STM JOURNALS

**Journal of Remote Sensing & GIS**
ISSN: 2230-7990(online), ISSN: 2321-421X(print)
Volume 7, Issue 3
www.stmjournals.com

# Satellite based Monitoring of Water Resource Project using Google Earth: A Case Study of Bhima LIS

***J. Harsha**, R. Pandian, M. Thulasidharan, V. Raghunathan***
Monitoring South Organization, Central Water Commission, Jalasoudha, HMT Post, Bangalore, Karnataka, India

***Abstract***

*Monitoring of physical progress of water resources projects is challenging because the field inspection has serious limitations as the canal network isn't uniform across the command area. The canal network consists of main canals, distributaries and minors of varying dimensions right from head works towards tail end. Hence, use of remote sensing and geographical information system (RS and GIS) offers tremendous scope in monitoring of progress of water resources projects as the field visits are limited by accessibility to command area, time constraints and constraints to choose the location. But the varying dimensions of canal network in command area is also challenging for RS and GIS as it demands very high resolution satellite images to map the alignment of canal network that varies as less as 50 cm and discriminate the breaks in canal network. Bhima lift irrigation scheme (Bhima LIS) in southern Indian state of Karnataka has been chosen for the present study. The study illustrates how the challenges encountered during monitoring of physical progress in Bhima LIS such as limitations of India's Cartosat images were overcome using Pleidas satellite images and GIS tools of Google Earth. The present study then unravels the various short comings in the execution of canal network of Bhima LIS through use of RS and GIS techniques of Google Earth which could have been impossible with either field visits as well as Cartosat satellite images.*

***Keywords****: Monitoring, irrigation potential, remote sensing, GIS, Google Earth, distributary*

****Author for Correspondence*** E-mail: infoharsha@yahoo.com

## INTRODUCTION

The federal government of India funds several water resources projects executed by state governments. It sets well-defined timeline for completion of the dam head works, canal networks and achievement of targeted ultimate irrigation potential in its command area [1]. One of the key challenges for monitoring of water resources projects is to verify the progress of canal network and therefore the ultimate irrigation potential existing on ground. The execution of canal network or its physical progress during different periods of time is one area where remote sensing and geographic information system (RS and GIS) techniques offer tremendous scope for mapping the progress and decision making vis-à-vis targets/timelines. This is because physical monitoring with field visits has serious limitation that it is next to impossible to verify every kilometer or every hectare of the vast command area of water resources projects. But, the present study had a different challenge not only with monitoring of water resource project but also the limitation of spatial and spectral resolution of Indian satellites Cartosat 1 and 2.

## STUDY AREA

Realizing the advantages offered by satellite based remote sensing and GIS, the federal government of India initiated (on pilot basis) the monitoring of physical progress of water resources projects in 2013–14 [2]. One such pilot water resource project chosen for satellite based monitoring was Bhima lift irrigation scheme (Bhima LIS) located in the southern state of Karnataka in India. Bhima LIS is situated across river Bhima, a tributary of river Krishna in the Kalaburagi district (earlier Gulbarga district) of the state of Karnataka in India (Plate 1). The location co-ordinates of the project are 17°03′59.50″ and 17°18′14.00″N Latitude and 76°07′37.81″ and

76°32′58.72″E Longitude. Bhima lift irrigation scheme consists of a barrage built across river Bhima near Sonna village of Afzalpura taluka in Kalaburagi district that impounds 3.166 thousand million cubic feet of water. It also consists two foreshore lift irrigation schemes, one across left bank of the tributary of river Bhima namely Bori, called Balundgi lift irrigation scheme and another across right bank of river Bori called Allagi lift irrigation scheme. The main canal of Balundgi lift has a total length of 63.785 km whereas the main canal in Allagi lift, located at right bank of Bori River, has total length of 35.78 km. There are about 39 distributaries, one branch canal Ghattargi in Balundgi Lift and 20 distributaries in Allagi Lift according to the plan of canal network. The whole project proposes to create 24292 ha of cultural command area [3]. The command area is shown in the base map Figure 1. The project is executed by Karnataka Neeravari Nigam Limited (KNNL), a public sector organization under the water resources department of government of Karnataka.

