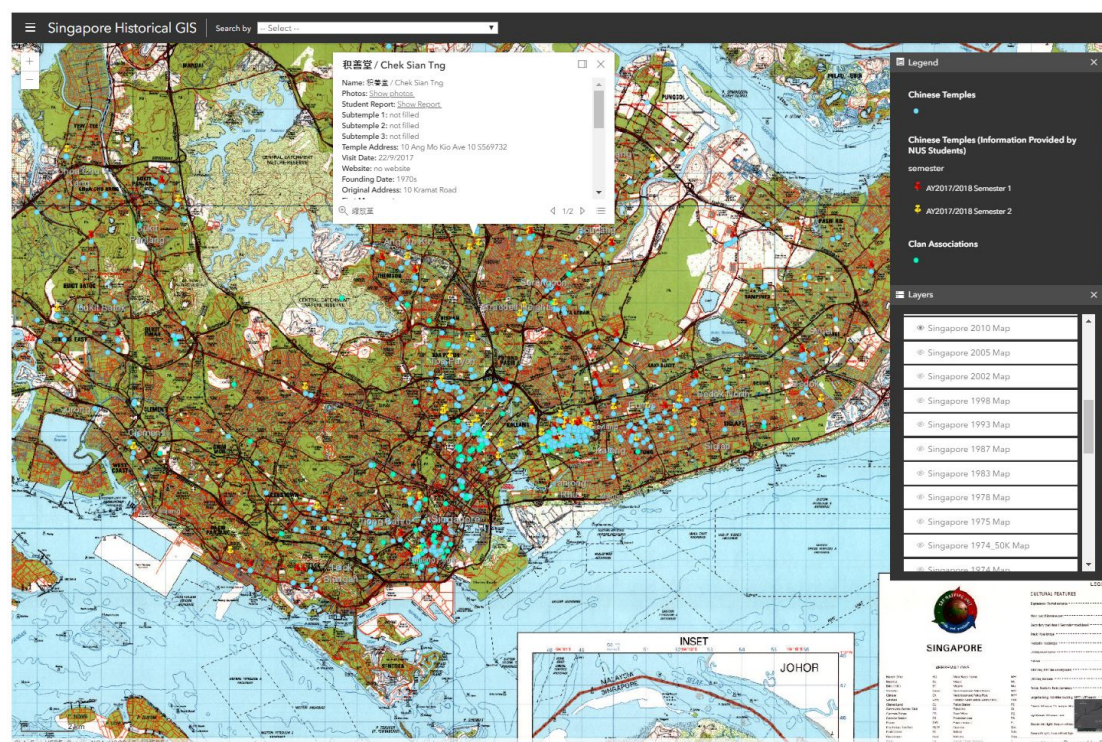
Figure 3. Screenshot illustrating the WebGIS application that displays three web feature layers about the Chinese Temples and clan associations in Singapore.

Figure 4. (**a**) Detailed report in PDF format and (**b**) photographs about the Chek Sian Tng Temple.

3.5. Time-Aware Maps

Figure 5 illustrates a WebGIS application showing a time-aware map of the spatiotemporal distribution of the annual religious festivals in Singapore. A popup box is enabled to show the detailed attributes of one of the festivals. More time-aware maps about the relocations of Chinese temples and clan associations throughout history can be found in the SHGIS website (https://shgis.nus.edu.sg). The green points are the festivals that take place between 4 April and 15 May, indicated by the pointers on the time slider, and the gray points are the festivals that fall outside this period of time.
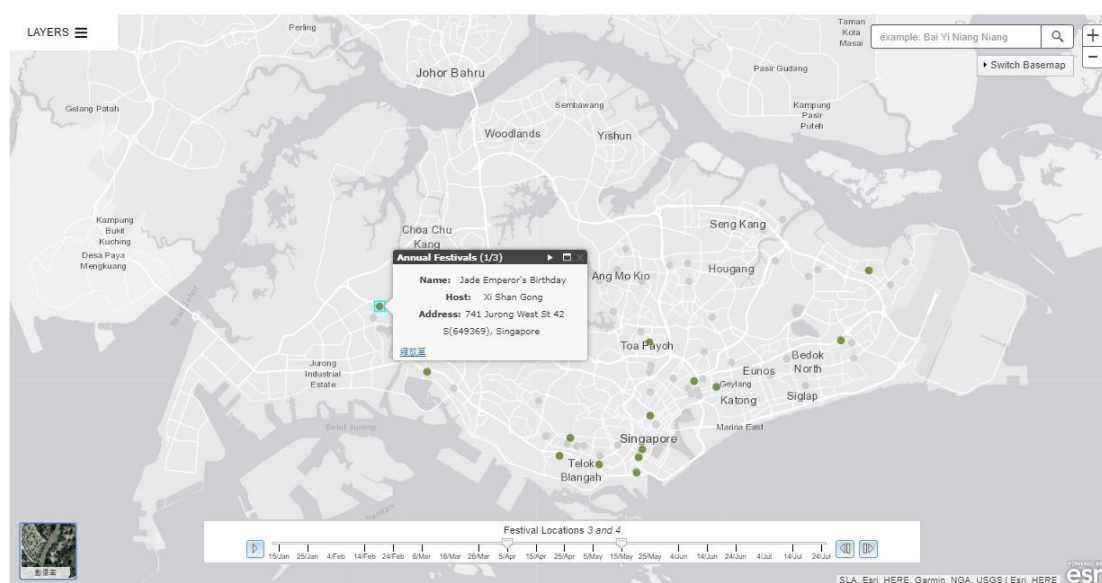
Figure 5. A time-aware map showing the spatiotemporal distribution of annual religious festivals in Singapore.

