Preparation of Database of Archeological Sites

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Key words,
Archeological Database, Very high resolution satellite Imagery, LiDAR data

SUMMARY
Archaeology is the scientific study of human remains and artifacts which provides a different perspective on human history and culture. Archaeology helps us understand the past development status. Nepal has a very rich history, number of archeological sites can be observed even in a small area. Some of these sites are in need of immediate protection from the encroachment from local people. Several sites has been discovered, conserved and promoted by Department of Archaeology (DOA) Government of Nepal, but also they are incomplete without the information like exact location and extend of area.

Most of settlements of Nepal of Terai and lower hill were attached and destroyed occasionally from the south in the past specially during Mogul period and was converted into forest. Most of these areas opened up during 1960s after eradication of Malaria. Therefore, the area was destroyed on the surface and land surface at archeological period was also buried few meters inside present surface due to siltation. Very high resolution satellite imageries/ orthophoto or LiDAR survey data are very useful to detect the archeological sites on or inside the surface and delineate spatial database.

Topographical maps, sketches of earlier period, verbal description, contour etc. are useful to identify the area described by earlier archaeologists and asses the differences in the land use changes. This also helps in analysing the importance of archeological sites and their extent in past and present.

The database with descriptive information about individual site, map with with the extent of the archeological site along with the other relevant information like topography, location (spatial and descriptive), religious and cultural importance, custodianship etc can be prepared using modern methods in more effective way than the existing file system.

This article briefly describes the uses of very high resolution satellite imageries, orthophoto and LiDAR survey data along with field data to detect and the preparation of database of archeological sites.

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1. BACKGROUND

Archaeology is the scientific study of human remains and artifacts which provides a different perspective on human history and culture. Archaeology deals with artifacts, architecture, biofacts (also known as eco-facts) and cultural landscapes (the archaeological record) that can lead towards the human activities and development status of ancient past.

Nepal is a multiethnic, multicultural, multi religious, and multilingual country with great diversity in its geography due to which it has a very rich and diverse history. From the written history of Nepal, its archeological study is very young (around 1893 A.D) as compared to its neighboring countries but According to the paleontologist, tooth of Ramapitheous was obtained on the bank of Tinau River near Butwal whose age was found to be 11 million years. This shows that there was settlement of human beings in Nepal since pre-historic era. Kathmandu, Budhalinkhantha area was settled since 20,000 years ago and caves in Himalayan region were used by human earlier than 10,000 years. The hulaki road of Nepal is used in Mahabharata for transportation since Pauranic period. The script in Nepal was developed earlier than Gautam Buddha, where he studied 12 scripts like Brahmi, Kharosti, Kiranti etc. Many other unprotected heritage sites including stone hinges are still visible in Nepal. These study shows Nepal retain different and unique evidences of antiquity.

Most of settlements of terai region of Nepal and lower hill were attached and destroyed occasionally from the south in the past especially during Mogul period and was converted into forest. Most of these areas opened up during 1960s after eradication of Malaria. Therefore, the area was destroyed on the surface expected those presented land surface at archeological materials were also buried few meters inside present surface due to siltation. Similarly, in hilly area these sites are being destroyed due to ignorance, natural disaster like flood, landslide, earthquake and use of archeological materials for household needs. There are more than thousands of archeological sites identified by Department of Archeology, Nepal which are published in various books and archieved.

2. OBJECTIVES OF THE ARTICLE

Several sites has been discovered, conserved and promoted by Department of Archaeology (DOA) Government of Nepal with or without any foreign assistance like Lumbini, Pashupatinath, Janaki Temple etc. The identification and promotion of eight heritages sites that are listed in World heritages of UNESCO has been done by UNESCO. There are hundreds other sites that has been identified but are incomplete without the information like exact location and extend of area. Due to which there is prodigious possibility of trailing the evidences of such sites in very near future. Some of these sites are already in need of immediate protection from the encroachment from local people. With the rapidly

growing of population, urbanization and increasing value of land it has now become crucial to immediately identify such sites, preserve and promote them. Nepal which is also very prone to earthquake, it is now or never situation because if it is not identified earlier, it cannot be identified later. In this situation it is required to identify the sites and recognize its extent through modern photogrammetric and remote sensing technologies.

