A Landscape Analysis of Fortification in Tamil Nadu Using Satellite Images

Smriti Haricharan[1], N. S. Nalini[2], Sharada Srinivasan[1] and S. Ranganathan[1]

1. Heritage Science and Society Program, School of Humanities, National Institute of Advanced Studies, Indian Institute of Science Campus, Bangalore – 560 012, Karnataka, India *(Email: smriti.haricharan@nias.res.in, sharadasrini@nias.res.in, sranganathan@nias.res.in)*
2. NITTE School of Architecture, Gollahalli, Yelahanka, Bangalore – 560 064, Karnataka, India *(Email: arnalinins@gmail.com)*

Received: 20 July 2019; Revised: 17 September 2019; Accepted: 08 October 2019
Heritage: Journal of Multidisciplinary Studies in Archaeology 7 (2019): 195-210

Abstract*: The study aims to combine different sources of evidence, including literary and material along with remotely sensed images to identify defence structures from southern Tamil Nadu. The present study explores the possibilities of using the satellite images and ground verification in order to identify fortification at Vallam and Gangaikondacholapuram. The ability of the satellite images to give synoptic view has facilitated in identifying a possible outer ring for the previously known fort at Vallam, Tamil Nadu. Whereas IRS LISS 3 image of Gangaikondacholapuram, Tamil Nadu, does not show any traces of a fort though it has been reported in the literature, and it is not very clearly visible in Google earth images either. But Land sat 7 images of 2010 display a weak signature of the moat in a rectangular pattern. The paper uses landscape studies in conjunction with literary sources to posit a hypothesis on power and politics across the medieval landscape of Tamil Nadu.*

Keywords: Medieval Fortification, Satellite Imagery, Landscape Studies, Historical Archaeology, Gangaikondacholapuram, Vallam, Tamil Nadu

Introduction

Remote sensing has played a major role in the investigation of archaeological sites during the last few decades (Corrie 2011; Custer et al. 1986; Ebert 1984; Pappu et al. 2010; Siart et al. 2008). Contemporarily landscapes are situated within certain cultural or socio-economic contexts; however, this does not necessarily mean that they retain all or even some aspects of the past cultural or socio-economic contexts. Landscapes today may be different from what they may have been earlier or as in some cases have been totally altered and what we find may be certain geometric patterns such as vegetation or crop marks which could help us retrace the past landscape (Agapiou and Hadjimitsis 2011; Lasaponara and Masini 2005; Verhoeven 2011). These marks are not identifiable on the ground easily whereas the synoptic views provided by the aerial or satellite images pick up the patterns which distinctively stand out from the rest of the

landscape (Parcak 2009). Remotely sensed satellite images have played an important role in the archaeological studies of the forts, especially as they leave a distinctive vegetation pattern because of the presence of a moat (Rajani and Settar 2010; Sen 2013; Sparavign 2012; Thakuria 2013).

Deloche (2007) suggests that with regards to studies in India on fortification systems the British archaeologists of the 20th century, followed by the Indian archaeologists, concentrated mainly on Copper and Bronze age, for example the Harappan fortification systems, with little reference to the early historic period. Out of the 22 early historic cities with forts in India which he has researched, three are from southern India namely Sannati in Karnataka, Nagarjunakonda and Satanikota in Andhra Pradesh. He states that the 'Harrapan fortification plans of the cities show that their layout consisted of two distinct parts, on the one hand an urban zone, on the other hand, the citadel, generally located at a higher level whose defensive works varied depending on the site'. While in contrast generally the early historic fortification sites are not separate complexes, but one large entity located often to take advantage of natural settings (Deloche 2007). He further states that three main aspects of a fortification require attention, the rampart-ditch, the flanking towers and the gates. The '*Kautilya*'s *arthasastra'* includes instructions on building the moat, rampart and walls for cities (Dieter 2013). Lewis (2009) uses ethnographic sources to understand fortification plans in Karnataka, and he stresses on the need to combine archaeological information along with cultural historical narratives in order to understand them better. He also stresses on the need to explore their role beyond defence structure, he uses examples such as Chitradurga in Karnataka to discuss different ruler's preferences as well as the role of forts as symbols on the landscape.

This study concentrates on three different archaeological sites, Vallam which is an early historic settlement site, with a later fortification (Subbarayalu 1984) as well as Thanjavur and Gangaikondacholapuram, in both examples the settlement and the fortification have been dated to the medieval period (Vasanthi 2010) (Figure 1). This study looks towards satellite images to add to the existing information on these two sites, both sites have been excavated, and have epigraphical data to support the archaeological evidence. These sites are located within the modern towns by the same names, Vallam and Gangaikondacholapuram. Vallam is around 12 km southwest of Thanjavur city and Gangaikondacholapuram is 60 km north of Thanjavur city.