4. Combining the Singapore Biographical Database and the Singapore Historical GIS

Since people develop and grow with the intertwined and inextricable systems of social networks and geographic landscapes, i.e., configurations of geolocated relationships that individuals establish and maintain, GIS approaches need to be coupled with social network analysis (Andris 2016). The GIScience community has just begun to take advantage of integrating interpersonal social connection information (i.e., geolocated social network data) (Ducruet and Beauguitte 2014). However, the existing efforts generally "forfeit rich data on a user's interpersonal ties—by simply showing a user's location—not his or her connections to other people in other places" (Andris 2016). This is probably due to the fact that the existing GIS tools for modeling people and places are ill-equipped to model social networks.

The SHGIS project plans to strengthen this area of research by developing the geolocated social network of Singaporean personalities (famous persons throughout the history of Singapore), revealing their interpersonal ties and their connections to various cultural places (e.g., religious buildings and clan associations).

An initial product called the Singapore Biographical Database has been developed (https://sbdb.nus.edu.sg/). At this stage of the project, a web application of non-geolocated social networks has been created based on D3 JavaScript Network Graphs from R (https://christophergandrud.github.io/networkD3/). Users can query individual persons and interpersonal relations in the social network. A popup box will be displayed by clicking the nodes in the social network to show details about a person, including the name, hometown, year of birth, year of death, and the sources of data (Figure 6). The next step for the SHGIS project is to spatialize the social network by coupling it with the GIS system based on known locality information (e.g., a person's hometown and dialect group) and perform spatial social network analyses.
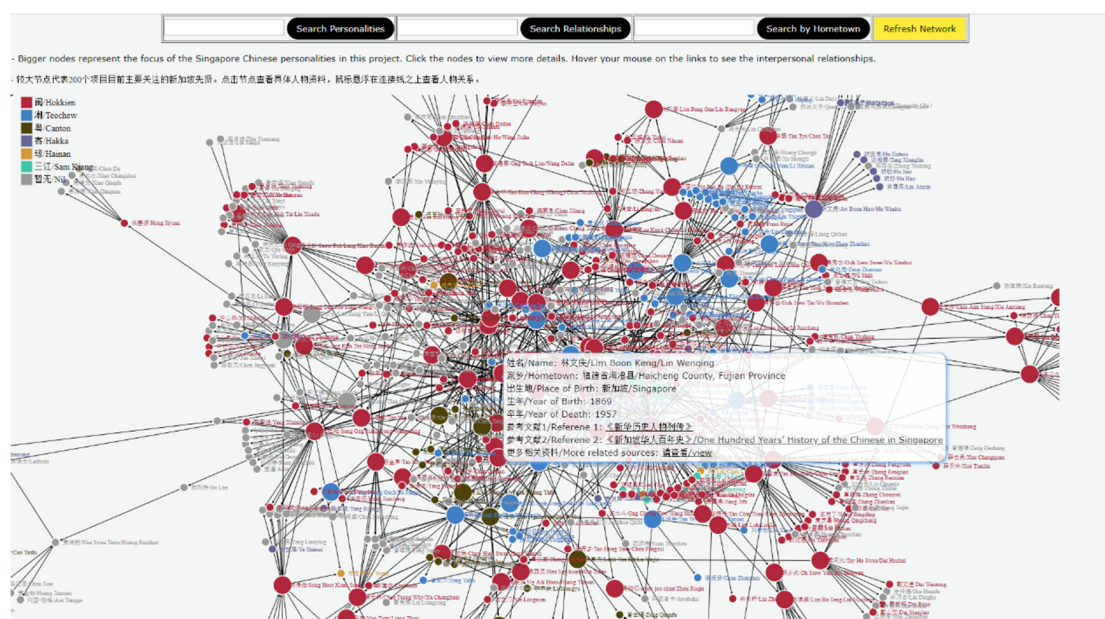
Figure 6. A social network of Singaporean personalities, from sbdb.nus.edu.sg.

One goal of the SGHIS project over the coming years is to develop maps for each of the eight generations (25 years each) into which we divide the 200 year history of Singapore since the founding of the open port by Sir Stanford Raffles in 1819. On each map layer, we will display the (constantly changing) locations of major Chinese temples, associations, churches, mosques and Indian temples of each respective period, in relation to individuals who were active in some or many of these sites. These maps will enable users to trace the growth and expansion of the settlements on the island, and the spread of temples and associations. They will also enable us to see where specific individuals lived, went to school, conducted their business, worshipped their gods, and gathered in groups. Currently, we have developed maps for the first three generations (1819–1834, 1834–1859, 1859–1888). Figure 7 shows the distribution of different dialect groups in the urban core up to the 1950s.

