

Research Paper

Recreation of Forgotten Colombo Fortification Using GIS Techniques

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ABSTRACT

A map can be defined as a scaled graphic representation of the Earth's surface. People have been using maps since the earliest civilizations. Initially, these historical maps were considered only as objects with historical value. However, with the development of Geographic Information System (GIS), new methods emerged to digitize these old paper maps using Georeferencing and overlaying them on various modern maps, such as satellite image platforms. Although the earliest map representation of Sri Lanka dates back to 139 AD, European colonials compiled detailed maps of the island. Under Dutch rule along the coastal areas of Sri Lanka, many maps of their fortifications were produced, with one of the most significant being the Colombo fortification. Originally constructed by the Portuguese and later developed and reconstructed by the Dutch, this monument is not visible today except for a few remnants. The Dutch compiled numerous plans and maps of the Colombo fortification; some are available for download in the Dutch archive in the Netherlands. Against this backdrop, the objective of this research was to georeference one of these historical Dutch maps, overlay it on a present-day Google map, and compare the past and present landscapes of the Colombo Fort area. Following the Georeferencing process, the historical map achieved a remarkably accurate overlay on the satellite map, with a Root-mean-square (RMS) error of approximately 7 pixels. The output provides a clear understanding of the Dutch fortification's function during the 17th century and the locations of its components in the present space of Colombo. Importantly, it underscores that while the fortress may be invisible today, the spatial arrangement of the current Colombo Fort remains akin to its Dutch predecessor.

Keywords: Colombo Fortification, Dutch, Georeferencing, GIS Techniques, Historical Maps

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1. Introduction

1.1 Background

People have been using maps from early civilizations. Since the first known map from Saint-Bélec, France which is datable to the Early Bronze Age (c.2150–1600 BC) (Nicolas, et al., 2021, pp 367-390), and the Babylonian map of the world which is at least no older than 9th century BC, (Horowitz, 1988, pp. 147-165) there are numerous examples can be found the usage of maps throughout the human history. Among those maps, Roman mathematician and geographer Claudius Ptolemy's map of Taprobana, compiled

in 139 AD, is considered the oldest map representation of Sri Lanka. It is believed that this map was compiled by referring to the world map by Eratosthenes (276 to 196 BC) created in 194 BC, which is not available in the present day (Sri Lanka Archaeology, n.d.)

According to the Britannica dictionary, a map can be defined as a graphic representation, drawn to scale and usually on a flat surface, of features—for example, geographical,

geological, or geopolitical—of an area of the Earth or of any other celestial body (Fuechsel, 2023). Most historical maps are drawn on paper, and these historical cartographic elements have been widely used by historians rather than modern mapping scientists. Therefore, early maps have been considered typical archive documents, testifying to the past territories and cities in diverse historical periods. (Balletti, 2006, pp. 32-42). However, modern-day GIS applications facilitate a way to digitize these historical maps by georeferencing and converting those into digital form. Georeferencing is the process of the internal coordinate system of a digital map or aerial photo relating to a ground system of geographic coordinates. Since the georeferenced map or image has been tied to a known earth coordinate system, it can be located on the Earth's surface (USGS, n.d.). Google Earth can be used to get images with a known coordinate system and that can be used to georeference a historical map as well. This process allows users to overlay the old historical maps with modern maps as well as satellite image platforms like Google Earth. Therefore, these historical cartographic documents are no longer considered documents only with historic, artistic, or sociological perspectives but presentations containing a lot of spatially referenced information affined to geometry, in general, and to geometry-related entities (Balletti, 2006; Fuse et al., 1998). Most historical maps and plans consist of contemporary situations and therefore, Maps can be used to study man and his environment in one-dimensional time and three-dimensional space where these become a unique tool for the study of human settlements and history, including archaeology (Fernando, 1986, pp. 82-114).

Even though some evidence has been identified Arabs and Maldivians have produced some Sri Lankan maps, it was the Portuguese who started to compile Sri Lankan maps during their occupation of the country after 1505 AD. Later, Dutch colonials, who occupied Sri Lanka from the Portuguese during the 17th century, carried out this process. These were produced by the Dutch East India Company (VOC) by copying from Portuguese and Spanish sources (Fernando, 1986, pp. 82-114).

Apart from the land and political boundary maps, the Dutch have produced maps and plans of their fortifications around the island. These plans and maps give a clear insight into those fortifications including the architecture, security strategies, the extent, land use pattern, and spatial arrangement inside the fortification. Studying those will enable a way to understand the temporal changes of those historical landmarks.