Subbarayalu (1984) states that from inscriptional evidence as well as from archaeological evidence that Vallam was occupied from the early historic period right through to the 18th century. Gangaikondacholapuram on the other hand was built in the 11th century by Rajendra I, though the excavation reveals there was habitation at this site as well in the early historic period (Vasanthi 2010). Vallam, Gangaikondacholapuram and Thanjavur have been historically associated with each other; Thanjavur also having a medieval fortification, as well as a temple built outside this fortification. Selvakumar (2012a) states that at Thanjavur, the moat around the

temple was perhaps dug during the late medieval period, when the fortification was part of defence strategy.

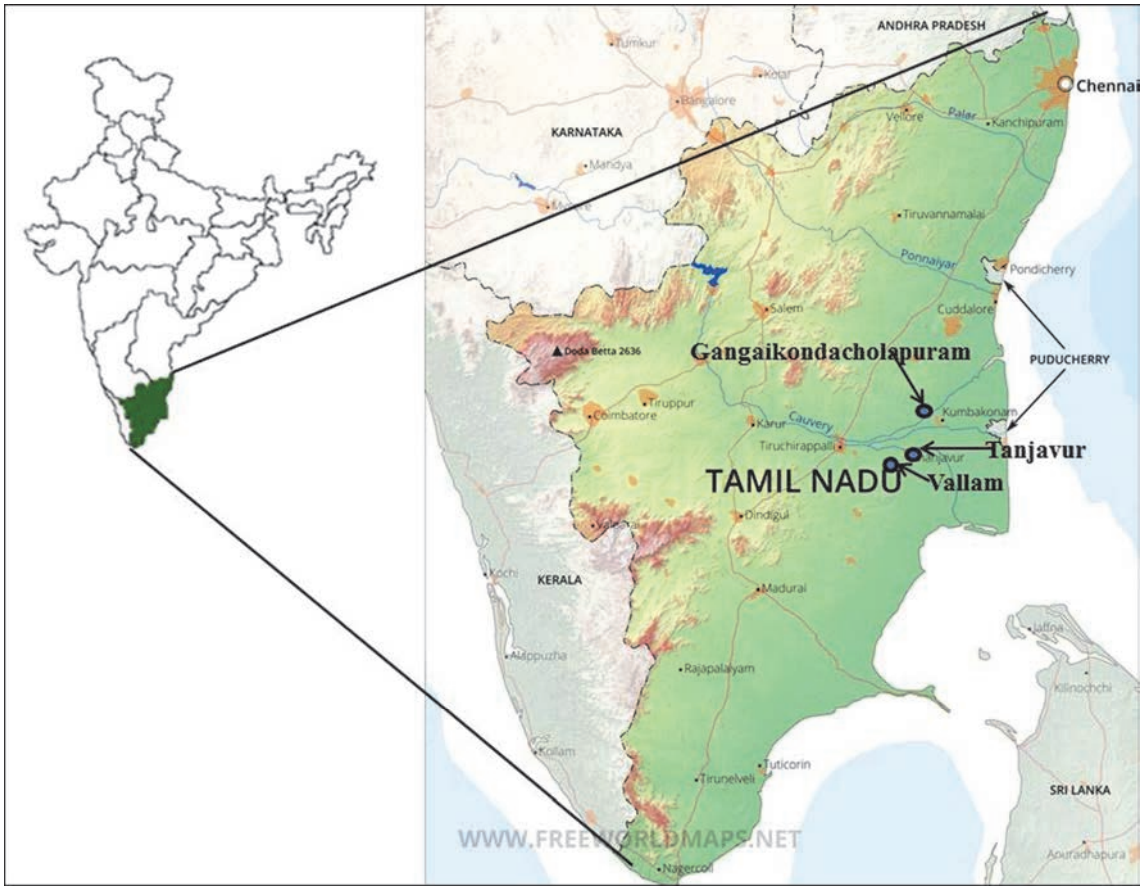

Figure 1: Map showing location of Vallam, Thanjavur and Gangaikondacholapuram, Tamil Nadu, India

Vallam: The History, Satellite Imagery and Archaeological Site

The earliest information from literary sources is through the ancient '*sangam*' literature which can be dated from around 300 BCE to 300 CE, the earliest samples which have been dated from the excavation at this site are 170 BCE thus, corroborating this date (Subbaryalu 1984). Excavations by Thanjavur Tamil University from 2013 near the *Vajeereshwarar* Temple (Selvakumar 2014) have revealed stratigraphic context similar to that at Pillayarpatti (Selvakumar et al. 2012b) with earliest levels of prehistoric tools, followed by Iron Age artefacts (identified by Black and Red Ware pottery and iron artefacts), followed by medieval artefacts (identified by coins, beads, iron artefacts) and remains from the more recent colonial context. Clearly this site has been in occupation over long periods, though its role may have varied, for example epigraphical sources suggest that it was possibly used as a treasury in the historical periods, and as an important mercantile centre during the medieval and post medieval periods (9th to 12th century CE) (Subbarayalu 1984). One of the trenches of the excavation at this site was laid specifically to understand the fortification, and subsequent 14C dates have

revealed that the first phase of construction of the fortification was the middle of the 7th century CE and excavation also revealed another phase of construction at a later period (Subbarayalu 1984). The moat mentioned here is clearly visible on satellite images, it is oval shaped and is 630m in length and 350m in average breadth (Subbarayalu 1984), however IRS LISS 3 MSS image has revealed a possible second fortification. Considering the historical evidence of this site having been an important mercantile centre and possibly acting as a treasury of sorts, this paper explores the identification of ground verification of the second fortification.