## OBJECTIVE

1. The objective of this study is to evaluate the physical progress and ultimate irrigation potential of canal network of Bhima LIS through use of RS and GIS techniques restricted to the main canals of Balundgi lift and Allagi lift, branch canal Ghattargi, their distributaries and minors.
2. Alternate techniques for RS and GIS to overcome limitations of Indian remote sensing satellites.

## LITERATURE REVIEW

A report by National Remote Sensing Centre titled "*Monitoring of Irrigation Projects using High Resolution Cartosat Satellite Data*" had claimed to have undertaken the phase-1 of satellite based online monitoring of water resources projects funded under central government scheme [4]. According to the report, Cartosat-1 (2.5 m spatial resolution) is a high resolution satellite that offers excellent opportunities to capture existing irrigation infrastructure, critical gaps and for project monitoring. But the report does not offer the limitations of Cartosat satellites in identification of canal network that possess network of main canal, distributaries and minors of varying widths much lesser than the spatial resolution of Cartosat satellite images. It does not comment anything on the limitations of gray scale pan-chromatic images of Cartosat that fail to distinguish between a cross-drainage structure and a gap in the execution of canal. In the illustration of NRSC Report the identification of distributaries or minors which are much lesser in width and harder in identification of gaps are not shown. Nothing like the challenges that differ from project to project is mentioned in the report. Also, the report of NRSC itself is not peer-reviewed. Apart from this NRSC report, there hasn't been any published case study for monitoring of water resource projects using Google Earth.

## METHODOLOGY

The methodology of the present study is illustrated in Plate 2.

1. Canal network map supplied by Karnataka Neeravari Nigam Limited, water resources department of the state of Karnataka was used as a base map to verify the canal alignment planned to evaluate the physical progress of works, identify the breaks and change in scope (Table 1). The detailed measurements of executed work of the canal network and their respective irrigation potential were obtained from KNNL (Table 2).
2. Digitization of the canal network in pan-chromatic Cartosat satellite images in NRSC's Bhuwan portal was initially tried in accordance with NRSC [4]. Doubtful/suspected breaks were encountered at several points while digitization of main Balundgi canal and therefore validation required ground truth verification at several points. Digitization of distributaries which were much lesser in width was found to be near impossible using Cartosat images.
3. Pleidas satellite images in Google Earth served as an alternative to Cartosat satellites. These satellite images were multi-spectral true color images with 50 cm spatial resolution. The same facilitated evaluation, digitization, verification of the work executed by agencies, the executed/completed length of canal, to identify "breaks" (if any) and estimate the irrigation potential created.

4. Ground truth verification was conducted to validate results of Pleidas satellite images.
5. The length of canal network as found by digitization was compared with the information supplied by project authorities to arrive at final results of the actual physical progress of Bhima LIS (Table 2).
6. Actual irrigation potential calculation:

$$I = \frac{A}{B} * T$$

Where,

I = Actual irrigation potential of the distributary,
A = Length of distributary measured by digitization in satellite image of Google Earth,
B = Total length of distributary,
T = Ultimate Irrigation Potential for the total length of distributary.
The irrigation potential of the length of canal up to the "break" is considered as the potential "created", and rest of the potential "claimed" was ignored.