The fort of Colombo is not visible in the present day. Apart from some remaining structures of the original fort such as the old Dutch warehouse, Hospital, and Delft gateway Colombo fort almost vanished in the modern Colombo city. However, there are many maps and plans of the Dutch fortification of Colombo that can be found in the Dutch national archives and these provide a clear understanding of

the forgotten fortification of Colombo during the Dutch period of the 17th Century.

Even though some research has been carried out about the Colombo Fort such as Mendis (2017), Weerakoon (2013), Biedermann (2009), Gunaratna (2002), and Fonseka (1997) no published research could be found on georeferencing an old map of the Colombo fortification. Not only old maps of Colombo, but there was no clue about any research related to georeferencing a historic map of Sri Lanka.

Gunaratna (2002) discusses the evolution of Colombo city as well as the fortification of Colombo from the beginning of the Portuguese period. It is based on literature and has been using some historic maps to elaborate on the development and evolution of the fortification of Colombo. It explains the evolution of the Colombo fort and the suburbs according to periods such as Portuguese, Dutch, and British as well as post-independence development programmes within the Colombo city limit. Weerakoon (2013) also divides the expansion and evolution of the Colombo fort as well as the city according to the colonial periods and later development phases. It uses different historical maps according to the colonial era and compares them with the modern scenery of the city. Fonseka (1997) takes another approach to discuss the evolution and changes in the historic landscape of the Colombo city by studying the architectural heritage of the city limits. Even though this research mentions the fort of Colombo, historical maps were not used to discuss it. Biedermann (2009) examines comparatively Colombo fort with Cannanore fort in India which have similar geographic attributes and functions. This study is limited to the Portuguese and Dutch periods and historical maps are used to explain the contemporary functions of both fortifications. Mendis (2017) uses some geospatial technologies to identify the remaining of the Colombo fortification. This research plots some remains of the fortification of Colombo on the Google map, such as the remains of Battenberg battery inside the harbor, Old warehouse *Pakhuizen*, now the Maritime Museum, left of Commissariat Street, Dan Briel bastion, in the Navy Headquarters, Remains of the wall south of Dan Briel, in the Junior Police Officers' Mess premises, Remains of the wall north of Dan Briel, in the Navy Headquarters, Postern Gate or the Slave port, in the Navy Headquarters, The Delft Gate, in the Commercial Bank premises on Bristol Street. However, no historical maps were georeferenced during the overlay process of the historical landmarks with the Google map during the above research.

Framed within this backdrop, the research question centers on understanding the disparities in the landscape of the Colombo fort area during the Dutch period compared to the contemporary era. With this research question in focus, the primary objective is to Georeference a specific historical Dutch map delineating the Colombo fort. This process involves precisely assigning geographic coordinates to the historical map. Subsequently, the georeferenced map will be overlaid onto the current Satellite map of Colombo city.

The ultimate aim is to identify and analyze the temporal changes in the city's configuration, shedding light on how the Colombo fort area has transformed over time.