To understand the implication of satellite images in the study of selected archaeological sites various images of forts in southern India were analysed. After the preliminary analyses of Google earth images available in Digital globe, IRS LISS-3 and Cartosat images, purchased from NRSC were also examined for supplementary analysis. The study from the satellite images were further strengthened by the historical evidence available in the literature. The high-resolution image of Vallam from Digital Globe which is also natural colour composite clearly displayed inner fort, whereas the outer fortification is not clearly delineated (Figure 1). The upper half of the moat is presently filled with stagnated water whereas the lower half is dry and less discernible in satellite images. This may be due to the elevation difference in the terrain. The ground slopes towards the north and the height difference between the southern point and the northern point is around 10 m. Multispectral image of IRS LISS 3 shows the possibility of existence of an outer or second fortification (Figure 2a).

Multispectral scanners in the satellites are provided with three sensors to pick the infrared, red and green wavelengths of electromagnetic spectrum and these are projected in red, green and blue filters in the computers known as false colour composites (FCC). The reflection of vegetation is higher in the infrared region than it is in green band whereby the vegetation patterns are much more obvious in FCC images than in true colour images.

The fort layers as seen in the LISS3 image were digitised and overlaid on SRTM DEM. SRTM is an international project spearheaded by the National Geospatial-Intelligence Agency and NASA, and to obtain elevation data on a near-globe scale to generate complete high resolution digital topographic database of the Earth (JPL). SRTM DEM is available at 3 arc second resolution which is 90m spatial resolution. Figure 3 shows the Digital Elevation Model (DEM) of the study area and the location of Vallam fort with reference to the fort of Thanjavur and the river system (Figure 2b). Both are located on an elevated area and away from the river. The elevation of the settlement and the presence of the water bodies perhaps tell us that the moat was fed from rain and ground water.

Vallam: Was there Another Moat?

To support the analysis done using satellite images and to obtain more evidence, field visits were carried out. After identifying the second fortification on the satellite image