The main objective of this paper is to identify various method of identification of location of archeological sites and preparation of database using recent available photogrammetric and remote sensing techniques along with other methods.

3. METHODOLOGY

3.1 Literature review

The archaeological survey is a set of preliminaries aimed at identifying and understanding the archaeological facts, their nature, extent and timing. Archaeological research is conducted with scientific methods for obtaining the evidences where the maximum work is done in field.

Archaeological sites are evidence of human activity which are often associated with concentrations of artifacts. These artifacts are either collected on the surface of the ground or through excavation. Excavation of archaeological sites is a systematic removal of soils for artifacts. Archaeological sites are similar to research laboratories where data is collected, recorded, and analyzed. Excavation and the information relative to the soil layers and the artifacts associated with each layer allows archaeologists to search for patterns in past human behavior. They study these patterns and changes in human behavior over long periods of time, as evidenced in the artifacts.

3.2 Study of earlier map and description

Changing of local names and administrative boundaries as per time have always become problem in data collection of every survey works. It is required to relate the names and description of sites provided by historic literature to identify the real site. Therefore earlier maps and sketches are necessary to be studied in order to relate those site on the recent field and existing maps. Study of earlier maps also helps in identifying the real extent of the site. Also it helps on understanding the change in land custom.

3.3 Pre identification

This is a planning phase where the sites to be visited are analyzed for their accessibility. After doing some reviews on the published papers, books, articles etc. listing of archeological sites is carried out. Normally, from the literature review it is known that the sites of archeological importance are usually mound, barren land, land with cultivation of red beans, ruins, field with broken pieces of earthen wares, bangle, bricks and broken chiseled stone works and artifacts in the hill area visible, fortified area surrounded by canals along with places of religious importance. Therefore, some possible mounds can be

identified or suspected. Similarly land with red beans, sites surrounded by past canals or religious sites can be recognized on image before going to field. Such sites are then spatially determined to be visited in the field. The images, topographical maps and map of project area is prepared showing road, rivers, canals etc. along with the location of archeological sites for easy movement to the sites and identify the extent of them on ground. They can provide constant support to field work, both in excavations and surveys, and also to the management of data in archaeological GIS.

It is much necessary to have a good interaction with public during the field work to extract the genuine information hence a proper questionnaire form must be prepared and completed which include name of archeological site (local name), geographical and administrative location, general and archeological description and sketch.

3.4 Field Visit

The primary objective of the fieldwork is to collect data that would assist in identifying and assessing the integrity of any archeological resources. Field efforts consisted of a combination of pedestrian inspection and surface testing procedures and are subjected to examination in laboratory which consisted of the cleaning, inventorying, and preparation for storage of all artifacts recovered during field excavations. Later the ingredients use for preparing this artifacts, its structure, architecture, designs are wholly analyzed in order to link it to the era they belong to.
The easiest and effective way of locating the site in the field during field work and later identifying on image is through the use of handheld GPS. In order to use GPS for determining the location of sites and renewing it with new coordinates, GPS needs to be calibrated accurately. GPS points, trigonometrical points as ground controls are used for geo-referencing the images accurately for updating existing maps and ortho images.
Using the knowledge of the local people and existing maps/images the location, the extent of archeological site are determined for detail study. The systematic form of questionnaire is to be filled correctly. This will later be used in preparing a valuable database. It is very much necessary to understand and draw a sketch showing the extent of the site. This extent is generally determined by the experience of archeologist and knowledge of local people about the situation of site.

3.5 Use of images/ ortho photo

The application of digital image processing, gives the necessary outputs like maps, DEMs, 3D models which can also be used for the detection of buried archaeological remains. With a very high spatial and radiometric resolution and various application of digital image analysis techniques, it can give many valuable information to the archaeologists. Therefore, very high resolution satellite imageries/ ortho photo or LiDAR survey data are very useful to detect the archeological sites on or inside the surface and delineate spatial database.

3.6 Registration of Image

The Ground Control Points (GCPs) that are identified on image of the project site are used to georeference image/ortho photo. One must be very careful while registering the image/ortho photo. It is because, later this image/orthophoto is used for comparing the land use of present and past. Once the images are georeferenced with GCPs, the image/ortho photo must be rectified with very high accuracy of around or more 0.3 - 0.6 pixels for PAN ortho photo and 0.5 – 2m for MS (Multispectral). All the images/ortho photo necessary to cover the site are then fused together to form a mosaic.