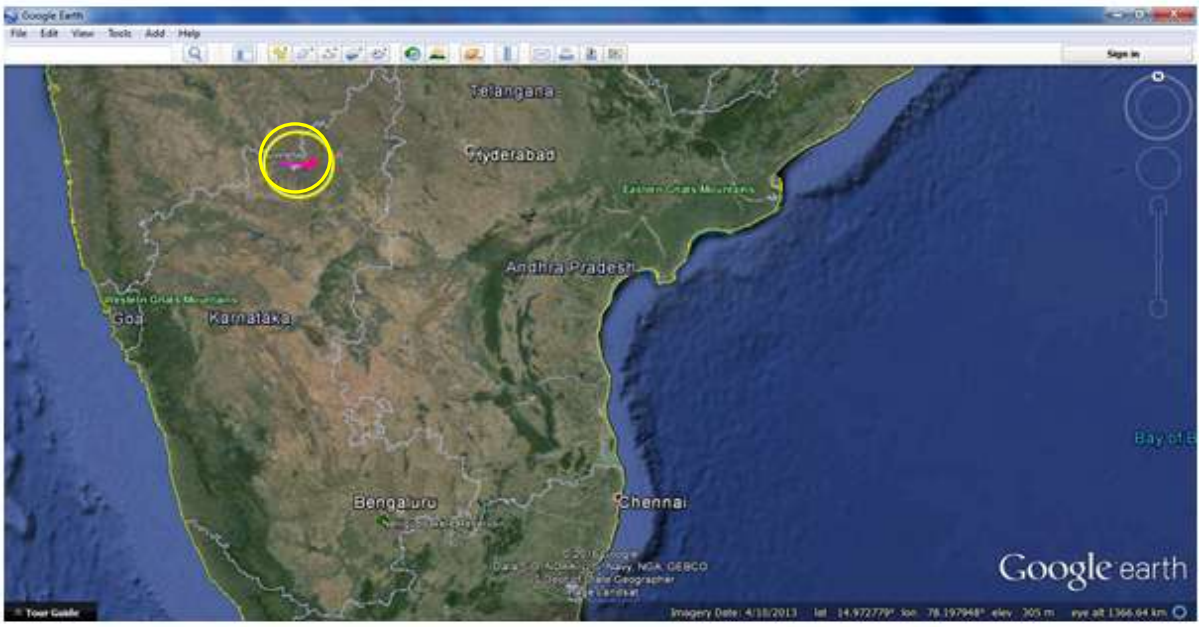



***Plate 1:*** *Index Map Showing the Location of Bhima Lift Irrigation Scheme in Kalaburagi District, Karnataka State (Digitization of Canal Network Visible within Yellow Circle).*