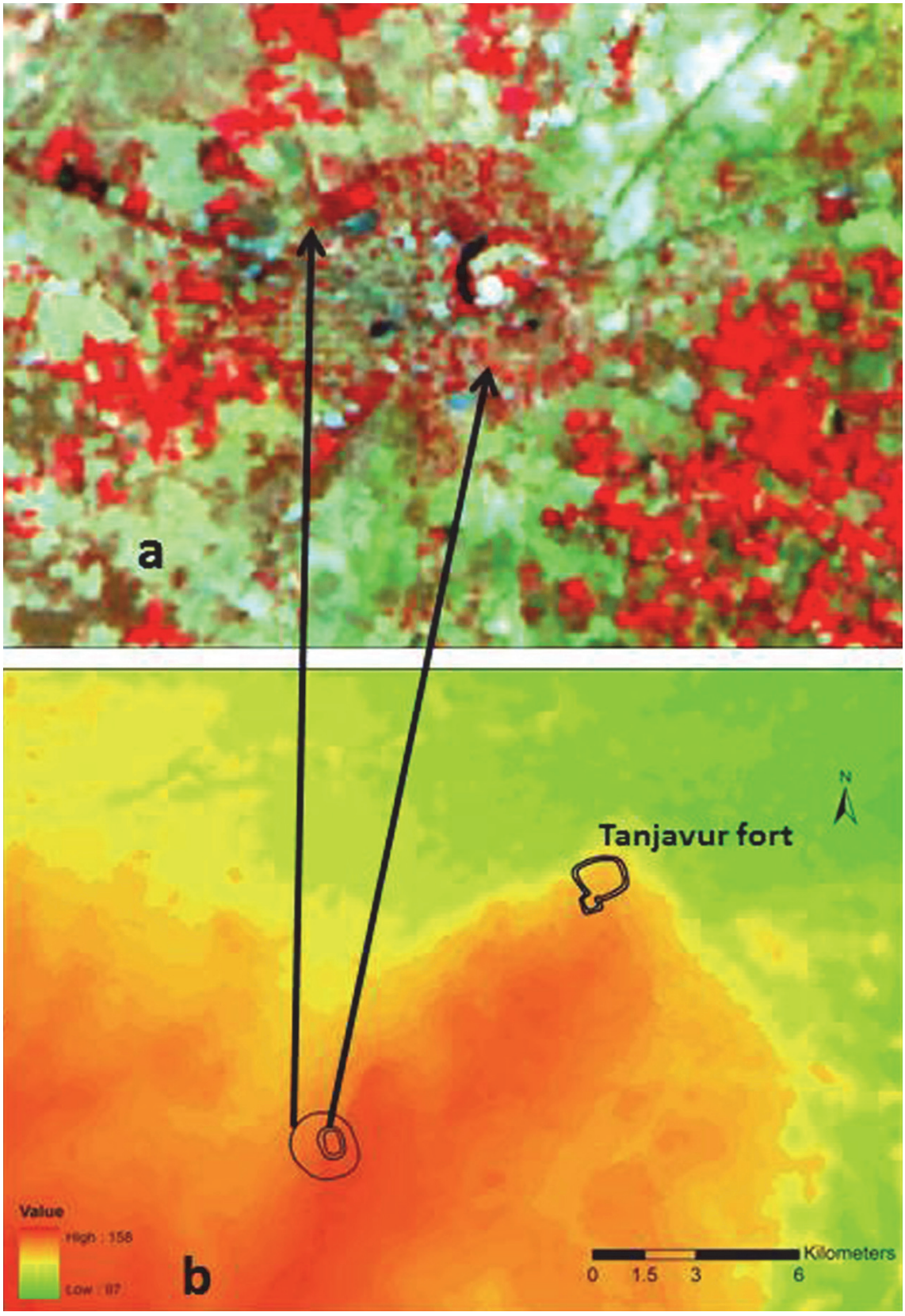

Figure 2 (a): Vallam: A possible second fortification seen through satellite images LISS III, (b): DEM showing Vallam and Thanjavur

Figure 3 (a): Google Earth image of Vallam showing tracks and points from the field, (b): Photo of ditch at Vallam as seen on the ground

for Vallam, 12 points were located on Google Earth. These points were uploaded into the Garmin e-trex GPS, and were relocated by navigating in the field. The points are labelled in Figure 3a as Vallam 1 to Vallam 6. The signature of the second moat as seen in satellite images is far less clear on the ground. From interviews conducted at the study area, local memory reinforced the existence of the oval shaped moat and that it was believed to have been rainwater fed. This could also be explained through the DEM image (Figure 3), as well as exploration report of Subbarayalu (1984) where it has been clearly noticed. The inner fort at Vallam has slight downward slope from the north to the south, explaining why one half of the oval fort is more clearly visible than the other. One of the field points, Vallam 5 was located in the south and on top of an outcrop which provided a good vantage point for the area around. From the *Google Earth* image it seemed that the area in the northwest was most likely to have any clear signatures on the ground (Figure 3a). In fact, between Vallam field points 1 and 2 was an area of land which looked like a possible moat. During exploration in the field it was noticed that in this area the more prominent depressions ran in the east west direction, and while there were shallow depressions in a more north south axis, these were much harder to discern (Figure 3b). These were identified as dried up water channels or pathways running into the city, these channels run east to west and can be seen on *Google Earth* images. The previous year, an excavation had been conducted near a temple, and most of the pottery pieces recovered was from this area.

Gangaikondacholapuram: The history

Gangaikondacholapuram was built around 1025 CE, by Rajendra I and functioned as a capital of the Chola rulers for about 250 years (Nagaswamy 1979; Prichard 1995). The history of this city is known from epigraphy and archaeological evidence. Nagaswamy (1980) states that after 250 years of Chola rulers, the city was attacked by the Pandyas (neighbouring political rivals of the Chola kings) and an inscription of a Pandya king is found at the Gangaikondacholapuram temple from 1251 CE. The city passed through a succession of different political rulers till finally in 1801 it was annexed by the British. It is believed that the temple suffered some amount of damage from being used as a fort during the time that it was under the British (Nagaswamy 1979). The excavation conducted in this area included trenches laid at the centre of the fort at a village called Maligaimedu (Vasanthi et al. 2011). Rajavelu (1996) suggests that the suffix 'medu' refers to mound and is generally indicative of an early historic settlement. Prichard (1995) describes the outer enclosure as measuring 1900x1359m with a wide moat. He also states that the inner rampart which surrounded the palace area was like the outer fort wall made of bricks; however, it is unclear whether it ever had a moat (Prichard 1995). Vasanthi (2011) states that dating using magnetic studies suggests that the samples from the earliest occupation levels were dated to around 500-600 CE. Prichard (1995) suggests that the fort walls were built with bricks and had wooden poles placed on them. Vasanthi (2011) suggests that it could be as early as 100 CE due to the occurrence of Black and Red Ware at this site, however this pottery is known to be problematic for relative dating (Haricharan et al. 2013). While the existence and

location of the inner and outer fort walls and a possible moat was known, interestingly neither was visible either on Google Earth or satellite images.