3.7 Use of large scale topographical maps

The topography of the sites are determined through the use of contour and spot height. Lidar data are also very useful to detect archeological site. It is used to detect many sites even in dense forest or settlement. An example of Balapur, west bank of Rapti River of Banke district is shown on Fig 2 which shows the possible sites in forest.

4. DATA MANAGEMENT

The spatial data and its attributes from field work needs to be check thoroughly. This includes filtering out the redundant data and checking them thoroughly. The GPS points collected from field must be made to fit for the use The topographical maps of decades earlier is also necessary along with the recent topographical data. For the recent topographical data, recent satellite image or ortho photo can be used for updating.
The earlier maps are used to relate the location of sites described by earlier archeologist and detect the change of river coarse and the land use of the site.

4.1 Land system mapping

Land System Mapping Report conducted during 1980-86 described the nature of erosion and situation in Nepal. It is expected 5cm/year siltation in terai and valleys. Similarly, erosion of 10/year in hill areas is possible. Therefore the sites that were discovered must be documented properly in order to protect them from the threat of loosing their identification.

4.2 Mapping of the known sites

The known sites are generally the sites that are extracted from the pre-identification. Topographical maps with the existing land use is prepared for each individual sites along with some renowned features such as temple, ancient well, canals etc.

4.3 Searching for undocumented sites

This paper is not only focused on the mapping of known sites using imageries but also the use of high resolution imageries for finding out the possible sites of archeological importance. As explained above knowing the general nature of an archeological sites, the topographical data, imageries, contour, DEM can be used to identify some undocumented sites before and after field visit.

5. ANALYSIS

Analysis of data involves comparing of data of different periods of maps, imageries and verbal description and involves methods of identification of sites and their extent.
The maps with contour of 0.25m – 1m contour will be useful to detect the shape of the sites which can link to the past fortified or ruins areas. Land use like local temple or shrine areas, fortified area, low productive agricultural areas like red beans plantation on previous settlement areas, earlier canal or river channel will show the humid area. This data will be useful to detect possible archeological sites. The river are also changing their course, old beds are also humid which is shown on map as low ground and humid soil on imagery and aerial photos.

The following image shows the analysis on how the use of verbal description of Hiuen Tsiang in Buddhist Records of the Western World was helpful in finding the undocumented site i.e Balapur of Kamdi VDC of Banke district.