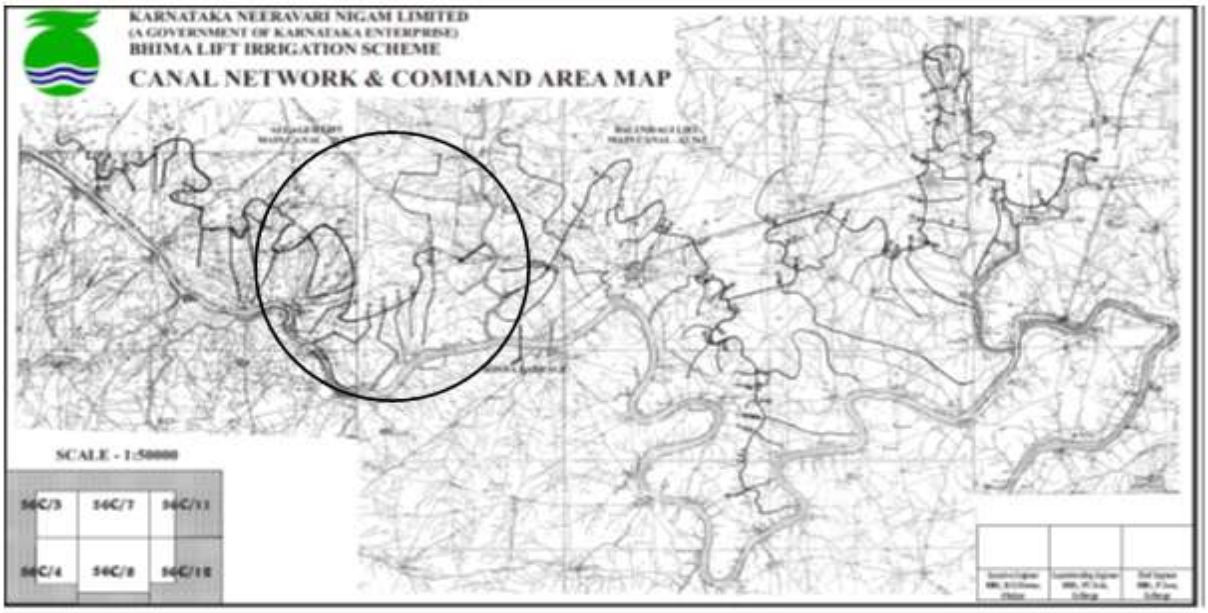



***Fig. 1:*** *Canal Network Base Map Supplied by KNNL. Source: Author*

*Break in Distributary 31 of Ballundgi Main Canal as Seen in Google Earth Image.*


*Break in Distributary 31 of Ballundgi Main Canal as Seen in Bhuwan Cartosat Image (at Highest Zoom Level and Further Zoom Lead to Appearance of Pixels).*