The Singapore Biographical Database (SBDB) was launched in Feb 2019 at the Singapore National Library. Currently, the SBDB enables users to visualize links between 200 key Singaporeans and 600 of their friends, relatives, business partners, and colleagues. We intend to add larger data-sets of individuals and their connections to the SBDB, drawing on biographical materials in temple and association commemorative volumes, burial records from cemeteries, tomb inscriptions, and lists of names of individual and business donors found in Singaporean Chinese inscriptions.[5]

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[5]   We are aware that there are limits of scalability and that the increase of data and the number of nodes may impact the display speed and legibility of data visualization of social networks on our web interface. We have discussed maintaining a user-friendly public web interface for the visualization of the social networks of famous Singaporeans, along with a greatly expanded EXCEL biographical database that users could download and explore with desktop SNA software such as GEPHI.
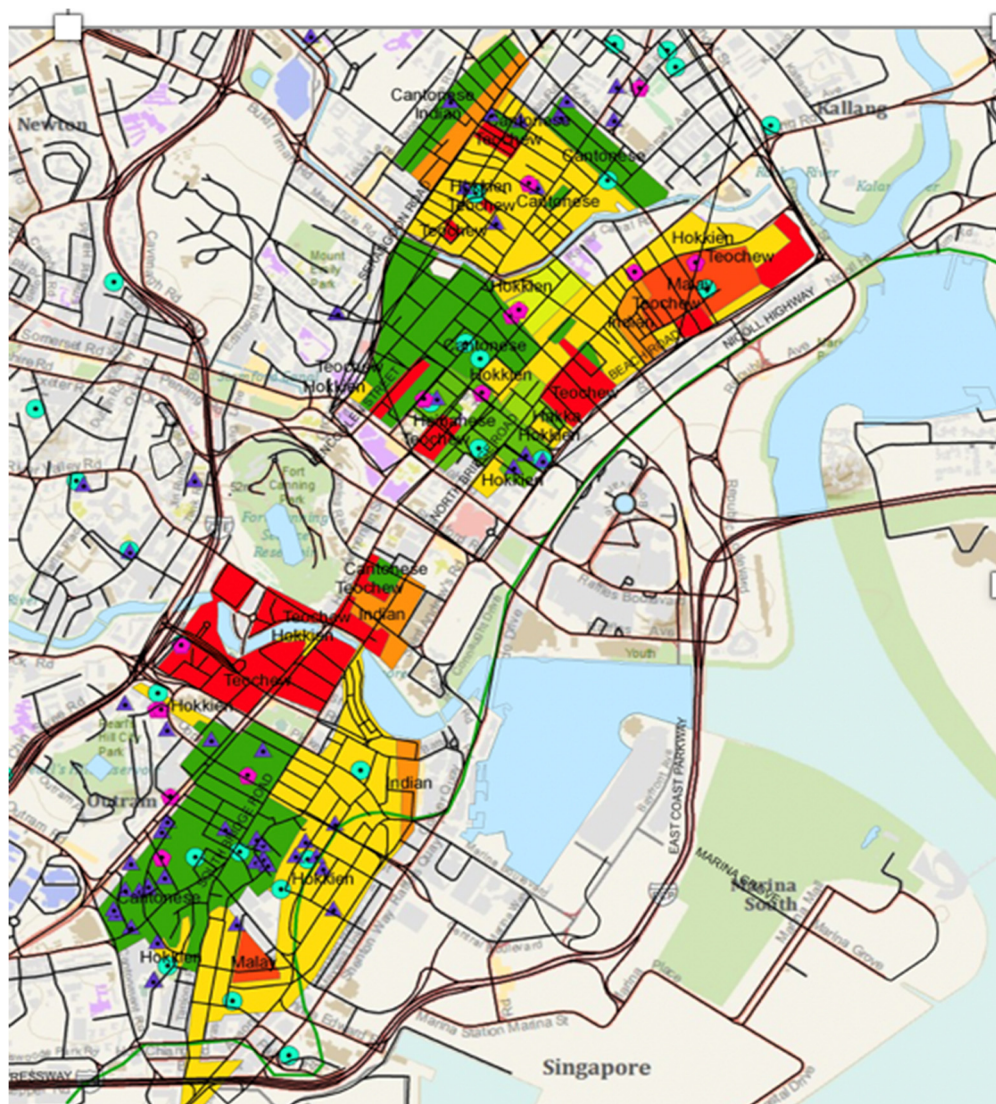
Figure 7. The distribution of different dialect and ethnic groups in Singapore**,** showing the territory of the Hokkien in yellow, the Teochew (Chaozhou) in red, the Cantonese in green, the Indians in light orange and the Malay in darker orange. Light green dots represent temples dedicated to gods of each regional pantheon. Purple triangles and magenta dots represent regional and clan associations respectively. These dialect-defined neighborhoods remained largely intact until the late 1950s. The green line crossing the middle of the image from top to bottom shows the original line of the sea, before large-scale land reclamation. Based on Hodder (Hodder 1953); see also Yamashita (Yamashita 1986).

5. Models for This Project

This project draws inspiration from the CHGIS and CBDB (Chinese Biographical Database) developed by Harvard University.

