Stone fortress of Chitledroog: visualizing old landscape of Chitradurga by integrating spatial information from multiple sources

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The city of Chitradurga, known for its seven-tiered stone fort, is situated in Chitradurga District, central Karnataka. This city consists of many ancient temples and monuments interspersed between the strong stone layers of the hill fort. Enormous amount of information is available about these historical structures in the form of literary texts, old paintings, old photographs and old maps. This article discusses the methods of integrating the information from different sources using the GIS platform, thereby studying the change in the landscape over a period of time. In this study, an old surveyed map prepared by a British officer in AD 1800 is used. This map is georeferenced and the required information is extracted by digitizing the necessary layers of information. Three-dimensional perspective views of the hill fort similar to old paintings were simulated using digital elevation model, thereby analysing the changes in land use and modern development in the vicinity of the hill fort.

Keywords: Chitradurga hill fort, old map, old painting, 3D visualization, spatial data integration.

History

CHITRADURGA (was called Chitel-Droog by the British) is located 202 km to the northwest of Bangalore in Chitradurga District, central Karnataka. The geology of this region consists of textually mature quartz-rich sand stones, textually mature, mafic-rich sand stones and textually immature grey wackes[1]. The city is popular for its 16th century AD stone fortress on the rocky hill. One can find temples dedicated to Indian mythological characters such as Hidimba, Bhima and Arjuna. The city has legendry connections with *Mahabharata*; it is said that the temple of Gopalakrishna was built by Janamejaya, grandson of Dharmaraya. This place was ruled by many dynasties. Edicts of Emperor Ashoka of the 3rd century BC were found near Molakalmuru, a taluk in the same district. To the west of Chitradurga, there was once an ancient city called Chandravalli, where excavations revealed the presence of a prehistoric city. To the south of the city there is a magnificent fort built in between rocky boulders. The original fort is said to have had seven tiers. Three lower tiers are adjacent to the hill and four tiers are on the hill. The first tier has four doors: *Rangaiyyana bagilu* (Rangaiyya's gate) on the east; *Santhe bagilu* (market gate) on the north; *Seenirina hondada bagilu* (sweet water pond gate) on the northwest and *Lal Kote Bagilu* (red fort gate) on the south. The fort walls were constructed by *Paleyagaras* (local rulers) and later strengthened by Hyder Ali and Tippu Sultan. There are 14 important temples in the fort. Among them Hidimbeshwara, Ekanatheshwari, Sampige Siddeshwara, Gopalakrishna and Phalguneshwara are the important ones. *Maddu bisuva kallu*, huge grinding stones used for making gun powder, were installed by Hyder Ali and Tippu Sultan. *Onake Obavvana Kindi* (Onake: pounding stick, Obavva: name of a lady, Kindi: secret passage) is on the west side of the fort. Obavva was a valorous woman who killed many enemy soldiers (AD 1779) who were stealthily entering the fort. The old Chitradurga town, comprising of Chikpete (small town) and Doddapete (big town) are on the northeastern side of the hill. This town was called Sulgallu during the Chalukya period (6th–12th century AD); Bemmattana kallu, Bramhagiri, Perumalepura during the Hoysala period (10th–14th century AD) and Chitrakaldurga, Chitradurga during the Vijayanagara period (14th–17th century AD). Hyder Ali named it FarooqYab Hissar and Tippu Sultan named it Farooqabad (18th century AD). Caves formed by the huge projected boulders house the Hidimbeshwara, Ekanatheshwari and Sampige Siddeshwara temples. The architecture of the shikaras is of Chalukyan style. The Navaranga and Mukha mandapa which are projecting

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out of the rock are later additions by the Hoysalas. Two huge gopurams in front of Hidimbeshwara and Siddeshwara are said to be built by Mallanna Odeya of Vijayanagara[2].