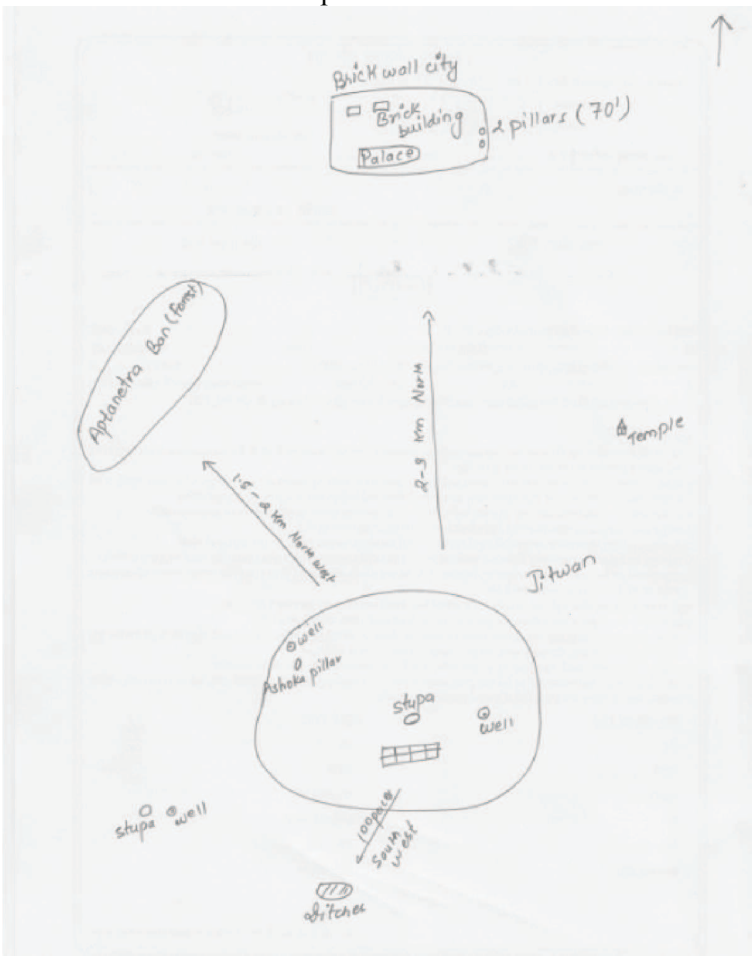


Fig1: Sketch made from the verbal explanation of sites in Balapur: extracted from Buddhist Records of the Western World

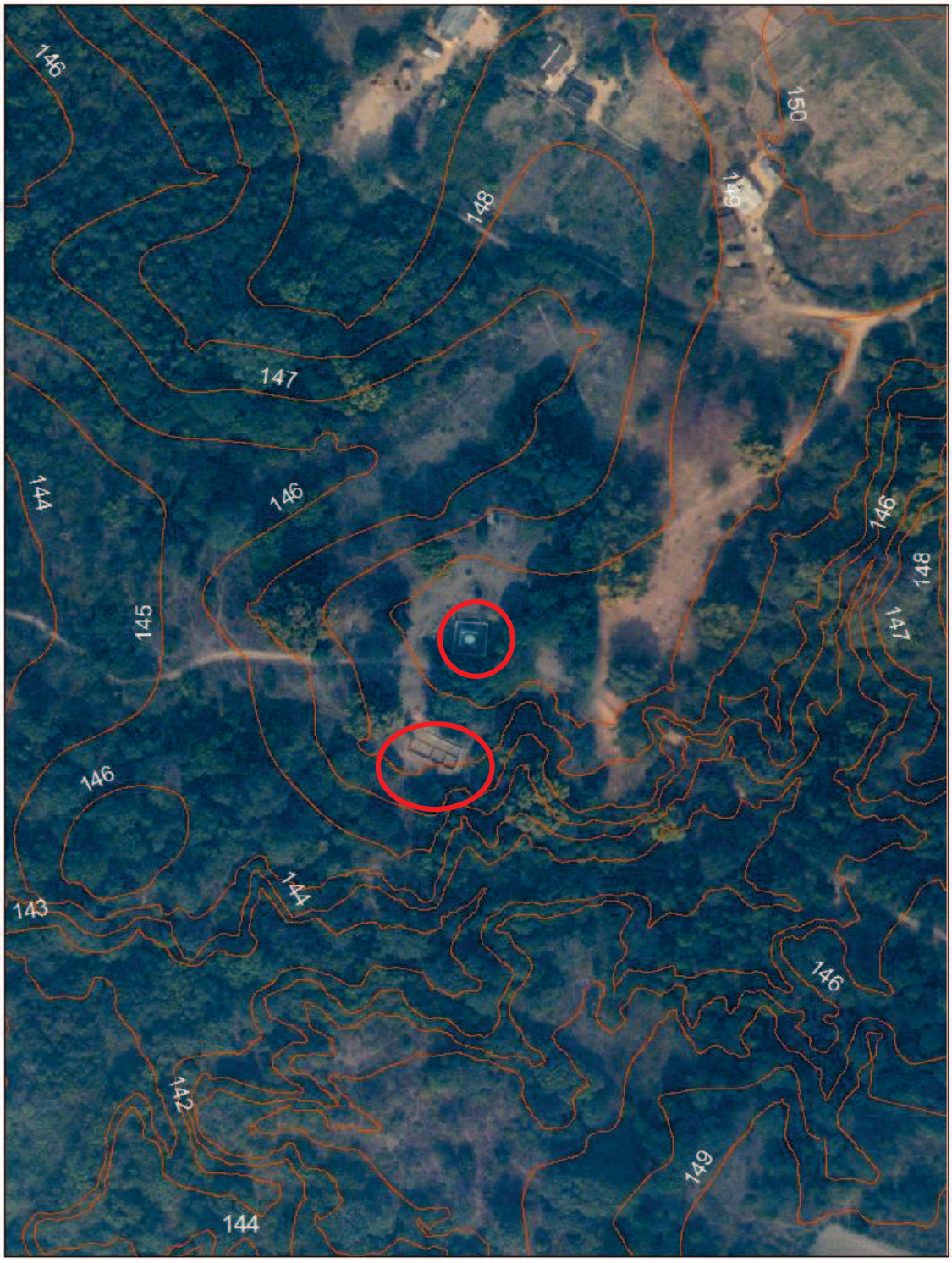


Fig 2: Recent Aerial photo of Balapur:Red circle showig the stupa and hall that were explained by Tsiang in his book