1.2 The Study Area

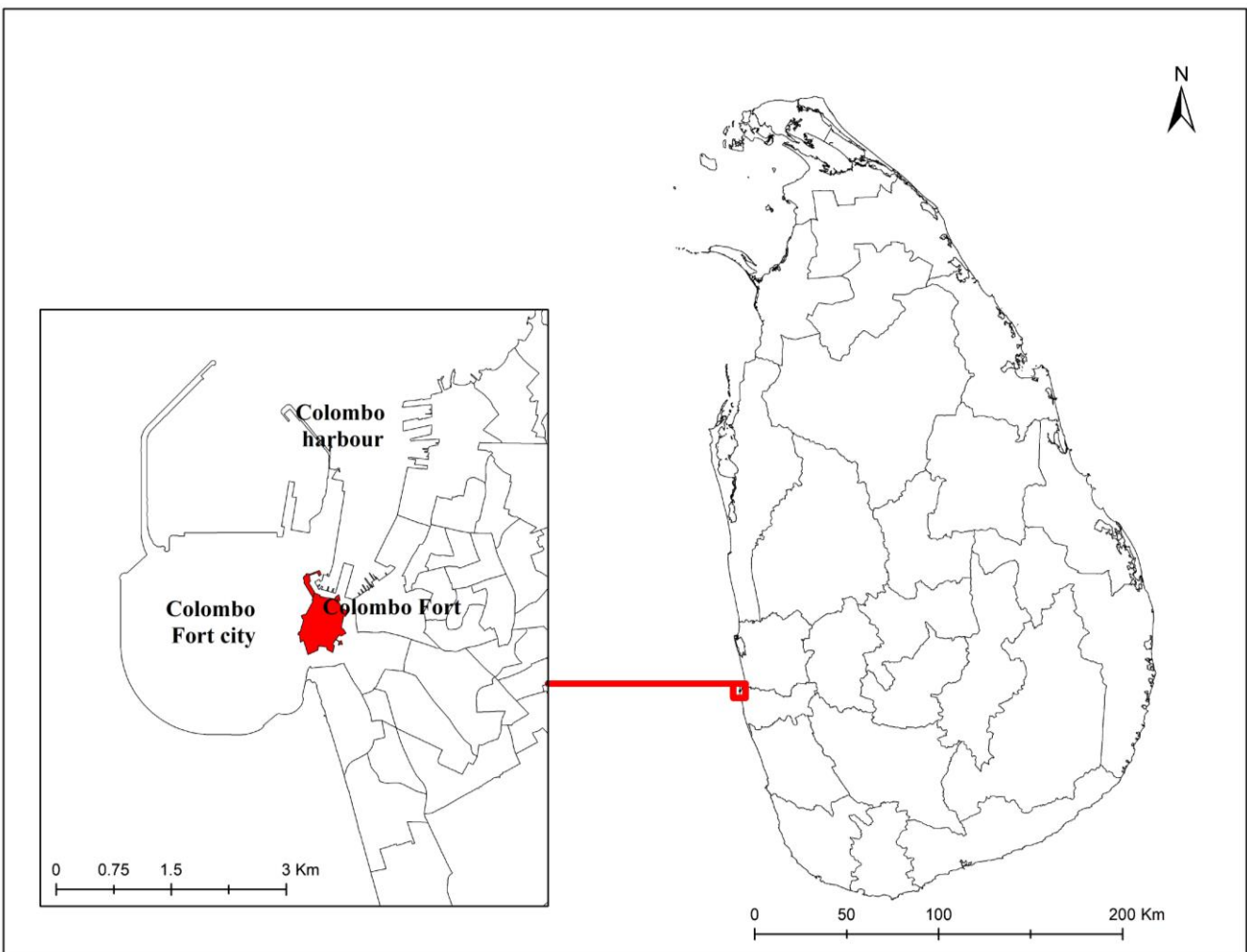
The Colombo Fort area has been used to conduct this research. It is in the present-day Colombo DSD (Figure 1). The Dutch, as well as the British colonials, developed the Colombo fortification originally built by the Portuguese. In 1518, Portuguese Governor Lopo Soares de Albergaria ordered to built a fortress near Colombo. They occupied land on the northern tip of the peninsula of Colombo and a piece of land called "Galbokka" due to its rocky surface to construct the fort. Construction began in late 1518 on the Point which they called St. Lawrence, after receiving the permission of the King of Kotte (Mendis, 2017, pp. 56-69; Beidermann, 2009, pp. 413-459). Since the early period of the fortification, it has been strengthened continuously by the Portuguese in relevance to the political conflicts on the island as well as the threats of other colonials from the West (Gunaratna, 2002, pp. 1-34).

In 1602, the presence of the Dutch changed the political shape of Sri Lanka. In 1638, their intervention in the local political situation derived King Rajasinghe II of Kandy to enter into an agreement with the Dutch East India Company to win over the Portuguese. This resulted in the eradication

of Portuguese rule in the coastal region of the country. However, on 12th May 1656, The Dutch broke their agreement with King Rajasinghe II and occupied the Colombo fort and they didn't hand over the Colombo fort according to the agreement (Mendis, 2017, pp. 56-69; Pieris, (1914).

Dutch extended the Portuguese base into a few more Square Kilometers, including the areas currently known as Pettah, Slave Island, and Modara. They centralized all administrative activities, official residences inside the Fort which was known as the Casteel, and the other activities to the east called the Oude Stad or Old City (Mendis, 2017, pp. 56-69; Weerakoon, 2013, pp. 177-188). The Dutch, reconstruct the fortification with more advanced security strategies and a well-planned moat. All the main features of the fort were completed by the 1680s with few additions and modifications in the subsequent years (Mendis, 2017, pp. 56-69). They divided the inner fort into blocks which are named "A" to "I" and different buildings such as Governors' and other officials' quarters and the hospital. There were eleven bastions around the fort and Dutch named them after the locations in Denmark. The main entrance to the Fort called the "Delft gate" was located in between the Delft and Hoorn bastions from the East (Figure 02).