Focus of research

The Chitradurga fort signifies fame, prosperity and heritage of Karnataka. Lot of information about the fort is available in the form of research papers, publications, documentary films and also on the internet. Old maps, paintings and photographs also give us information about historic places which are lost or ruined. Lectures and seminars are conducted to create awareness among the people about the value of our heritage. But due to lack of proper management the heritage site is getting encroached by dwellers. Cultural resource management activities for this site should be planned and implemented in order to increase public awareness and attract tourists.

Objectives

GIS is a platform where data from different sources can be integrated to develop a complete information system. The main objectives of the present study are: (1) To use information from spatial and nonspatial sources, such as old maps, paintings and historical texts along with recent satellite images to ascertain the changes in the landscape and therefore analyse the extent of encroachment and destruction of the heritage site due to modern development and urbanization. (2) To map the whole fort area with monuments and develop a GIS database for the site.

Methodology

Google Earth images of this area are of very high resolution; most of the high-resolution satellite imagery in Google Earth Maps is the DigitalGLobe Quickbird, which is roughly 65 cm pan-sharpened (65 cm panchromatic at nadir, 2.62 m multispectral at nadir). The area of interest was marked in Google Earth and several scenes covering the area with closer zoom were extracted. The zoom was adjusted to get a clear view of the temples and monuments. The scenes were mosaiced in Photoshop and georeferenced with Google Earth coordinates using Erdas Imagine 9.2 software. The old surveyed map was downloaded as a high-resolution image to get good clarity. The same procedure was followed to get the mosaiced image and georeference with the Google Earth image. All the layers of the fort walls along with the monuments, water bodies, moats, pathways and roads were digitized using Geomatica software.

Data sources

Spatial data were obtained from Google Earth images and Survey of India (SOI) toposheets. Old surveyed maps of Chitradurga which are available in the British library website were used[3–5].

Reconstruction of the fort using old map

The old map of AD 1800 (Figure 1), prepared by British surveyors, shows all the tiers of the fort with remarkable clarity. Apart from the well-known seven tiers of the fort, one more tier, a mud fort wall, outside the first one can be noticed. The existence of this wall is perhaps not documented anywhere in the literature. This wall starts from the northeast corner of the first tier and runs to a short distance in the northerly direction. Then it turns west, which is a long stretch and ends with a small hillock comprised of huge boulders. The Google image does not show any traces of this wall. But Figure 1 gives us an idea about the original total extent of Chitradurga fort. The map legend mentions that this mud-wall enclosure of the petta is entirely uninhabited since the war of 1791–1792. The settlement, Doddapete and Chikkapete (referred to in some of the books), which was within the

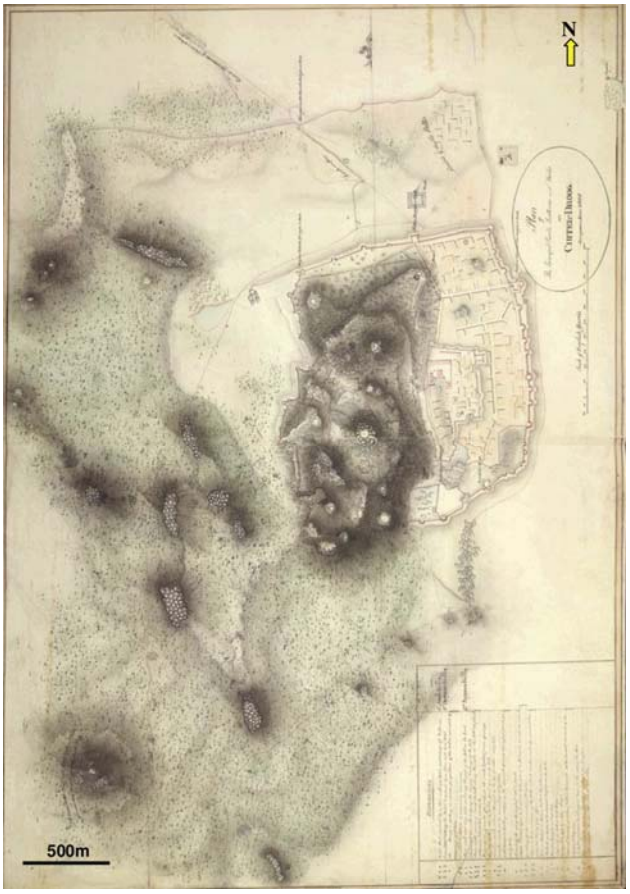

Figure 1. Old map of Chitradurga surveyed in 1800 (ref. 3).