The first picture is the sketch made according to the verbal description of Hiuen Tsiang from Buddhist Records of the Western World, Book II which was published in the year 1906 A.D. According to which there was brick wall city with a palace on the west bank of the river and to the 2-3 km South of it, there was a stupa, hall on ancient Jitwan with other feature as shown on the sketch. The second picture is the recent aerial photo with contour of 1m. The application of contour and the verbal description of indian archeologist Fuhrer,Phd in Basant Bidari's book, Kapilbastu: the world of Siddhartha gave the suspection of having Balapur as the possible site of ancient Jitwan. Since the image shows the stupa and hall so clearly matchning it with the sketch, there is possbility of having this site the ancient Jitwan site as explained by Fuhrer. This is an example which shows the great application of high resolution imageries and contour for archeological study. There are other more methods for determining known and unknown archeological sites.

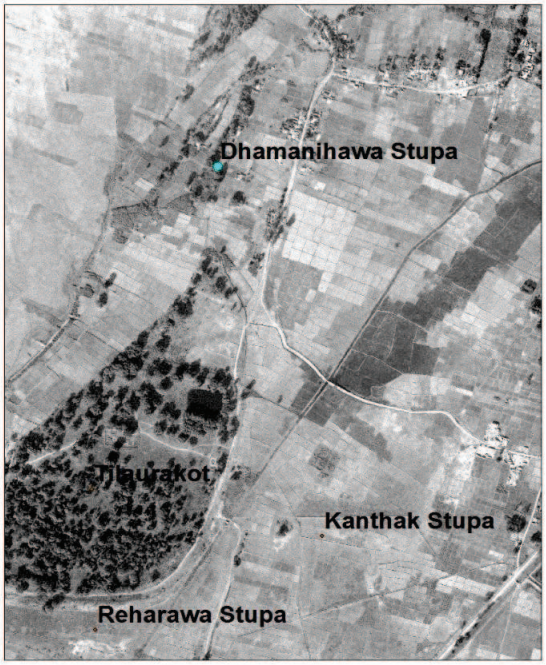
5.1 Study of periodic land use

The change in settlements, forest, agricultural field is observed as per time. The development of physical infrastructure has also major role in changing of land use. The change in land use give information about the old geomorphology (old streams, old ownership boundaries), and thus, for many cases initial estimations during the pre-identification can be confirmed.
Therefore, it is necessary to study the changes in the land use of the sites to analyzing the condition of sites.
Changing of course of river, Increase in number of fish pond for irrigation, fisheries or in the name of finding treasure the land use change has been affecting the area of archeological study. There are several other factors that has lead in diminishing the area of sites and sometimes it is concealed or occupied due to increased settlements. Therefore study of periodic landuse is much necessary in order to wholly understand the sites of archeological importance.

5.2 Preparation of database

Preparation of database of archeological sites is a computerized communications network for the archeological and historic preservations in order to improve access to information on archeological activities in local and regional level. This database provide the inventory of millions of records on archeological sites and provide key information about those sites to archeologist, paleontologist and other interested people.
Generally the database consists of two types of data: spatial and attribute/non spatial. The spatial data consists of spatial location or coordinates, Ground Control Points, maps, ortho photo or image maps, geographical extent of the archeological sites, elevation patterns, administrative boundary and other data. The map displays the graphical portrayal of real ground feature along with the cultural and environmental resources and administrative boundary, extent boundary.
Similarly non spatial attributes are usually the administrative location, importance of sites along with the information of archeological interests, site photos, field forms, past studies, reports on general and archeological description. The reports generally contains every primary information about the archeological sites.

Database also needs to develop metadata. This metadata can be useful for knowing the contains in the database and also in finding what is in where.
The database will permit different level of user to query the reports, photos, maps etc. by certain keyword like district name, VDC name, site name, year of publication, title, author, etc. Every can view every entry of the inventory of the archeological records. If possible download them as well.
Cadastral data can also be included to acquire land for preservation and development of local tourism.