***Fig. 2:*** *Comparison of Satellite Image in Google Earth and Cartosat Image in Bhuwan.*

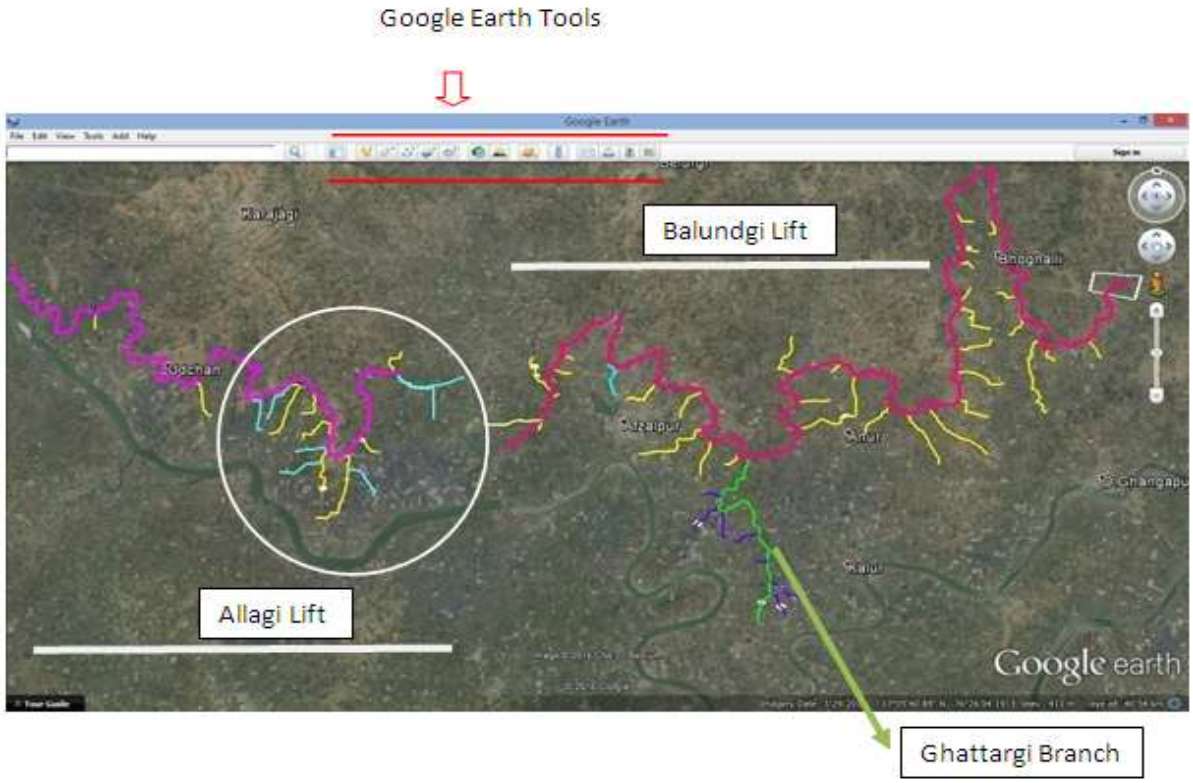
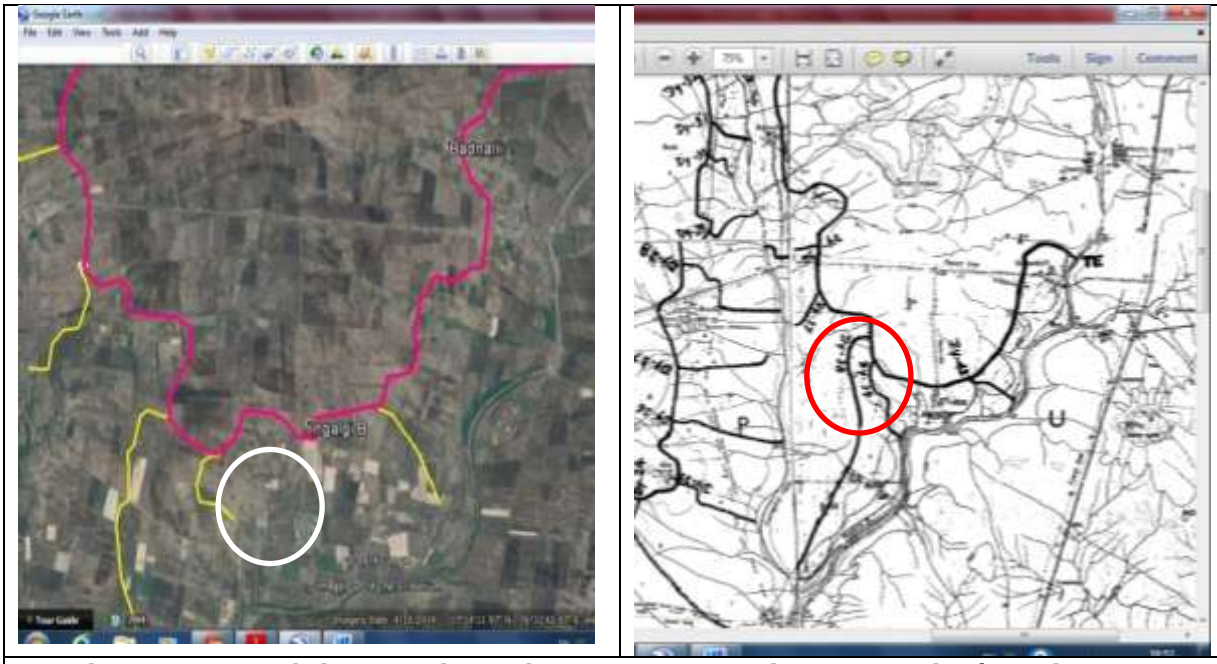
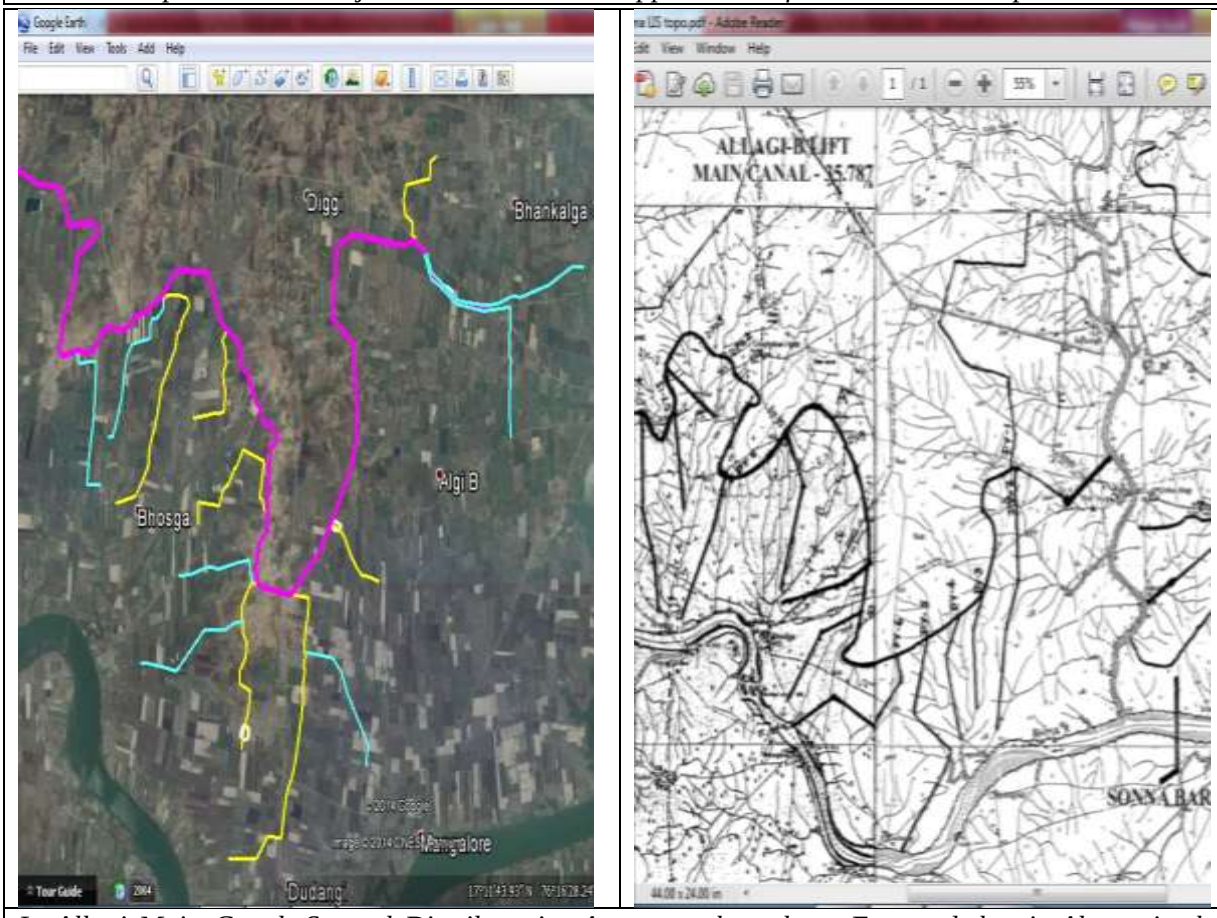