Figure 01: Location Map of the Colombo Fort (Source: Survey Department of Sri Lanka)



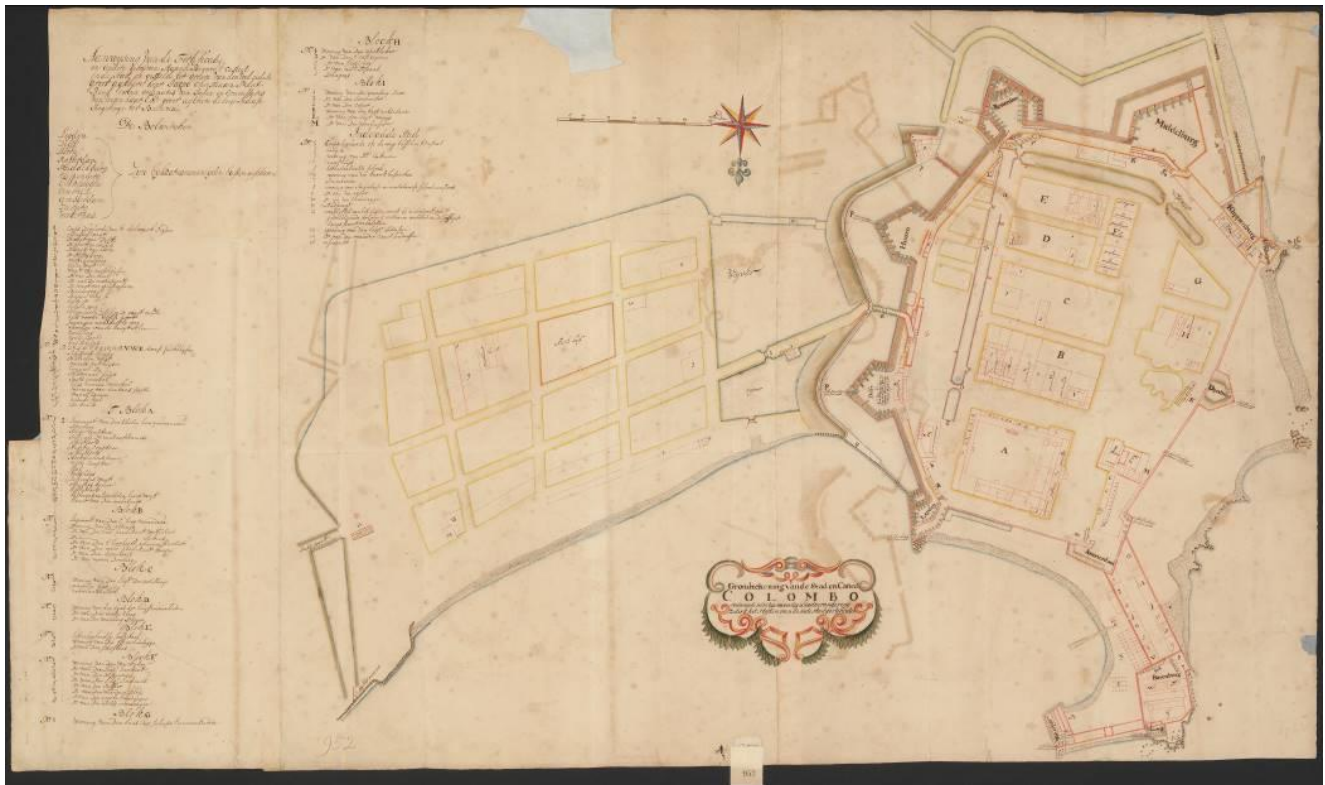


Figure 02: Historical Map Used for Study (Source: Dutch national archives)

On 16th February 1796, the British captured the Fort of Colombo. By 1815, the British extended their rule all over Sri Lanka. The advanced military technology of the British neglected the walled fortification around the city. Therefore, they started to demolish the walls of the fort in 1869 (Gunaratna, 2002, pp. 1-34). With this, Colombo began to evolve as a trade city instead of a fortification and different development phases have made the city into its current look.