The main objective of the CHGIS project is to create a flexible tool, in the form of a documented database of places and administrative units, which can be used to investigate any sort of geographically specific data related to China... Users will be able to associate their own data with CHGIS records, and then use the CHGIS database to sort, query, and display their data for different historical periods and at different levels of aggregation. The CHGIS project is designed to provide a GIS platform for scholarly and scientific research. (chsgis.fas.harvard.edu)

Bol (Bol 2016) and his colleagues at Harvard University also launched the Chinese Biographical Database (CBDB), which currently includes data on over 400,000 individuals. This data can be downloaded in whole or in specific searches. This data can then be visualized and analyzed using desktop social network analysis software such as GEPHI.[6]

Harvard's CHGIS and CBDB were key inspirations for the development of the SHGIS and SBDB. However, these projects have many contrasting features when compared with the SHGIS and SBDB. First of all, Singapore's modern history (not including archaeological finds dating back to the 14th century) is only 200 years long, and its current land mass is only 725.7 square kilometers. The CHGIS covers a vast region over a 2000-year timespan. In terms of biographical data, the majority of the individuals included in the CBDB are literati officials who appear in imperial documents and literary anthologies. Our current SBDB is made up of Chinese merchants, bankers, and community leaders, along with a few journalists, educators and artists. The CBDB does not include many merchants or religious figures. Different issues arise when analyzing the social networks of merchants and businessmen. Many held positions on overlapping boards of directors of social and cultural institutions as well as various companies. G.W. Skinner (Skinner 1957; Skinner 1958) made hand-drawn diagrams of the interlocking business directorates and the office staffs of Chinese associations and community offices in Thailand in the late 1950s. Currently, computer SNA programs can be used to create, display and analyze these interconnections.

Ultimately, the uses of these different databases will determine their future potential for evolution and common platform building. We envision linking our databases where possible with those of the CHGIS and CBDB. For example, the CHGIS has proven helpful in identifying some of the home villages of migrants to Singapore. We have recently gathered data on places of origins from 1500 Qing period tomb inscriptions still extant in Singapore. For one set of 460 relocated tombs of early Fujian migrants, we were able to identify 130 home villages, towns and cities in the Minnan-speaking part of coastal Fujian (Hue et al. 2019). We hope to add additional data from lineage genealogies linking lineages across the Chinese diaspora, as well as drawing on personal names and names of companies and boats from stone inscriptions in temples and associations to further link individuals to multiple locations across the diaspora.

Another difference with the Chinese historical data is the relative wealth of records for local socio-cultural and commercial organizations in Singapore, although many of the Chinese language sources have yet to be fully explored. The National Archives, the National Library, and the rare books room of the Chinese Library of NUS, along with the local archives of temples and associations, preserve over 1000 commemorative volumes. Other sources include extensive records of land-holdings, temple sites and their movements, and the original locations of villages (kampongs), as well as the spread of the HDBs. These sources provide detailed data for historical GIS reconstruction and analysis of changes. Indeed, there are still many Singaporeans alive today who lived for many years in the now vanished kampongs (villages). With new crowd-sourcing WebGIS digital outreach tools, it should be possible to gather considerable oral historical and documentary data on these villages, their temples and rituals, and their processes of transition into HDB flats. Many temples and associations have compiled commemorative volumes outlining their past histories and moves, and listing the members of their successive boards of directors. Thus, we envision drawing on these sources to develop additional layers of data on the SHGIS/SBDB, increasingly linking in social network analysis (that is, putting people back into the places through which they moved and mapping the networks they formed).

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[6]　By contrast, the SBDB website currently displays 200 individuals in their connections with 600 others. Data was drawn from biographical dictionaries, and NLB (National Library Board) and NUS Chinese library data sets, but issues of verification of data persist. We have developed an expanded EXCEL database of 4000 individuals that can be downloaded. We are working on the best ways to integrate data from other sources such as inscriptions, burial records, genealogies, and tomb inscriptions. Incorporating this data would lead to a database of over 200,000 individuals.

6. Mapping Singapore from the Jackson Plan to OneMap: Contrasts with the SHGIS

The development of map making and more recently the GIS mapping of Singapore is discussed in Mok (Mok 2015). Mok explains each era in the mapping of Singapore, starting with the work of early map makers, including the Jackson Plan of 1828, the earliest town plan drafted by Lieutenant Philip Jackson of the Bengal Artillery. This plan divided the coastal town into a Chinese section (south of the Singapore river), a Western town to the north of the river and below the Governor's Mansion on Fort Canning, and a Malay town centered on the Sultan's Palace in Kampong Glam on the northern stretch of the beach. From 1855 to 1877, various surveyor generals were appointed, and from 1872 to 1920, a series of colonial engineers took over the work of the surveyor generals, producing several important maps showing the expansion of the settlement and providing many cadastral maps of landholdings linked to land deeds. In the interwar period of 1920–1939, the new Survey Department produced topographical maps based on new trigonometrical surveys. The first such topographical maps were completed in 1924, at a scale of 1:15,824. In the post-war, pre-independence period, from 1945–1965, topographical maps at a scale or 1:10,000 were produced, as were street directories (starting in 1954 and continuing until 2011 at irregular but frequent intervals), as well as aerial photo-maps at a scale of 1:6366 in 1950 (published in 1954). In the post-independence period of 1965–2020, the Survey Department produced many maps, including a set at a scale of 1:2500 in 1970–1971. The Singapore Armed Forces Mapping Unit (SAFMU) was established in 1970, and took over the production of the first metric topographical map series in 1974.

By 1993, the first computer-aided maps were produced, and in 2002, the first topographical map of Singapore based on a GPS-compatible mathematical reference system was published. The most current edition, published in 2011, is Edition 7 of the SMU/075. In 2012, the Singapore Land Authority (SLA) began to develop a large-scale national-level 3D topographical map called the National Digital Terrain Model.