***Fig. 3:*** *Mapping of Canal Network of Bhima LIS in Google Earth.*



*Distributary 39 Encircled in Google Earth Image is Executed up to Length of 0.82 km as against 1.393 km with a Short Fall of 0.573 km. The Distributary should Touch the Stream Shown in Canal Network Map. However, Project Authorities have Supplied the Information as "Completed".*




*In Allagi Main Canal, Several Distributaries Appear to have been Executed that is Absent in the KNNL Supplied Canal Network Map. Blue Coloured Digitization Indicates those Distributaries that are not as per the Alignment Shown in the KNNL Supplied Canal Network Map.*

***Fig. 4:*** *Comparison of Canal Network Alignment with the Base Map.*

***Fig. 5:*** *Allagi Main Canal with Breaks Identified in One of the Minors*.

## RESULTS

The outcome of mapping canal network in Cartosat satellite images in Bhuwan portal of NRSC had to be abandoned due to constraints elaborated in preceding sections; however, the objectives succeeded with Pleadas satellite image of Google Earth as mentioned below:

**Balundgi Lift**

1. The total length of main canal i.e. 63.785 km of Balundgi lift was verified and validated. The alignment of main canal executed on the ground matched with the alignment shown in base map (Figures 1 and 3).
2. Thirty nine distributaries belonging to Balundgi lift, were digitized, their lengths measured and irrigation potential calculated. The details are tabulated in Table 2.
3. Amongst the distributaries, breaks were identified in distributary-4, 31 and 37 on satellite image (Figures 2 and 4). Distributaries 31 and 37 were reported as "completed", but as on March, 2014 they were discovered as false.
4. Distributary 7 and 8 was found to have changed in alignment in comparison to the base map (indicated as blue in Figure 3).
5. Distributary 10 and 33 were found to be missing due to non-visibility of canal lining in the satellite image (Both were chosen for verification on ground).