fort, can be easily identified. This map was georeferenced with Google Earth coordinates. The clearly visible fort walls were digitized as different layers (Figure 2). The vector layers were then overlaid on the Google Earth image. Considerable shift can be noticed which may be because of the different map projections used. Scales of the two images were also different, which added to the shift. SOI toposheets have polyconic projection and Everest datum and GPS and Google Earth both use WGS 84 datum and geographic spherical projection.

The fort layers that were overlaid give an idea of the present condition of their locations. The urban development can be seen on either side of the outermost tier for a distance of 500 m inside and around 1.5 km outside on the east. On the north it spreads 300 m inside and around 1.75 km outside the outermost tier. It is almost engulfing the heritage site slowly. Many of the heritage sites in India are on the brink of destruction due to uncontrolled urbanization[6]. The mud fort wall coincides with a part of the national highway to a certain extent, whereas the moat outside the first layer also matches with the road close to it. The walls of the first layer have got completely destroyed leaving some ruins on the southern side of the fort. The doors on the east and north have been restored fairly well, whereas the southern and northwestern doors are in bad condition. This enclosure was supposed to have 32 batteries according to the legend given in the map. The second tier has completely disappeared without leaving any trace, though the second entrance door is still standing after restoration. The existence of Tippu Sultan's palace within this enclosure is recorded in several literary records[2] as well as in the old map. The third doorway which at present has become the main entrance to the fort, stands as testimony to the grandeur of the lost empire. The moats of the first three tiers have completely disappeared. The other tiers (fourth, fifth, sixth and seventh) of the fort have been restored fairly well along with the doorways.

Only few monuments are shown in the map among the ones that are existing in the fort. The pathways that were used to enter the fort and the roads are clearly marked in the map, which gives a good comparison with the present modifications in the layout.

On the contrary, one would see more details of the fort in Google Earth than in the old map. For instance, there are more number of bastions in the southern part of the fort seen in the Google Earth image (Figure 3 *a*) than what is shown in the old map (Figure 3 *b*). The reason for this could be that this part of the hill is very steep and has

Figure 2. Old map overlaid with digitized layers. The numbers indicate the different tiers of the fort.