2. Research Methodology

2.1 Historical Map Used

The historical map of the Colombo fortification (Figure 2) which was used to conduct this research was downloaded from the National Archives of the Netherlands (<https://www.nationaalarchief.nl/en>). However, this is rather a plan than a map. Even it is mentioned on the map as the "Ground plan of the city and Casteel". For the easiness, this plan will be mentioned as a historical map rather than a plan. It was compiled in 1733 (The National Archives of the Netherlands, no date). The map contains of a description, a legend that has elaborated the place names, North Arrow, and a scale bar. The map shows the Colombo fortification and the outer city. Dutch is the language used to write descriptions. The scale is in "Roeden" which is also known as Rod in English. The length of the Dutch roede varied from place to place. Approximately it is around 3.6797722 meters (Cardarelli, 1997).

2.2 Georeferencing

First, some unique ground locations must be identified which are available on the historical map and in the present landscape. Old Dutch Hospital and the Old Dutch warehouse (Presently the Colombo Port Maritime Museum) are the two main buildings that have been preserved to the current day. Both buildings are marked on the map. Therefore, one corner of each building has been used to get the Ground Controlling Points (GCP). The structure of the outer city has not changed till today. The streets on the map and the present-day layout of the streets in the Pettah area are similar. Therefore, a cross street from the Pettah has been used to get another GCP. The shore around the point of Colombo is mostly having a rocky surface. That prevents major changes in the shoreline due to sedimentation or coastal erosion. However, the historical landmarks of the coastal line of the Fort area have been changed due to the reclamation of the Colombo Port City project. Therefore, historical imagery from Google Earth was used to get the GCP from a pointy area which is visible on the historical map also (Figure 3).

Then these GCPs marked on the Google Earth image and extracted the coordinates from that. The satellite image is also extracted from Google Earth. Afterward, the saved Google image underwent georeferencing using the coordinates extracted from the GCPs. After georeferencing the Google image of the Colombo fort area, the Historical map was then georeferenced using the same Google image. WGS 84 was used as the geographic coordinate