**Ghattargi Branch Canal**

1. The branch canal Ghattargi that takes-off from Balundgi main canal, after distributary no. 14, was found to have not been executed as planned in KNNL supplied map (Figures 1 and 3).
2. Some of the distributaries were discovered to have not completed. Breaks were discovered while digitization of distributaries. The distributaries branching out from Ghattargi branch were also found to be in short of targets (Figure 3).

**Allagi Lift**

1. The length of Allagi Lift main canal measured in Google Earth indicated that the length of execution on ground closely matched with the alignment shown in the KNNL supplied map.
2. It was found that distributary-2 was missing; two new minors that were never part of the canal network originally envisaged were discovered (shown in KNNL supplied base map Figure 1 and compared with Figure 3).
3. Several distributaries in the order shown in base map were not reflected on the ground. It was found that several new distributaries have been introduced. Overall, when the digitization/mapping of Allagi lift was completed, it was discovered that the whole alignment had

been changed, thereby changing the scope of the project.

4. Due to the change in scope of Allagi lift, the calculation of irrigation potential through satellite based monitoring was restricted to that of Balundgi lift.
5. Out of the 9745 ha of irrigation potential creation reported by project authorities as on March, 2014, it was found that 7661 ha was actually created in Balundgi lift. Therefore, it was found that the irrigation potential initially reported by project authorities for Balundgi lift was an inflated Figures 4 and 5.
6. The calculated actual irrigation potential (I) of Balundgi lift is shown in Table 2.

***Table 1:*** *Features Identified for Ground Truth Verification.*

| **Balundgi Lift** | | | **Allagi Lift** | | |
|---|---|---|---|---|---|
| | **No.** | **Feature** | | **No.** | **Feature** |
| Distributary | 37 | Break | Distributary | 2 | Missing |
| Distributary | 33 | Missing | Minors | 1 and 2 | New features |
| Distributary | 31 | Break | Distributary | 3 | Change in alignment |
| Distributary | 23 | Short in length | Distributary | 7 | Change in alignment |
| Distributary | 10 | Missing | | | |
| Distributary | 7 and 8 | Missing/Change in alignment | | | |
| ***Ghattargi Branch Canal*** | | | | | |
| Distributary | 3 | Progress of work | | | |