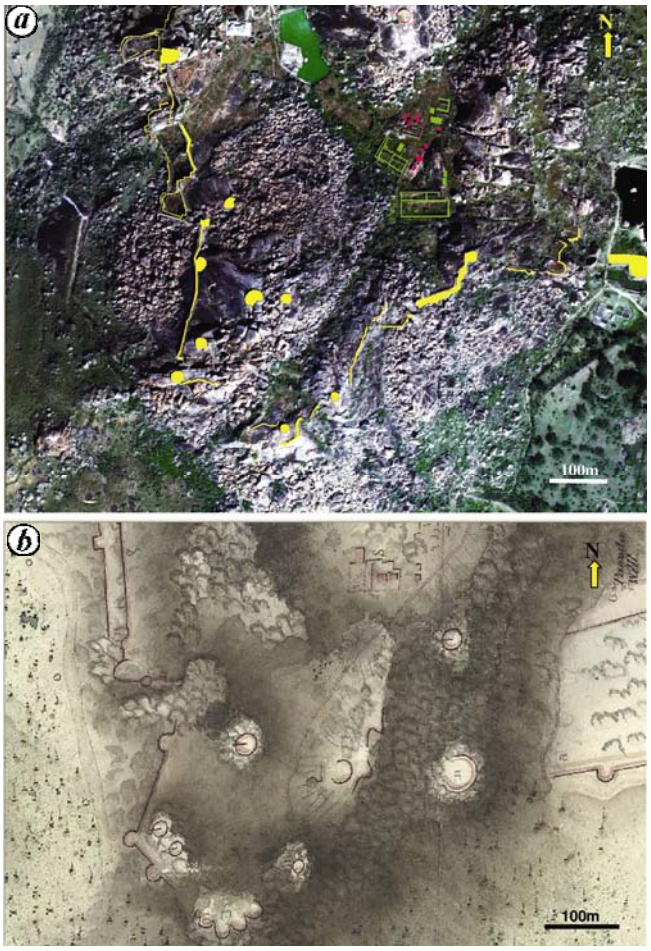

Figure 3. Google Earth image showing more remnants (***a***) than the old surveyed map (***b***).

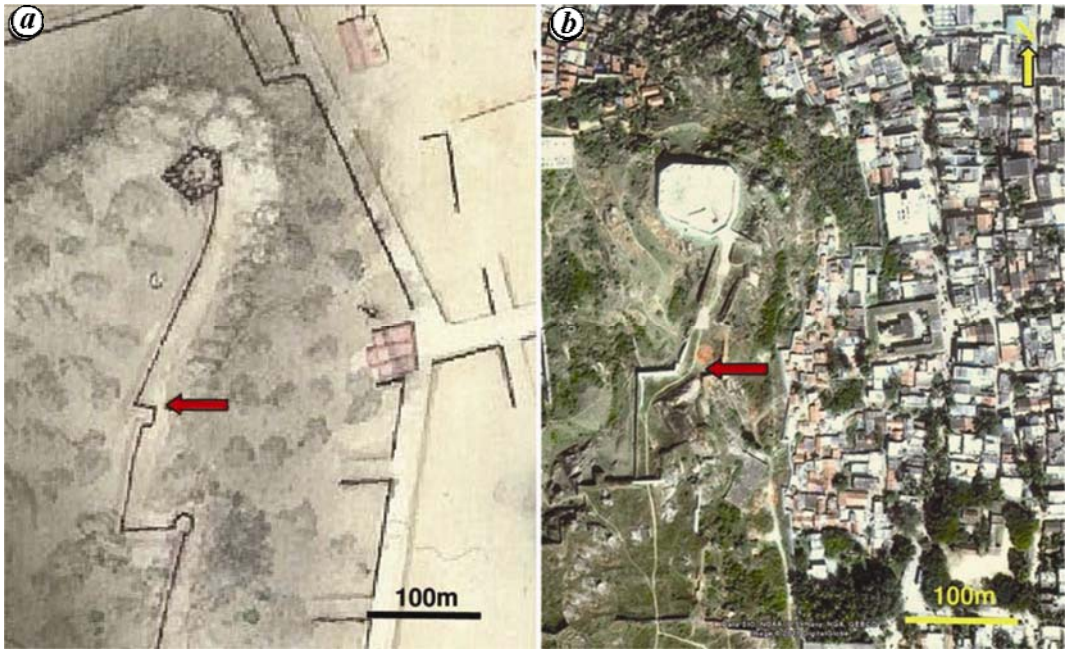

Figure 4. Differences in the fort wall layout can be seen between two scenes. See red arrow. ***a***, Old map with *Basavana Buruju*. ***b***, Google Earth image of *Basavana Buruju*.