Figure 4 (a): Google Earth image showing Gangaikondacholapuram with GPS tracks, (b): Photo of possible moat in the form of paddy field and raised foot path at Gangaikondacholapuram

Gangaikondacholapuram: Satellite Imagery and Archaeological Site

The fort at Gangaikondacholapuram does not show any vegetation mark in Google Earth (Figure 4a) and neither had there any patterns resembling a moat or fort wall located using higher resolution LISS 3. But when the region was examined in a Landsat 7 image with band combination of 4, 5 and 3 a very faint rectangular shape is visible on the landscape, close to the huge water body and next to the temple (Figure 5). The location can also be determined by the location of roads which are comparable with Google Earth image.

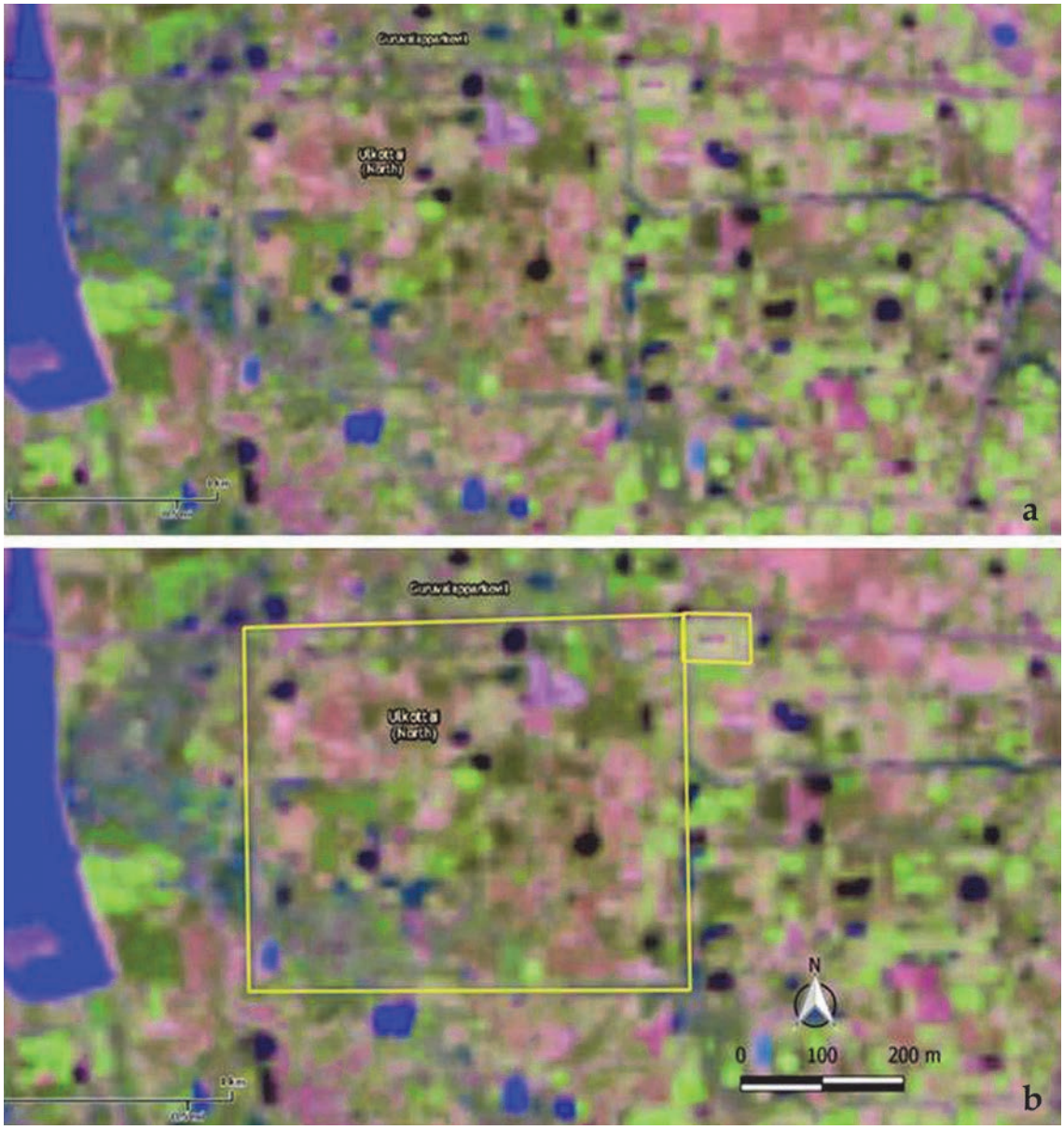

Figure 5 (a): Landsat 7 image of 2010 of Gangaikondacholapuram, showing weak signature of moat and temple, (b): Digitised lines of moat and temple of Gangaikondacholapuram

Figure 6 (a): Exposed section by the side of the path seen in figure 4b, (b): Pottery and tiles collected from surface of the path