FID	Shape	Object_ID	creation_t	name	lat	long	easting	northing	elevation	Status	Site_no	Topography	VDC_Munici	Ward_no
97	Point	1032	2015-02-03T10:21:55Z	Bagadi	27.574275	83.155727	3050997.58788	418649.704645	96.072		34	Flat	Patariya	
98	Point	1034	2015-02-04T03:38:59Z	Pipara N	27.59717	83.188383	3053627.19482	417716.872338	91.249		21	Flat	Banganga NP	
99	Point	1035	2015-02-04T04:28:24Z	Karaliya	27.601915	83.188234	3054038.57059	419879.158094	96.604		19	Flat	Banganga NP	
100	Point	1037	2015-02-04T05:23:28Z	Galahi	27.597856	83.219056	3053569.25063	422918.542275	99.019		20	Flat	Banganga NP	
101	Point	1040	2015-02-04T06:46:32Z	Chetiya	27.620721	83.163104	3056136.78568	417412.848509	103.268		14	Flat	Banganga NP	
102	Point	1054	2015-02-04T08:40:04Z	Bhadasadawa	27.614949	83.150154	3055507.97604	416130.456488	105.568		11	Flat	Banganga NP	
103	Point	1055	2015-02-04T09:18:47Z	Gharabudhiya	27.626756	83.16053	3056809.17693	417163.371694	109.797		10	Flat	Banganga NP	
104	Point	1058	2015-02-04T10:06:52Z	Siuti	27.649629	83.156718	3059346.05117	416804.502569	111.362		6	Flat	Banganga NP	
105	Point	1062	2015-02-05T04:34:22Z	Nandanagar S	27.458462	83.170773	3038155.80523	418049.366659	70.593		109	Flat	Bijuwa	
106	Point	1063	2015-02-05T04:51:38Z	Madhanagar	27.458703	83.16791	3038184.3988	417766.590156	73.104		105	Flat	Bijuwa	
107	Point	1065	2015-02-05T08:44:18Z	Koptaiya	27.664207	83.199395	3060933.2432	421025.516898	122.824		4	Flat	Banganga NP	
108	Point	1068	2015-02-05T07:20:09Z	Koptaya	27.673525	83.209109	3061959.48715	421990.393119	128.053		2	Flat	Banganga NP	
109	Point	1076	2015-02-05T07:54:05Z	Tenua	27.677679	83.201776	3062424.40525	421270.053731	128.676		3	Flat	Banganga NP	
110	Point	1092	2015-02-05T08:49:24Z	Jungha	27.660724	83.18338	3060557.68241	419443.128719	120.281		1	Flat	Banganga NP	
111	Point	1095	2015-02-08T03:38:35Z	Dharampaniya shiwalaya	27.534342	83.119628	3046597.90307	413054.245187	76.985		120	Flat	Dharampaniya	
112	Point	1096	2015-02-08T04:36:55Z	Athkoniya	27.485225	83.120966	3041154.91016	413147.824259	71.662		121	Flat/Well	Baluhawa	
113	Point	1097	2015-02-08T05:21:33Z	Baluhawa	27.482076	83.108606	3040816.13799	411726.420352	75.066	Mound	122	Mound	Baluhawa	
114	Point	1098	2015-02-08T05:59:52Z	Ganshpur Stupa	27.473318	83.091269	3039856.76999	410203.842797	77.067	Mound	123	Mound	Baluhawa	
115	Point	1099	2015-02-08T06:58:32Z	Belaha	27.527829	83.084197	3045901.62928	409549.570391	89.186		124	Flat/Well	Dohani	
116	Point	1100	2015-02-07T02:58:33Z	Chetaradehi	27.560563	83.038979	3051760.5607	405128.678678	89.507	Mound	125	Mound	Dhankauli	
117	Point	1101	2015-02-07T03:42:41Z	Darewa	27.567707	83.048779	3050346.44326	406085.214359	83.999		126	Flat	Kapilbastu NP	
118	Point	1104	2015-02-07T04:14:37Z	Taueshwornath	27.544815	83.053281	3047806.60686	406510.333344	87.907	Mound	127	Mound	Kapilbastu NP	
119	Point	1105	2015-02-07T04:30:28Z	Thulo Bargadawa	27.538433	83.060786	3047093.84606	407246.139482	84.283	Mound	128	Mound	Kapilbastu NP	
120	Point	1107	2015-02-07T05:26:33Z	Siddhipur	27.596977	83.086063	3053561.81257	409790.430837	90.899		129	Flat	Kapilbastu NP	
121	Point	1108	2015-02-07T05:52:30Z	Ramapur Stupa	27.599208	83.088245	3053807.19536	410007.635082	93.175		130	Flat	Kapilbastu NP	
122	Point	1120	2015-02-07T08:56:23Z	Dhamanihawa Stupa	27.58194	83.058846	3051917.3642	406893.73502	98.482	Mound	131	Mound	Kapilbastu NP	
123	Point	1121	2015-02-07T07:09:17Z	Kanthak Stupa	27.574898	83.058178	3051136.11077	407019.098373	89.882	Mound	132	Mound	Kapilbastu NP	
124	Point	1123	2015-02-07T07:29:35Z	Reharawa Stupa	27.572485	83.053639	3050872.16742	406589.118586	98.182		133	Mound	Kapilbastu NP	
125	Point	1124	2015-02-07T08:25:24Z	Kopawa Stupa	27.644854	83.122504	3058818.34691	413424.992998	102.015	Mound	100	Flat	Somdih	
126	Point	1125	2015-02-08T05:44:41Z	Tilaurakot	27.578113	83.054348	3051248.33321	406485.108648	79.291	Fortification	31	Mound (Capital)	Kapilbastu NP	
127	Point	1126	2015-02-10T02:49:43Z	Hardewa	27.512222	83.043889	3044057.94834	405469.572866	82.142		75	Mound	Basantapur	
128	Point	1127	2015-02-10T03:27:15Z	Bardahawa	27.529444	83.052139	3046136.16123	406386.251139	75.082	Mound	135	Mound	Kapilbastu NP	
129	Point	1128	2015-02-10T04:13:22Z	Hastiorata	27.57	83.048944	3050764.96131	405940.915192	84.166	Mound	136	Mound	Kapilbastu NP	