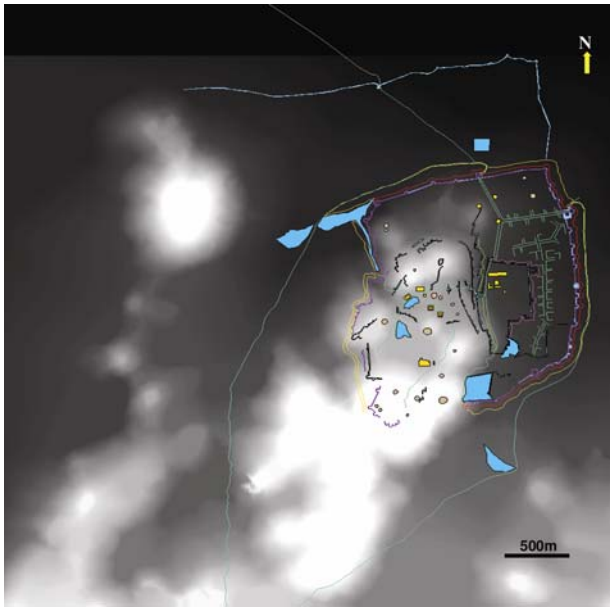

Figure 5. Digital elevation model overlaid with digitized layers from the old map.

the highest elevation. Legend of the old map also mentions that this is the highest point or rock. The rugged terrain might have made surveying very challenging for the British. Using satellite images for mapping such terrains may be more beneficial.

In recent years the Archaeological Survey of India (ASI) has taken up conservation of the fort and has rebuilt the walls in many places. While rebuilding one needs a reference drawing or a map to do the work properly. Reference to the old map would have helped the authorities in the reconstruction of the fort walls more accurately. Differences in the layout of the walls can be seen between the two maps; for example, near the *Basavana Buruju* shown in the Figure 4.

Digital elevation model

Digital elevation model (DEM) was generated using the topographical map to understand the topography of the terrain. There are many different ways of generating DEM, some of which have been discussed in the literature[7,8]. The 20 m contour interval provided by the topographical map along with the spot heights were used for generating DEM. GPS readings collected during the field visit were also used. The digitized fort walls were then overlaid on DEM to see the location with respect to the position of the hills (Figure 5). It is interesting to see that the fort was intended to be built between the hills, thereby using them as natural boundaries. This strategy can be seen at the higher levels of the fort also.

Views to match old paintings with the help of virtual reality

Virtual reality is a tool widely used for studying old landscapes for example, Takase *et al.*[9] have used virtual reality to model the city of Kyoto from the 20th century to the 17th century. For the present work on Chitradurga a virtual fly-through was generated by overlaying the