Landsat images with different band combinations for delineating land/water boundary, vegetation analysis and infrared images are available from 1970 to 2010 in ESRI website (link given in References). Land/Water image maps display the near infrared band (4) in red, the mid infrared band (5) in green and the red band (3) in

blue. The Land/Water Boundary image map is very similar to the Healthy Vegetation image map. The only difference is that red band (3) rather than the blue band (1) is displayed in blue. However, the image will seem sharper because the shorter wavelength, and bands (1 and 2) are omitted. Vegetation appears as variations of reddish brown, green, yellow, and orange (ESRI). The Landsat 7 data is corrected for Scan Line Corrector (SLC) errors. It was enhanced with radiometric correction and histogram stretching to make more visually appealing. This combination offers added definition of land-water boundaries and highlights subtle details not readily apparent in the visible bands alone. Inland lakes and streams can be located with greater precision when more infrared bands are used. This combination demonstrates moisture differences and is useful for analysis of soil and vegetation conditions.

Gangaikondacholapuram: View of the Fortification from Field

As in the case study of Vallam, in this case study as well once the image of the fortification was noticed on the satellite image for Gangaikondacholapuram six points were located on Google Earth. These points were fed into a GPS and located in the field. The points are labelled in Figure (4) as GKC 1 to GKC 6. During field work the identified fortification wall from the northeast corner to the end of the southeastern corner was traversed by foot. The north eastern corner was located near the Chola temple named Gangaikondacholapuram temple and known to have been built by Rajendra I. At this point numerous pottery pieces and tiles were located. Approximately 500 m south of this point and along what could be the fort wall a section with pottery pieces was also located (Figure 6). The whole of the length of this possible fortification wall was a raised foot path, and to the east of this path a series of water bodies was noticed (Figure 4b) and this could also be seen on the Google Earth image. This could possibly be signatures of what was originally a moat, as seen from the image published in Prichard (1995).

Vallam and Gangaikondacholapuram: Discussion

Excavations done in Sendamangala, Villupuram District, Tamil Nadu show a rectangular fortification and it is found that the fort was made of two walls filled in with river sand (Vasanthi et al. 2011). Similarly, a fort wall was also noticed at Padavedu, Polur Taluk, Tamil Nadu of the dimensions 76x60 cm, 53x60 cm and 58x62 cm, height and breadth of 1.15m and 2.45 m, made of granite (Kasinathan 1993). In this particular site, local sources at the present-day village believe that there were two fort walls called *Chinakkottai* (small fort) and *Periakottai* (big fort) (Kasinathan 1993). The Thanjavur fort, Thanjavur District, Tamil Nadu is believed to have been modified during the Nayak period and maintained during the Maratha occupation of Thanjavur, it is also believed that terracotta pipes were used to circulate water through the fort from important water sources (Chakravarthy 2010). Building more than one fort wall as a defence strategy is not unusual in Tamil Nadu. In fact, this is a pattern noticed at many historic fortifications in India, depending on the importance of the site (Rajani and Settar 2010). The historic evidence for both sites suggests that they were both

inhabited from the early historic period of Tamil Nadu and were important sites which may have had more than one defence wall around them. Deloche (2007) says that at Trichchirapalli District, Tamil Nadu, the defence structure increased in size over time due to growth in population. He states from studying four fortification structures in Tamil Nadu that the forts of Tamil country largely remained faithful to the older traditions, even after the invention of fire arms. Pichard (1995) has also observed that with regards to temples being located outside the fortification as noticed at Gangaikondacholapuram, this is probably due to the ancient texts which prescribe that the Siva temple should be in the northeastern corner.

Each archaeological site differs in its topographical conditions, soil moisture content, vegetation pattern and even configuration. Remote sensing is one method for analysing archaeological sites, within which different satellite images can be used for studying these sites. As we see in the case of Vallam infrared high-resolution images were more helpful than Google Earth or Landsat images. But in Gangaikondacholapuram coarse resolution images with different band combinations are helpful in picking the subtle details than high resolution images. Deloche (2007) has described using maps from later colonialists the forts at Trichchirapalli and Plaiyamkottai; the Google Earth images at these sites, much like Gangaikondacholapuram are barely visible today. All signs of the existence of these forts have been obliterated in these cases due to urbanization. We do have archaeological evidence at both Gangaikondacholapuram and Vallam which shows that the fort walls were built with bricks, and were also renovated over time (Nagasawamy 1970; Subbrayalu 1984). Prichard (1995) also states that villagers around Gangaikondacholapuram have been using the bricks from Maligaimedu for contemporary house building activities.

Deloche (2007) reports that 18th century observers have stated that at Thanjavur the ditches around the moat were not deep enough and therefore harder to fill with water. In Vallam the oval fort shows a similar pattern whereas the outer one does not currently retain any water. Therefore, the outer tier might be harder to locate today because the moat around it may not have been deep enough when constructed, or it could be the long period of disuse, since current local memory does not recall such a fort wall. But because of the slope of the site lower part of the fort on the northern side show better vegetation than on the southern side, this has also been noticed during the excavation by Subbarayalu (1984). On other hand at Gangaikondacholapuram though it is a historic site with a temple dating to 11th century AD much later than Thanjavur and Vallam signs of the existence of a fort and moat have almost totally disappeared except for few water bodies existing in the place of the possible moat.