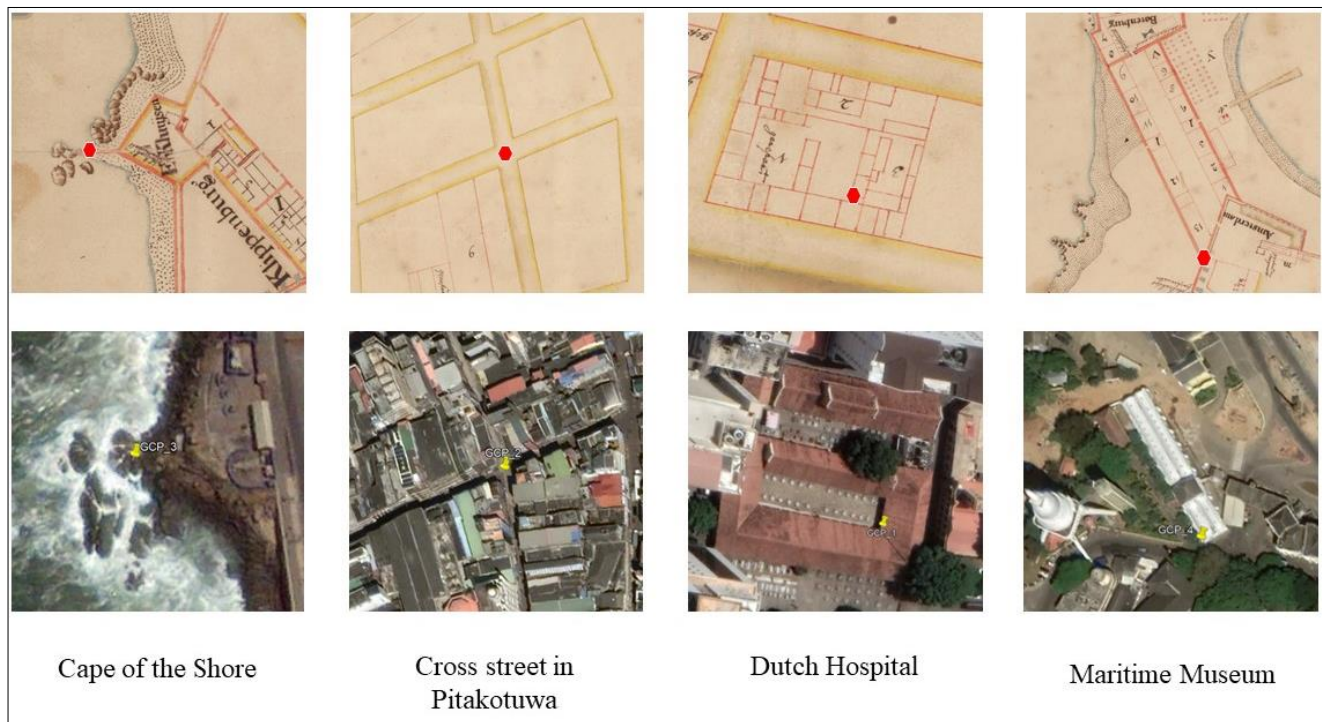


Figure 03: Locations of GCPs. (Sources: Dutch national archives (above) and Google Earth (11.03.2010 and 08.08.2022)).

system during the georeferencing and digitizing because of the easiness while overlaying on Google Earth.

Then the georeferenced historical map was digitized using ArcGIS software and the digitized map was overlaid on the Google Map.

Even though the historical map covers both the fort area and the outer city (Pettah) only the fort area was considered in this study.

3. Results and Discussion

3.1 Accuracy

The historical map has been georeferenced using the present-day satellite map with a total Root-mean-square deviation (RMS) error of $6.36327e-05$. (Figure 4) The historical map rotated upside down once it was georeferenced because it wasn't compiled according to the North direction. In addition, it lost its original rectangular shape and transformed into a quadrilateral shape.

The accuracy of the georeferencing process can be identified by observing the places that have been used to get GCPs. The condition was that both maps should have these places. Therefore, it is easy to determine whether the historical map overlaid on the satellite map correctly by examining those. Due to constrained access to high-end GPS receivers and challenges related to accessibility, a GPS-based accuracy assessment was not executed.

Figure 05 illustrates the locations of GCPs and from behind the satellite map appears while the historical map was overlaid on it. The hand drawing of the historical map can be seen in red colour. According to the historical map, the old warehouse (Maritime Museum) was located near the Amsterdam bastions. The historical map reveals that, this unique building with a double-barreled roof used to be more lengthier than the present situation and it used to be a twin building. The left corner from the bottom of this building has been used to get the GCP and when the georeferencing is completed less than 10 meter difference could be identified between the satellite image and the historical map. This difference was less than 5 meters in the Pettah cross street and the GCP was taken from the edge of the roof of the Dutch hospital. (Figure 5) This gave a total RMS error of $6.36327e-05$. RMS error is the distance between the input location of a GCP and the retransformed location for the same GCP. In addition, the remaining portions of the Delft gateway and the Denbriel bastion are perfectly overlaying with the same locations on the Historical map.

Mendis, (2017, pp 56-69) has mapped and overlaid on the Google map some remaining parts of the fortification of Colombo. It was based on field data and therefore the interpretation should be more accurate. Those findings are also consistent with the results of this study and therefore, the reliability of the overlaying process seems to be more confirmed.

3.2 Comparison of two periods

Even though almost every component of the fortification vanished in the present space, the spatial arrangement in the present fort area is similar to the Dutch period. It is like



Figure 04: Georeferenced historical map when overlaid on the Google image. The historical map was made transparent in order to visualize better both the historical map as well as the satellite image (Source: Dutch national archives and Google Earth)

the Dutch blueprint is still left in the modern fort area of the Colombo city. Figure 6 shows the overlaid historical map on the top of the Google map and the digitized boundary (Black line) of the Casteel and the moad (Blue line). The historical map clearly indicates that the Casteel was divided into different blocks and those blocks were occupied with different events and high-ranked groups.