In 2010, the SLA launched OneMap.sg, a web-based platform for the general public to access government agencies' location-based services and information. OneMap contains an amazing amount of data and services.[7] However, the OneMap.sg website includes very few religious sites, including only those few temples, mosques, and churches included in the Registry of National Monuments. It would be interesting to combine our maps and the rich diversity of religious sites of Singapore with the entirely secular sites included on OneMap.sg. We expect to find significant areas of intersection, overlap and perhaps redundancy between the areas of neighborhood charitable activities (education, eldercare, TCM, community outreach) of many of the Chinese temples (and mosques, Indian temples, and Christian churches) and areas covered by various government social services (see Figure 8).

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[7]　OneMap's services include OGC (Open Geospatial Consortium data, proprietary GIS services (such as services published using the ESRI ArcGIS APIs) as well as custom services. See https://www.onemap.sg/home/.
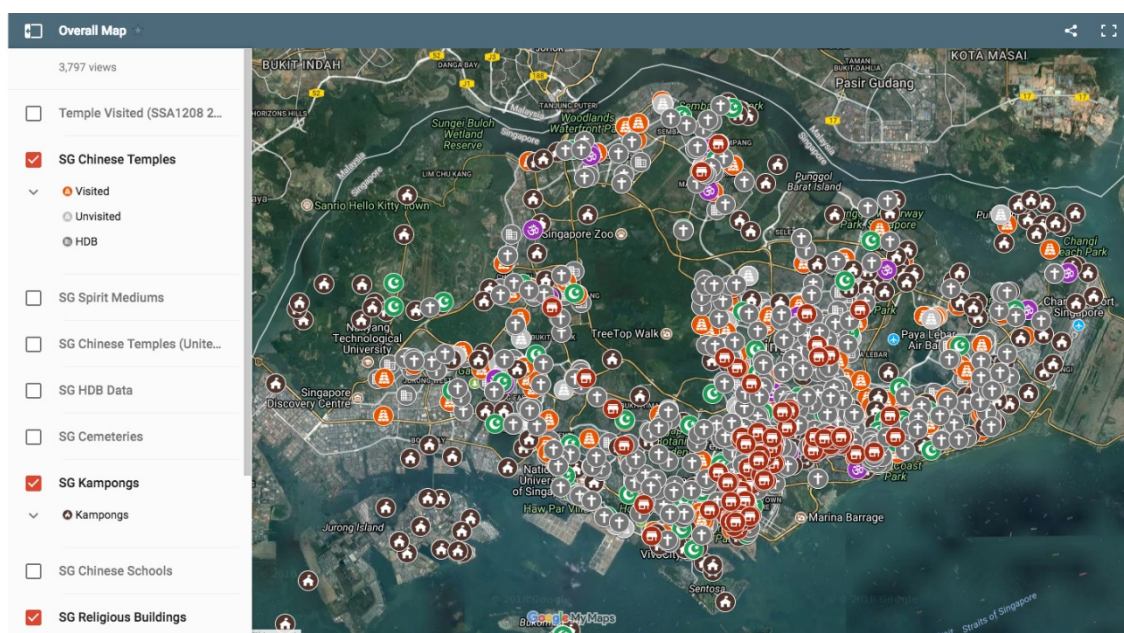
Figure 8. Map of Chinese temples, churches, mosques and Indian temples in Singapore.

7. Adding Cultural Data to the SHGIS: Linking Stone Inscriptions to Digital Maps

This section of the paper introduces an important set of sources (epigraphy) that can provide data for the comparative study of the Chinese diaspora in Southeast Asia, and thus point to possibilities for collaborative research. The study of Chinese epigraphy in Southeast Asia can be traced to a 1969 publication of Professor Jao Tsung-i entitled "Brief Historical Overview Based on a Chronological Arrangement of Singapore-Malaysian Chinese Epigraphy" (Jao 1969). Jao's essay drew on the information in the inscriptions to bring out many new features of the history of the Chinese communities in Malaya and Singapore island. However, for the most part, the history of Singapore has been written from the British Colonial records, rather than from the records of the Chinese institutions of Singapore—the temples, associations, schools, and companies whose collective archive fill in many of the missing elements of the "Singapore Story".

Collections of Chinese epigraphic materials have already been published for some parts of Southeast Asia. From 1980–1995, Wolfgang Franke and his associates produced seven volumes including photos and partial transcriptions of inscriptions from 1143 sites in Malaysia, Thailand, and Indonesia (Franke and Chen 1982–1985; Franke et al. 1988–1997; Franke 1998). As shown in Table 1 below, Franke et al. collected 5049 inscriptions from 1599 sites (including temples, cemeteries, associations, ancestral halls, etc.) in these three countries. Figure 9 provides a map of the distribution of these sites over several centuries.

Table 1. Inscriptions included in Wolfgang Franke et al. Epigraphic Materials.