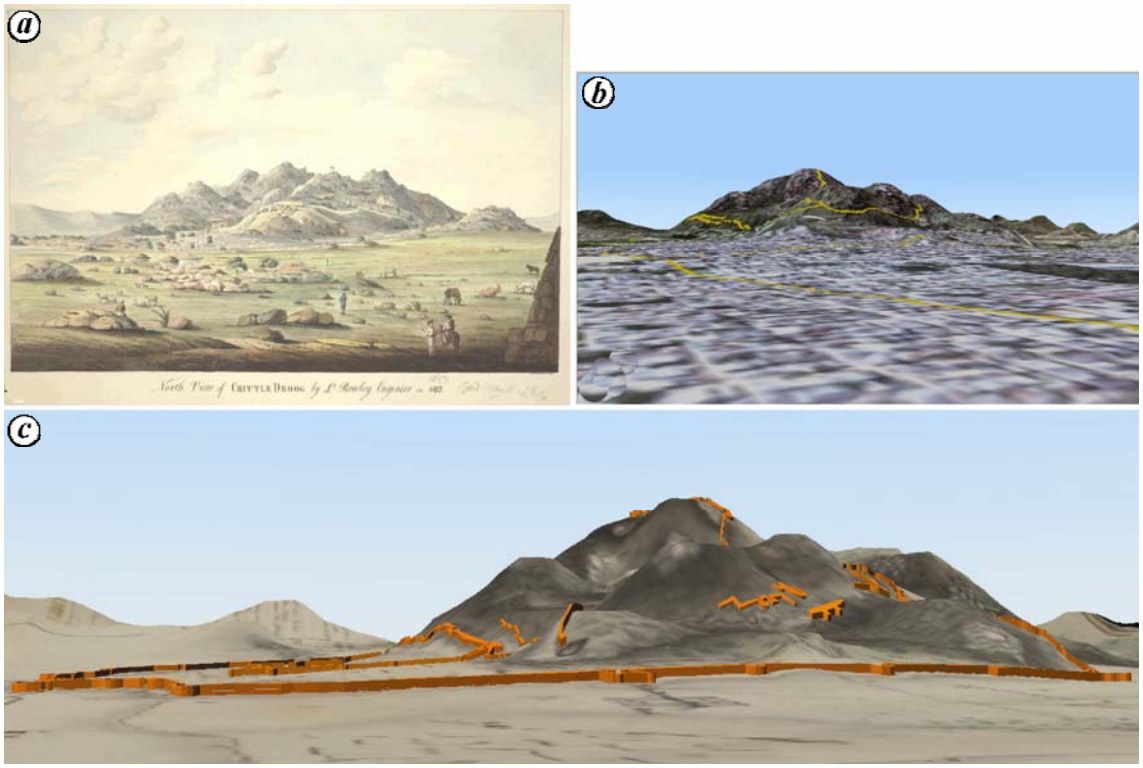

Figure 6. ***a***, An old painting[4]; ***b***, Simulation of the view of the old painting using DEM and Google image; ***c***, Simulated view of the old painting by draping the old map[3] on DEM.