Figure 7 shows the different digitized entities from the historical map which are overlaid on the satellite image. This allows comparing the spatial changes in the Colombo fort in both time periods. Block “A” was located in the northmost part of the fort. (Figures 6 and 7). The legend of the historical map indicates this area as “Regiment of the noble lord governor”. The map gives a list of 17 sections of this block. Since this is the block where the governor lived it can be considered as the heart of the whole fortification. Today, this is the area where the Ministry of foreign affairs, the Police headquarters of Sri Lanka, and the employees’ trust fund are located. It is surrounded by Church street from the North, York street from the east, Sir Baron Jayathilake Mawatha by the south, and Janadipathi Mawatha from the east. The next most important block must be the block “B” where the quarters of the commander were located. Apart from the commander’s quarters, some other residencies were also located in this area. This block was located on the southern side of the block A. Today, this area is occupied by the Cargills building

and some other buildings. It is also bounded by Janadipathi Mawatha from the west and York street by the south while Sir Baron Jayathilake Mawatha and Mudalige Mawatha are located from the north and the south respectively. The



GCP on the old warehouse

GCP on the cross street of Pettah

GCP on the old Dutch hospital

Figure 05: Locations of GCPs when overlaying the historical map on top of the Google image. The historical map was made transparent in order to visualize better both the historical map as well as the Google image.

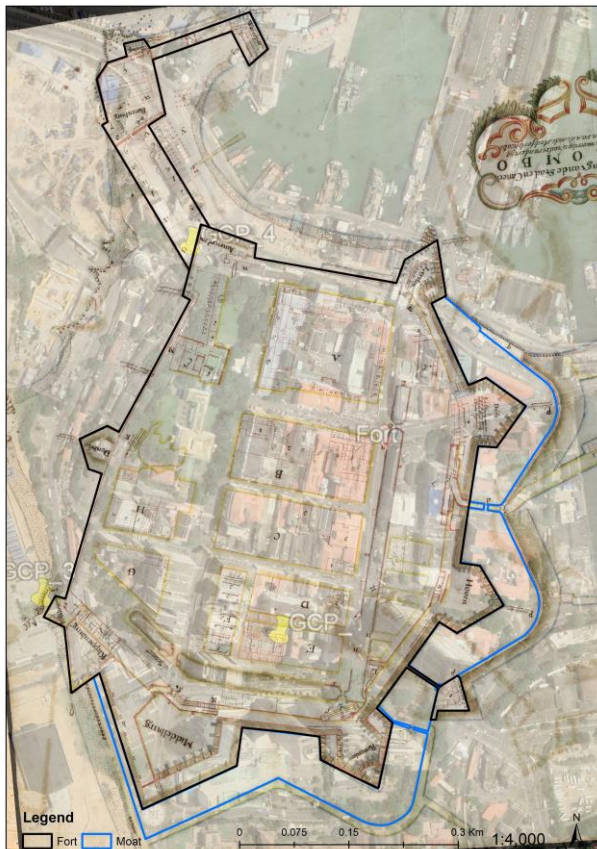


Figure 06: Georeferenced historical map overlaid on the Google image; a closer look of the Casteel and the moat. The historical map was made transparent to visualize better both the historical map as well as the Google image. (Source : Dutch national archives and Google Earth)

Block C also had residencies of Dutch officials as well as this is the block where the Dutch school was located. The place where the Dutch school was located is an empty land for now. Same as other areas this block is also occupied by different government ministries, institutions, and some private sector businesses by today. Block D and F also consisted of the residencies of Dutch officials while the Block E was the place where the Dutch hospital was located. This hospital building still stands as a major attraction in the Colombo fort area with a different function than a hospital. This area is surrounded by the Janadipathi Mawatha from the east, Chatham street by the north, York street from the east, and the Lanka Banku Mawatha from the south. The central bank of Sri Lanka is located in the block G of the Dutch Casteel. The area where the modern President's house is located was an empty surface during the period in which this map was compiled.

The Leyden bastion was in the northern part of the Casteel. If it ever existed by today, it would be facing the Colombo harbor directly. Today, the building of the Ports Authority is standing in the area where the Leyden bastion used to be. The next bastion from the right side of the Leyden bastion was the Delft bastion. It was standing in between the Gaffoor building and the YMBA building. The point of the Delft bastion faced towards the Khan clock tower and Sir Baron Jayathilake Mawatha goes middle of this bastion.