Fig 4: GIS database of few archeological database

The above is an example of GIS/PRS database which shows the both spatial and non spatial data of the archeological sites. It contains the layer of high resolution orthophoto, with the spatial location of the sites along with the other related information on the respective table.

5.3 Advancement in methods used

The archeological study in Nepal is carried out through collection attributes and artifacts from field. Slowly it is moving into GIS/RS concept. But there are already some technology that has been used by other countries and been successful in easy and effective study and analysis of the archeological sites.
Late 1970s five rings canals around Simrogad was observed with Landsat images and present Nepal-India border runs inside 3rd rings canal while LIDAR survey was carried out for forestry and irrigation purposes. Archeologist may also study these data and find it useful to detect the unknown sites. Also, orthophoto of large area of valley and terai of Nepal prepared by DOS with assistance of government of Finland in 2001 A.D can be useful for archeologist for mapping the extent of the sites.

6. CONCLUSION AND RECOMMENDATION

The archeological study in case of Nepal is being done without any proper linkage on spatial data. Moving on to GIS/PRS can be an excellent tool for archaeologists and other persons interested in history. These techniques are essential to assure reliable interpretation and to maintain the high quality of the available data. In archaeological application, very high resolution images/ortho-photos could be used as detection and monitoring tool to assess the current structural condition and to understand future developments.

Identification and documentation of the archeological sites has been done from long time from the archeological authorities but now it is time to move on to new technology. The new PRS/GNSS/GIS technologies that is described above can lead us in effective recognition of such sites. Identification, fencing and achieving is not sufficient for protection of sites. Therefore, publication in regional and local level is required to preserve this sites. The local government should also take the responsibility for regulation, protection and its wise use.

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BIOGRAPHICAL NOTES

I (Sushmita Timilsina) am a Geomatic Engineer currently working as Survey Officer in Geodetic Branch of Survey Department under Ministry of Land Reform and Management. I had worked as Asistant Lecturer in Himalayan College of Geomatic Engineering and Land Resource Management from September 2014-August 2015. While working as an instructor in the college I was enrolled in a project of UNESCO: Database of heritage sites within Kapilbastu.

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