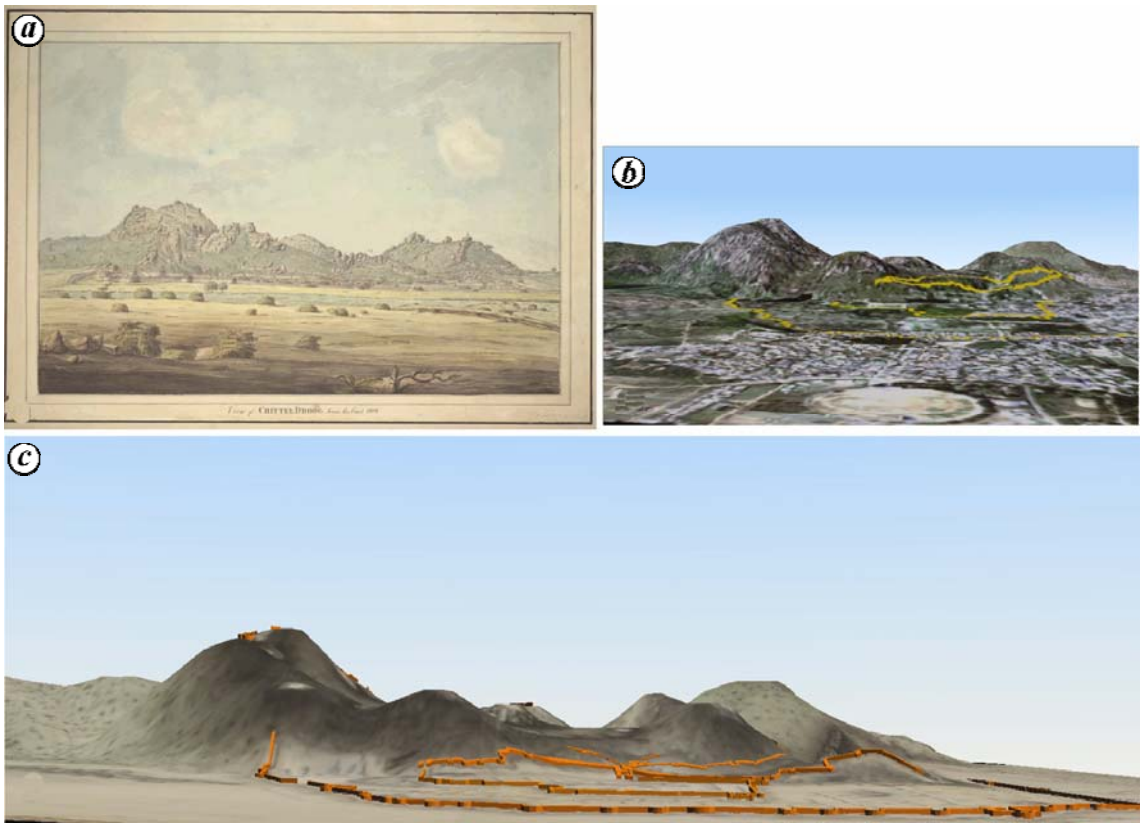

Figure 7. ***a***, An old painting[5]; ***b***, Simulation of the view of the old painting using DEM and Google image; ***c***, Simulated view of the old painting by draping the old map[3] on DEM.

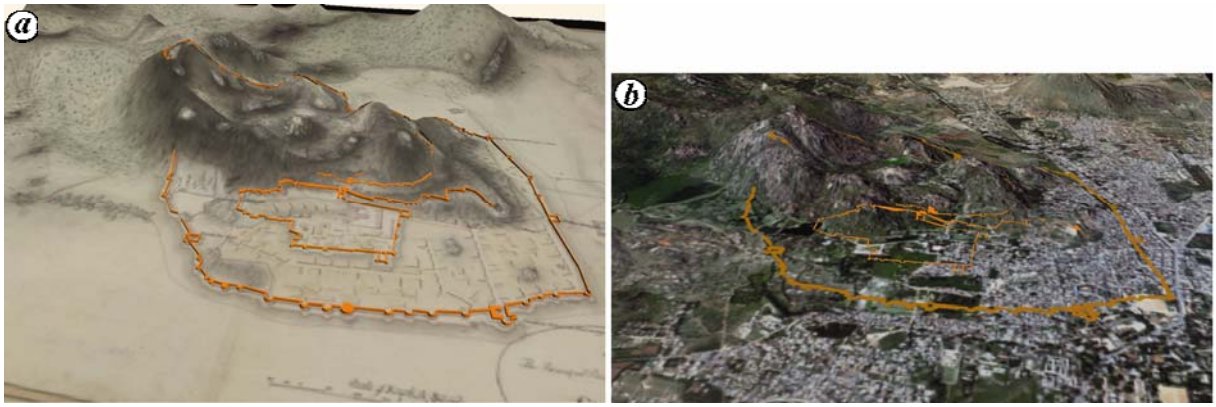

Figure 8. Simulation of the landscape using virtual reality. ***a***, Old map overlaid on DEM with fort walls showing the landscape of AD 1800; ***b***, Google Earth image overlaid on DEM with fort walls showing the present landscape.