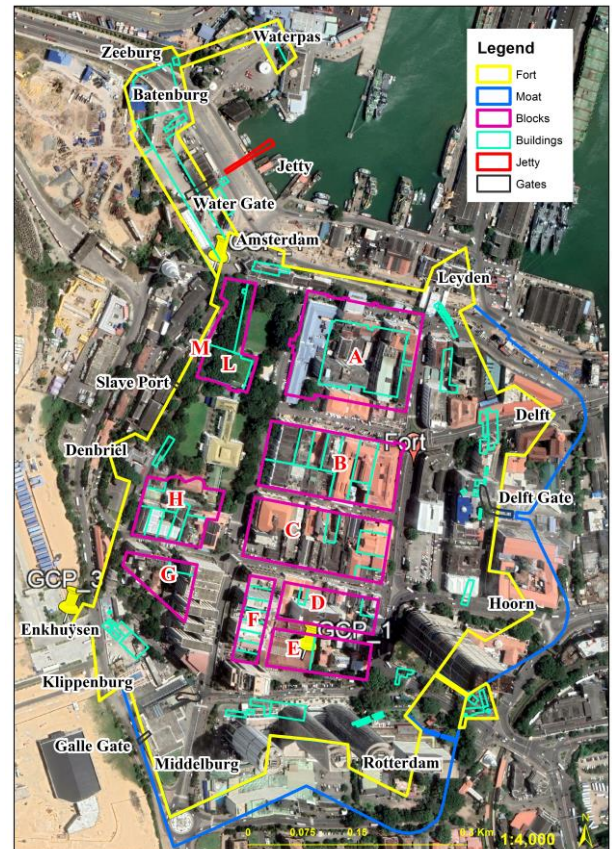


Figure 07: The digitized historical Dutch map over the Google map (Source: Dutch national archives and Google Earth)

Hoorn bastion was the next bastion after the Delft bastion, and it was in the area where the Sri Lanka telecom building and the Transworks building are standing now. The Delft gateway, which is still visible is located in between these two bastions. Hilton Colombo and a part of the World trade center are standing on the place where the Rotterdam bastion used to be. The Middelburg bastion used to be the largest bastion in the Colombo Casteel. It was located facing modern-day Galleface and its tip used to be standing in the place where Galle Road begins. The Klippenburg and Enkhuisen bastions were located facing the Indian Ocean from the Southwestern side of the Casteel. The location is now facing Colombo Port City. Both bastions were located bound to each other and another entrance to the fort (Galle Gate) (Mendis, 2017, pp. 56-69) was there in between the Middelburg and the Klippenburg bastions. The Denbriel bastion was located on the west coast side of the Casteel and the Navy headquarters premises occupied the land there at present. Amsterdam bastion was located on the northern side of the Casteel. This is the place where the building of the ministry of ports is standing right now. Batenburg, Zeeburg, and Waterpas bastions were located on the land that protruded from the mainland towards the sea (harbor arm, also known as the hook of Colombo (Mendis, 2017, pp. 56-69) and this part appears to have been built for the defense of the harbor. This area is the present-day entrance area to Colombo south port as well as the administrative buildings of the Port.

According to the Historical map, there was a moat constructed all the way from the south corner of the Leyden bastion to the Klippenburg bastion. However, no clue on the moat can be found in the present space.

4. Conclusion

Georeferencing is the process of tightening up a map or an aerial / satellite image with a known geographic coordinate system. Even though a map is compiled with its internal coordinate system, this cannot be shown on a digital platform without assigning a known geographic coordinate system by that respective digital platform. Maps have been used from the earliest periods of civilizations. However, till the development of modern-day GIS technologies, these historical maps have been treated only for their historical perspectives. However, georeferencing provides a way to digitize the historical map and overlay those on their respective places on earth.

The development of the Colombo city fortification traces back to the era of Portuguese colonization. The Dutch made the fort more fortlike and they produced many drawings, plans, and maps of this fortification. Unfortunately, apart from a few remaining, the Colombo fort has totally vanished from modern Colombo city. However, historical Dutch maps can be used to recreate the fortification of Colombo by georeferencing it.

The map which has been used to conduct this research was downloaded from the Dutch national archives. It was georeferenced and overlaid on the present-day satellite image on Google Earth. The accuracy of the overlaying process between the historical map and the satellite image was determined using the existing Dutch landmarks that are visible in both the historical map as well on the Google image. The result shows an insignificant difference between the places on the map and the Google image but it was not more than 7 meters of distortion.

Dutch Casteel has been divided into different blocks and still, the spatial arrangement of the Colombo fort area is similar to these blocks. However, except for the Dutch Hospital and the old warehouse, all other Dutch buildings have been demolished or destroyed. Other than that, there are a few places that have some remains of the Dutch fortification. Those cannot be used to get a clear idea about the extent and the arrangement of the Dutch fortification. However, the outcome of this research provides the base to understand the 17th-century Dutch fortification by overlaying different time periods.

5. Acknowledgment

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