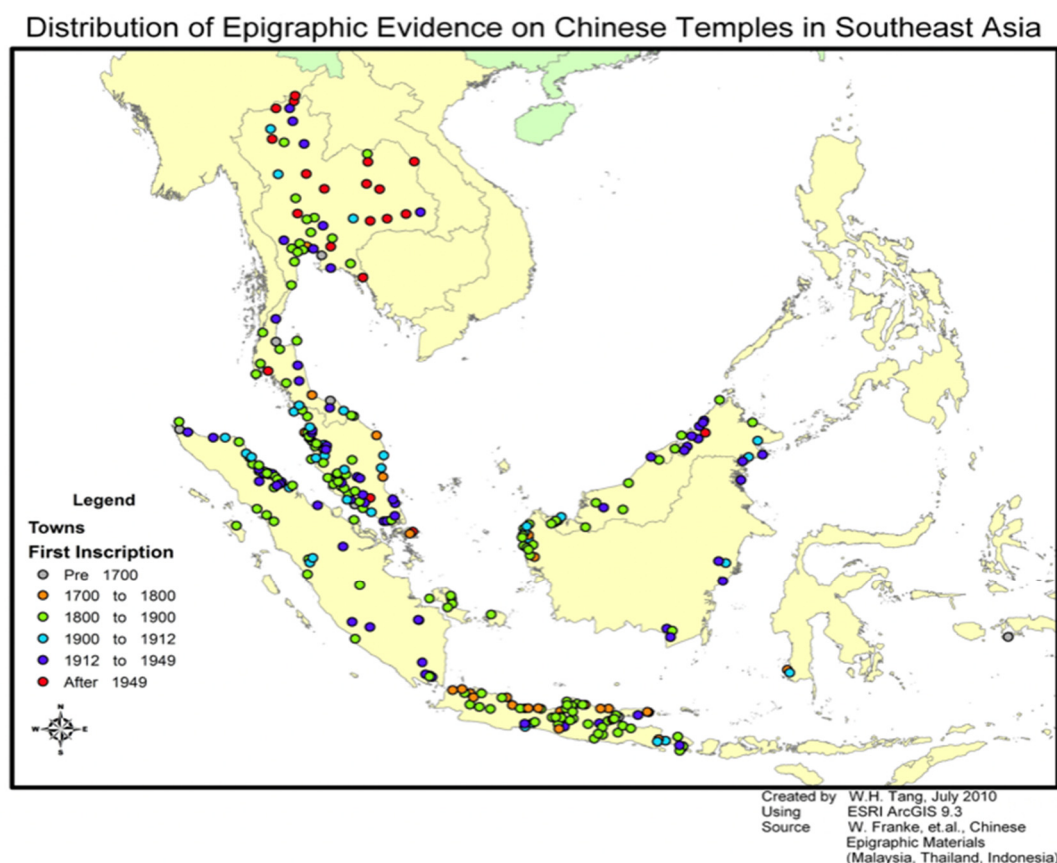|	Indonesia		Malaysia		Thailand		Total	
	Sites	Inscriptions	Sites	Inscriptions	Sites	Inscriptions	Sites	Inscriptions
Temples	237	1285	167	688	173	556	577	2529
Cemeteries	180	1207	99	383	70	350	349	1940
Associations	12	54	85	151	26	82	123	287
Ancestral Halls	18	114	26	89	3	7	47	210
Miscellaneous	9	15	20	38	18	30	47	83
Total	456	2675	397	1349	290	1025	1143	5049

Figure 9. Map showing the expansion of the epigraphic record of the Chinese diaspora from the 17th to the 20th centuries.

A collection of 117 Singaporean Chinese stelae and tomb inscriptions was published by Chen Ching-ho and Tan Yeok Seong in 1970 (Chen and Tan 1970). Dean and Hue published *Chinese Epigraphy of Singapore, 1819–1911*, 2 vols. (Dean and Hue 2017), a collection of 1278 inscriptions from 74 temples, cemeteries associations, and monuments in Singapore, with English translation of inscriptions (Table 2). They are currently collecting materials for a second set of volumes, which will include over 2000 inscriptions dating from 1911 to the present day from nearly 300 temples and associations (Dean and Hue forthcoming). In addition, they gathered and plan to publish 1500 Qing tomb inscriptions still extant in Singapore (Dean et al. forthcoming). The SHGIS research team made a digital version of the inscriptions found in *Chinese Epigraphy of Singapore, 1819–1911*, and marked up these texts using TEI (Text Encoding Initiative) standards to create a searchable HTML database of over 40,000 individual names, as well as over 10,000 names of companies (shanghao) and boat or shipping companies (chuanhao). We anticipate adding an even larger number of individual names and shanghao from the TEI text of our second two-volume collection of Singaporean Chinese inscriptions, supported by a grant from the Singapore Chinese Cultural Centre.

Table 2. Categories of sites and inscriptions of Singaporean Chinese Epigraphy (Dean and Hue 2017).
Chinese Epigraphy of Singapore: 1819–1911.

Temples, Shrines, Pavilions	Huiguan Native-Place Associations	Clan Halls	Schools	Hospitals	Other	Total
42	13	7	1	2	9	74

Stelae	Stelae	Plaques	Plaques	Couplets	Couplets	Other	Other	Total
1819–1911	1911–2012	1819–1911	1911–2012	1819–1911	1911–2012	1819–1911	1911–2012	
198	189	217	236	120	144	114	47	1265

Stelae	Plaques	Couplets	Other	Total
387	453	264	161	1265

Pre-1911 Cultural Artifacts	1911–2012 Cultural Artifacts	Total
649	616	1265

In a related data collection effort supported by the SHRC (Canada) over the last 30 years, Dean and Zheng gathered, transcribed, punctuated, and published seven volumes containing over 3700 inscriptions related to the history of religion in the Minnan-speaking areas of southeast Fujian, dating from the Tang dynasty up to 1949 (Dean and Zheng 1995, 2004, 2019b). These volumes include some of the earliest mentions of Southeast Asia in the Chinese inscriptional record. The Temple of Auspicious Responses stele of 1136 is still extant in Putian. Its inscription refers to a Quanzhou sea captain named Zhu who travelled to Srivijaya in Sumatra and returned the following year with a cargo worth 100 times the funds he had invested in the trip. After that, everyone sailing overseas first stopped to pray at this temple.