The names of villages or town or other features such as tanks or ponds could help indicate the possible layout of the fortification. Nagaswamy (1979) suggests that the names of villages located on the east of the Gangaikondacholapuram temple recall their association with the original layout of the city, namely *Vira cholapuram,*

Kollapuram, Meykavalputhur, Vanavanallur, Virabhogha, etc. However, another interesting village name is that of *Ulkottai* meaning inner fort, which is located to the south, just outside what would have been the fortification wall. It is also interesting that Vallam has been referred to as Vallam Kottai in 1659 CE and it has also been described as being located on top of a steep rock (Subbarayalu 1984). During the exploration it was noticed that VF 5 was located on an elevated area, or outcrop. It has also been noticed that a lot of the place names of villages to the east and south east end with Kottai, such as Nanjikottai and Soorakottai. However, Rajavelu (1994) states that the Chola kings had introduced a new system of naming and in some cases renaming villages for the sake of administrative convenience. He also adds that they often named villages after the personal titles of the king. Therefore, the term kottai may not be significant in terms of administration or economy of the Cholas.

Conclusion

The terrain influences the visibility of archaeological remains on the satellite image; however along with spatial aspects temporality also needs attention. The division into periods such as early historic and medieval while being useful can also mean that we divide the landscape into artificial divisions which can obstruct the long term understanding of landscape changes. Interactions with the landscape as well as decisions made in terms of place or locations can be better understood by landscape analysis across periods. The fortification identified at Vallam has not been earlier reported. The fort at Gangaikondacholapuram has completely disappeared whereas the fort at Thanjavur is better retained than the rest on the present landscape.

However, the use of fortifications to act as symbolic locations of power is an aspect which needs to be better understood. Are fortifications only motivated for defence or also meant to signify changes in territories and power, understanding not just their context within the landscape, but also their immediate socio-cultural and economic aspects and histories become as integral to research on fortifications as locating them on the landscape through satellite image. The move of the building of a fort may have been both a defence as well as administrative move during the medieval period.

Remote sensing clearly indicates that the landscape geomorphology and elevation implies that both Vallam and Thanjavur are located at a higher elevation seemingly providing better defence positions. On the other hand, Gangaikondacholapuram is located at a lower elevation. The study also brings attention to the fact that multi-spectral and multi-spatial satellite images collaborated with archaeological and epigraphical evidence can contribute immensely to field studies in archaeology. There is also a need for an integrated approach that takes into account developing technological advancements in what satellite images are used and the context in which they are used while at the same time integrating them with existing historical and archival material. As Petrie et al. (2019) draw attention to the toposheets and their use in archaeological field work and analysis, a source used often by archaeologist in India but maybe undervalued in light of current interests in satellite imagery.

Acknowledgements

We thank Dr. Rajawat, ISRO for all the help provided. We also thank Dr. V. Selvakumar, Tamil University, Thanjavur and Dr. S. K. Aruni, ICHR for sharing their research experiences and guidance.

References

Agapiou, A., and D. G. Hadjimitsis 2011. Vegetation Indices and Field Spectro-radiometric Measurements for Validation of Buried Architectural Remains: Verification under Area Surveyed with Geophysical Campaigns. *Journal of Applied Remote Sensing* 5 (1): 053554. doi:10.1117/1.3645590.

Chakravarthy, P. 2010. *Thanjavur: A cultural history*. Niyogi books, Delhi.

Christoph, S., B. Eitel and D. Panagiotopoulos 2008. Investigation of Past Archaeological Landscapes Using Remote Sensing and GIS: A Multi-method Case Study from Mount Ida, Crete. *Journal of Archaeological Science* 35: 2918–2926.

Deloche, J. 2007. Studies on Fortification in India. *Ecole Francaise D' Extre'me-Orient* 104:

Dieter, S. 2013. *Fortified Cities of Ancient India: A Comparative Study of Cultural, Historical and Textual Studies of South Asian Religions*. Anthem South Asian Studies. Anthem Press, New York.

ESRI website "Landsat imagery". Accessed June 7, 2014. *http://www.esri.com/software/landsat-imagery/viewer.*

Haricharan, S., H. Achyuthan and N. Suresh 2013. Situating Megalithic Burials in the Iron Age-Early Historic Landscape of Southern India. *Antiquity* 87(336): 488-502.

James, E. I. 1984. Remote Sensing Applications in Archaeology. *Advances in Archaeological Method and Theory* 7: 293-362.