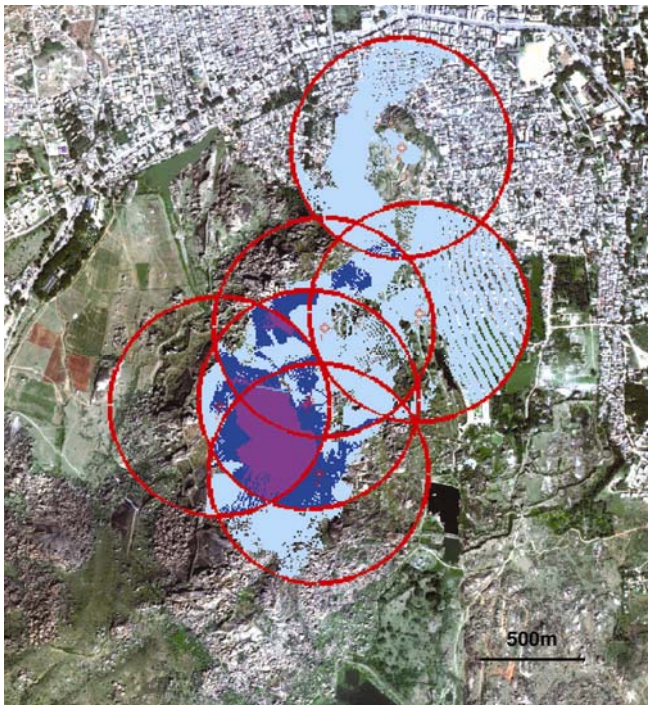

Figure 9. Viewshed analysis carried out for 500 m radius around the selected monuments within Chitradurga fort. (1) Hidimbeshwara temple, (2) Gopalakrishna temple, (3) *Tuppada kola*, (4) Palace, (5) Kamana Bagilu; (6) *Basavana Buruju*.

georeferenced image on DEM. This can be viewed as a three-dimensional image in the VirtualGIS window of Erdas IMAGINE software. A fly-through was run by digitizing the flight path and adjusting the parameters like yaw, pitch, above ground level (AGL) height, roll, speed and field of view (FOV). The two old paintings of the fort give the views from the eastern and northern directions. The fly-through was adjusted to match the views of the old paintings and thereby comparing changes in the landscape. Figure 6 *a* is the old painting showing the north view of Chitradurga. Figure 6 *b* is the virtual view simulated to match the old painting by draping the Google Earth image on DEM. In Figure 6 *c* the old map is overlaid on DEM to get a simulated view of the old painting. The landscape around the hill looks almost similar in Figure 6 *a* and *c*, because the old map and the old painting were prepared around the same time. The grey-coloured chequered pattern in the foreground of Figure 6 *b* represents modern urban sprawl. The figure displays a dense urban landscape in this area which has developed subsequently. Figure 7 *a* is the old painting showing the east view of Chitradurga. Figure 7 shows a similar comparison as in Figure 6 but for the eastern side. Figures 6 *b* and 7 *b* indicate the urban encroachment inside and outside the fort walls, which has been discussed earlier. This method can be used to simulate different views of old and new landscapes in order to understand changes in the layout (Figure 8). Improper planning of the urban centres has a serious effect on rich heritage sites, as discussed by Al-Houdalieh and Sauders[10] in the case of Ramallah in Palestine. Urban encroachment is evident in Chitradurga as seen in the view generated using the VirtualGIS. Two tiers of the fort wall have been completely destroyed without any trace of their existence. If proper conservation methods are not undertaken to preserve the hill fort, it may be completely ruined within a short period of time.

Viewshed analysis

Chitradurga is a beautiful ancient hill fort with its magnificent fort walls, temples and monuments. It is necessary to promote tourism here and popularize the place among the national and international tourists. The revenue collection is essential for the maintenance of the fort. Tourists visit any place only if proper facilities are available. Hence developmental activities are necessary near or in the fort. This may include restaurants, rest rooms, parking area, drinking water facility, etc. Their location and appearance should not hinder the heritage value of the fort. Hence necessary care should be taken to locate

these structures properly. In this regard viewshed analysis helps in deciding the locations of these structures. A viewshed is an area that is visible from a specific location.

In viewshed analysis the areas that are visible from a particular point within a given radius can be identified[11]. This analysis is especially useful in hilly areas, where some places are hidden and some are visible[8,12]. The hidden areas can be selected for developmental activities. Figure 9 shows viewshed analysis carried out for 500 m radius. Among the regions within the red circle, light blue colour indicates the areas visible from one monument; dark blue colour is the area visible from two monuments and pink colour is the area visible from three monuments.

Conclusion

Chitradurga is showing all the signs of becoming an information technology hub. This will lead to faster development of the city, which is dangerous to the cultural heritage of the hill fort. This article shows one of the ways to document, restore and manage the old grandeur of the fort using old maps and paintings. It also gives a clear estimation about urban encroachment into the heritage sites. The outermost wall that can be seen in the old map has disappeared without any trace. Viewshed analysis can help in taking decisions for easily locating new utilitarian structures.

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