Near Xiamen, in the Haicang area, we located two inscriptions from 1697 which detailed the sending of monks and temple managers to Batavia (today's Jakarta, Indonesia) to solicit funds to repair Buddhist monasteries and temples dedicated to local gods damaged during the Qing coastal evacuation enforced by the Manchu troops all along the southeast coast (Salmon 2007). Later inscriptions in these volumes repeatedly refer to donors from the Philippines, Indonesia, Malaysia, Thailand, Vietnam, Myanmar, and Taiwan, who have given funds to rebuild or restore temples, ancestral halls, monasteries, schools, and hospitals across southeast Fujian. We plan to digitize and mark-up these materials (using TEI), and to geo-reference these materials, in order to aggregate them into an overall database. Such a database would be an invaluable tool to visualize how the coastal ports of South and Southeast China were linked, and to gain new insights into the history of trade, customs and religion in the region.

As mentioned below, a recently completed project has located 1500 Qing period tombs still extant in Singapore (Dean et al. forthcoming). From the places of origin inscribed on one set of these tombs, we were able to map over 130 of the home cities, towns, and villages of these primarily Hokkien (Minnan-speaking) immigrants (Figure 10).
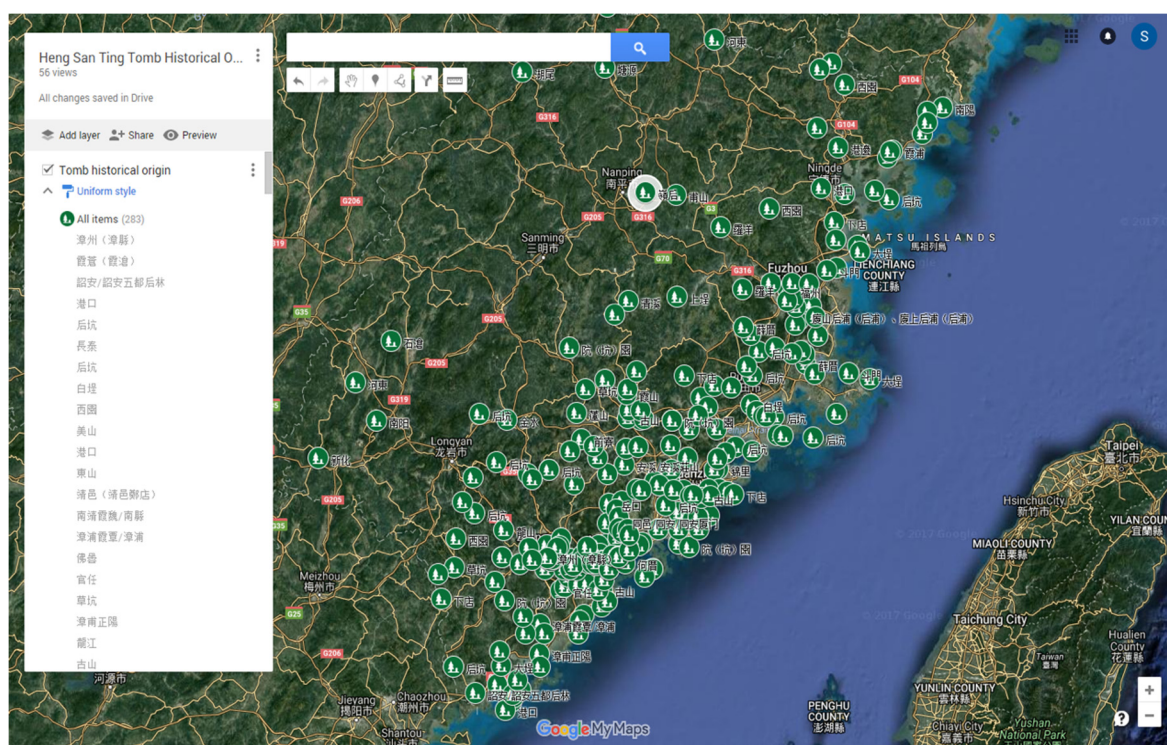
Figure 10. Places of origin inscribed on Qing tombs of Singapore.

8. Concluding Discussion of Future Prospects: A Collaborative Digital Humanities Platform for Southeast Asia

In what respect is the SHGIS/SBDB a collaborative digital humanities research platform? We would like to discuss five aspects of the platform/project in response. (1) We are working to make our data shareable and downloadable by uploading discrete sets of data to GitHub, an on-line clearing-house for shared data. Data can also be downloaded directly from the SBDB website. (2) We are eager to collaborate with scholars whose geo-referenced data we can process into ArcGIS formats, allowing it to be examined by them as well as other scholars alongside already existing distributed data. (3) We plan to move the Chinese temple/huiguan apps onto Apple Store, enabling members of the temple communities and members of the interested public to send in corrections and additional data in a collaborative effort to build a richer on-line archive of Chinese heritage in Singapore. (4) Our historical maps as well as our feature layers (i.e., the point, polygon, and polyline layers) are enabled with OGC (Open Geospatial Consortium) capabilities, enabling users to download and use this data. (5) We seek to expand and develop the comparative study of the Chinese diaspora in Southeast Asia by mapping Chinese temples and institutions in port cities and mining towns, and by developing a shared and downloadable database of epigraphy from these sites. Such research has to be collaborative, and we believe an expanded version of a Southeast Asian historical GIS should also include cultural and religious data from Islamic, Hindu, Christian, Jewish, Parsee and other communities.