Jay, C. F., T. Eveleigh, V. Klemas, and I. Wells 1986. Archaeology Application of LANDSAT Data and Synoptic Remote Sensing to Predictive Models for Prehistoric Archaeological Sites: An Example from the Delaware Coastal Plain. *American Antiquity* 51(3): 572-588.

Jet Propulsion laboratory, California Institute of Technology. Last updated April 28, 2005. *http://www2.jpl.nasa.gov/srtm/.*

Kasinathan, N. 1993. *Padavedu Excavation*. Department of Archaeology, Chennai.

Lasaponara, R. and N. Masini 2005. QuickBird-based Analysis for the Spatial Characterization of Archaeological Sites: Case Study of the Monte Serico Medieval Village. *Geophysical Research Letters* 32(12).

Lewis, B. 2009. Village Defenses of the Karnataka Maidan, AD 1600–1800. *South Asian Studies*, 25: 91-111.

Nagaswamy, R. 1979. *Gangaikondacholapuram.* State Department of Archaeology. Government of Tamil Nadu.

Pappu, S., K. Akhilesh, S. Ravindranath and U. Raj 2009. A Forgotten Heritage: Impact Assessment Studies at Prehistoric Sites in Tamil Nadu. Paper presented at the *Space, Time, Place: Third International Conference on Remote Sensing in*

Archaeology, Tiruchirappalli, Tamil Nadu, India, August 17-21.

Parcak, S. H. 2009. *Satellite Remote Sensing for Archaeology*. Routledge, London.

Petrie, C., H. Orengo, A. Green, J. Walker, A. Garcia, F. Conesa and R. Singh 2019. Mapping Archaeology while Mapping an Empire: Using Historical Maps to Reconstruct Ancient Settlement Landscapes in Modern India and Pakistan. *Geosciences* 9(1): 11.

Prichard, P. 1995. *Tanjavur Brihadisvara: An Architectural Study*. Ecole D francis ND and Pondicherry IGNCA, Pondicherry.

Rajani, M. B., and S. Settar 2010. Application of Multispectral Remote Sensing Imagery in Detection of Ancient Forts in South India. *BAR–S2118*: 123-127.

Rajavelu, S. 1994. Place Names of Archaeological the Chola Period. In M. D. Sampath and S. Swaminathan (Eds.) *Studies in Indian Place names* Vol 15. The Place Names Society of India. Geetha Book House publishers, Mysore.

Rajavelu, S. 1996. Place Names of Archaeological Importance. In M. D. Sampath and S. Swaminathan (Eds.) *Studies in Indian Place names* Vol 16. The Place Names Society of India, pp. 100-103. Geetha Book House publishers, Mysore.

Robert, C. K. 2011. Detection of Ancient Egyptian Archaeological Sites Using Satellite Remote Sensing and Digital Image Processing. *Proceedings at SPIE 8181, Earth Resources and Environmental Remote Sensing/GIS Applications II*, 81811B. October 27, 2011. doi: 10.1117/12.898230

Selvakumar, V. 2012. Heritage Management Plan for the Rajarajaswaram Temple, the World Heritage Monument at Thanjavur: A Few Suggestions. *Tamil Civilization* 24: 3-4.

Selvakumar, V. 2014. Vallam Excavation-2013: Brief Account of the Excavations of 2013 at Vallam. *Aavanam* 24: 146-147.

Selvakumar, V., S. N. Rajaguru, and R. Jhaldiyal 2012. Palaeolithic Occupation of Southern Tamil Nadu, India: New Evidence from South of the River Kaveri. *Quaternary International* 269: 74-86.

Sen, B. 2013. Structural Remains at the Early Mediaeval Fort at Raibania, Orissa. *Ancient Asia* 4: Art-8.

Sparavigna, A. C. 2012. *The Fortresses of Ejin: An Example of Outlining a Site from Satellite Images*. arXiv preprint arXiv:1210.7631.

Subbarayalu, Y. 1984. Vallam Excavations. *Tamil Civilization* 2 (4): 8-98.

Thakuria, T., T. Padhan, R. K. Mohanty and M. L. Smith 2013. Google Earth as an Archaeological Tool in the Developing World. An Example from India. *The SAA Archaeological Record*. January; 20-24.

Vasanthi, S. 2010. Excavation at Gangaikondacholapuram, the Imperial Capital of Rajendra Chola, and its Significance. In H. Kulke, K. Kesavapany and V. S. Manohar (Eds.) *Nagapattinam to Suvarnadwipa: Reflection on the Chola Naval Expeditions to Southeast Asia*. Institute of southeast Asian Studies, Singapore.

Vasanthi, S., V. Ramamurthi, M. Kalaivanan and S. Sreekumar 2011. *Sendamangalam in Archaeological Excavation on Tamil Nadu*. Vol. 1. Department of Archaeology, Chennai.

Verhoeven, G. J. 2011. Near-Infrared Aerial Crop Mark Archaeology: From its Historical Use to Current Digital Implementations. *Journal of Archaeological Method and Theory* 19: 132–160.