The SHGIS website currently includes a "Linked Project" set of pages. These cover a number of projects, including the Putian local historical GIS mentioned above. A second project is the Malaysian Historical GIS (MHGIS) on which we map the locations of all the 397 temples, associations, ancestral halls and cemeteries covered in Franke et al., 1980–1985, across Malaysia. For some parts of Malaysia, we have added point locations after taking the search for these sites down to the street level, using Google Maps and Google Street View to check addresses. This will enable researchers to revisit the sites and confirm whether the inscriptions have been preserved. On the basis of visits in Summer 2018 to sites in Indonesia and Malaysia, our research collaborators (Streiter 2017) found a retention rate of only 70%. A lot of the epigraphic heritage that Franke documented has vanished in the last 30

years. Moreover, there have been many new inscriptions set up in the years since Franke and his colleagues completed their work in Malaysia.

We conclude that Chinese epigraphy in Southeast Asia is endangered. Our pilot projects have shown that more than 30% of the artifacts Franke and his teams documented in Malaysia, and 40% of those in Thailand have already vanished only 30 years later. Moreover, Franke's black and white photographs of epigraphy from Malaysia, Indonesia and Thailand documentation are not adequate for today's needs. We need to produce sophisticated digital images in 2D and 3D, together with metadata, documentation, and analysis, and develop an analytic media database. Far from merely retracing Franke, we aim to survey new regions about which very little is known. Chinese epigraphy in Myanmar and the Philippines is still largely undocumented, while the epigraphy of the Chinese minority in Vietnam is also not well published or analyzed. With information from these places, properly aggregated into databases, researchers all over the world would be able to investigate the history of the Chinese diaspora. In addition, our documentation will preserve the heritage of Chinese migration into Southeast Asia, which is under pressure in some areas to assimilate, or to give into the effects of urbanization, leading to the loss of temples and other communal sites. The SHGIS research team is in the process of creating a digital database of Chinese inscriptions from Southeast Asia, in order to use this database to analyze the dense networks of individuals, temples, regional associations, clans, business firms, and shipping companies that linked the Chinese communities of the port cities of Southeast Asia together and back to China over the past five centuries.[8]

Through data-mining of on-line information and the digitization of printed sources, we have been able to add points, data and, in some cases, photos for over 1200 temples and over 4000 associations to the group of 397 sites covered by Franke and Chen (1982–1985). We plan to conduct comprehensive surveys of a representative sample of sites in Malaysia to: (1) ground-truth the data on the distribution of temples and associations; (2) estimate the rates of retention of earlier inscriptions; and (3) to expand the collection of inscriptions for a larger database. In this process, we can draw upon the work of Chinese Malaysian scholars who have published or are conducting studies of the Chinese temples and associations of Klang (Liew 2014), Johor, Malacca and Penang, tomb inscriptions from the Sanbaoshan cemetery in Malacca (Wong 2013) and Kuala Lumpur (Gu 2014), as well as studies of cave temples and inscriptions in Ipoh (Tan and Toh 2017). Note that the Ipoh caves were not included at all by Franke and Chen (1982–1985). We are currently adding points and polygons for the areas of some 460 "New Villages" established during the Emergency in the 1950s. Many different village temples and associations were gathered into these villages.

We will work with colleagues in History and Yale-NUS, who are collecting and digitizing early historical maps of Southeast Asia to include many historical map layers in a Southeast Asia GIS (SEAGIS). We will focus initially on Chinatowns in port cities around the South China Sea and the Indian Ocean. Within these neighborhoods, we will link points, giving the location of temples, associations and key businesses with photo and word document archives, as well as HTML versions of epigraphic sources. This information will be preserved in searchable multimedia databases.

The collaborative digital platform for the study of the growth of Chinese networks in Southeast Asia can process a wide range of data in addition to inscriptions. Our colleagues are developing ways to include architectural plans and photographs and 3D representations of temple architecture with embedded data on iconography and video footage of ritual practices. Virtual Reality (VR) technology holds out fascinating possibilities for recovering historical experiences and entering into immersive ritual environments. The collaborative DH platform is open to all kinds of aspirational engineering in order to realize its potential (Mah et al. 2019).

We invite interested scholars to collaborate in the development of these digital platforms. The SHGIS will be housed permanently in the NUS Central Library, and the SBDB will be maintained by

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[8] Various digital databases of epigraphy exist in other fields, especially Classics. The international federation, Electronic Archive of Greek and Latin Epigraphy (EAGLE, http://www.eagle-eagle.it), comprises several large collections of epigraphic materials.

both the Singapore National Library and the NUS Central Library. We trust that this will provide long-term sustainability for the platform and the data assets integrated into the system.

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