*Source: Author.*

***Table 2:*** *Comparison of Satellite Based Monitoring Results with Data Furnished by KNNL.*

| **Sl. No.** | **Distributary** | **Data Furnished by KNNL** | | | **Results of Satellite based Monitoring** | |
|---|---|---|---|---|---|---|
| | | **Length (km)** | **Ultimate Potential in Ha (CCA)** | **Potential Created up to March 2014** | **Length (km) March, 2014** | **Potential Created up to March 2014 (Potential Identified** |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** |
| 1 | Dist-1 | 4.448 | 1204.120 | 586.300 | 0.500 | 135.355 |
| 2 | Dist-2 | 2.346 | 360.690 | 360.690 | 2.346 | 360.690 |
| 3 | Dist-3 | 2.134 | 245.410 | 245.410 | 0.310 | 35.650 |
| 4 | Dist-4 | 8.580 | 1055.770 | 648.610 | 0.920 | 113.206 |
| 5 | Dist-5 | 0.872 | 53.950 | 53.950 | 0.872 | 53.950 |
| 6 | Dist-6 | 1.089 | 61.190 | 0.000 | 0.430 | 24.161 |
| 7 | Dist-7 | 1.056 | 90.640 | 58.470 | 1.056 | 90.640 |
| 8 | DPO-1 | 0.000 | 34.51 | 34.51 | 0.000 | 34.510 |
| 9 | Dist-8 | 1.865 | 185.530 | 185.530 | 1.865 | 185.530 |
| 10 | DPO-2 | 0.000 | 42.020 | 42.020 | 0.000 | 42.020 |
| 11 | DPO-3 | 0.000 | 40.270 | 40.270 | 0.000 | 40.270 |
| 12 | DPO-4 | 0.000 | 34.160 | 34.160 | 0.000 | 34.160 |
| 13 | DPO-5 | 0.000 | 27.100 | 27.100 | 0.000 | 27.100 |
| 14 | Dist-9 | 1.845 | 205.340 | 205.340 | 1.845 | 205.340 |
| 15 | Dist-10 | 2.073 | 125.710 | 125.710 | 2.073 | 125.710 |
| 16 | Dist-11 | 1.643 | 83.960 | 83.960 | 1.643 | 83.960 |
| 17 | DPO-6 | 0.000 | 28.250 | 28.250 | 0.000 | 28.250 |
| 18 | DPO-7 | 0.000 | 48.370 | 48.370 | 0.000 | 48.370 |
| 19 | Dist-12 | 3.811 | 574.940 | 574.940 | 3.31 | 499.357 |
| 20 | Dist-13 | 1.622 | 197.070 | 197.070 | 1.622 | 197.070 |
| 21 | Dist-14 | 0.866 | 63.520 | 63.520 | 0.866 | 63.520 |
| | Ghattargi Branch canal | 15.52 | 3739.070 | 925.870 | 10.000 | 925.870 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 22 | Dist-15 | 14.193 | 2802.760 | 0.000 | 0.000 | 0.000 |
| 23 | Dist-16 | 2.160 | 208.720 | 208.720 | 2.160 | 208.720 |
| 24 | Dist-17 | 1.303 | 172.970 | 172.970 | 1.303 | 172.970 |
| 25 | DPO-8 | 0.000 | 47.460 | 47.460 | 0.000 | 47.460 |
| 26 | Dist-18 | 3.516 | 157.580 | 157.580 | 2.280 | 102.185 |
| 27 | Dist-19/DPO | 0.850 | 44.480 | 0.000 | 0.850 | 0.000 |
| 28 | Dist-20 | 1.220 | 116.680 | 116.680 | 0.560 | 53.558 |
| 29 | Dist-21 | 2.110 | 201.530 | 201.530 | 2.110 | 201.530 |
| 30 | DPO-9 | 0.000 | 61.730 | 61.730 | 0.000 | 61.730 |
| 31 | Dist-22 | 1.790 | 190.290 | 190.290 | 1.790 | 190.290 |
| 32 | Dist-23 | 3.105 | 445.520 | 445.520 | 2.000 | 286.969 |
| 33 | Dist-24 | 3.995 | 566.550 | 566.550 | 3.100 | 439.626 |
| 34 | Dist-25 | 1.790 | 235.230 | 235.230 | 1.790 | 235.230 |
| 35 | Dist-26 | 2.040 | 192.180 | 192.180 | 2.040 | 192.180 |
| 36 | Dist-27 | 1.614 | 178.780 | 178.780 | 1.614 | 178.780 |
| 37 | Dist-28 | 2.540 | 197.400 | 197.400 | 2.100 | 163.205 |
| 38 | Dist-29 | 1.785 | 148.330 | 148.330 | 0.740 | 61.493 |
| 39 | Dist-30 | 1.207 | 128.510 | 128.510 | 0.790 | 84.112 |
| 40 | Dist-31 | 0.900 | 95.610 | 95.610 | 0.000 | 0.000 |
| 41 | Dist-32 | 1.010 | 128.520 | 128.520 | 1.010 | 128.520 |
| 42 | DPO-10 | 0.000 | 5.350 | 5.350 | 0.000 | 5.350 |
| 43 | Dist-33 | 1.297 | 90.73 | 0 | 0.000 | 0.000 |
| 44 | DPO-11 | 0.000 | 7.080 | 7.080 | 0.000 | 7.080 |
| 45 | DPO-12 | 0.000 | 20.210 | 20.210 | 0.000 | 20.210 |
| 46 | DPO-13 | 0.000 | 8.820 | 8.820 | 0.000 | 8.820 |
| 47 | DPO-14 | 0.000 | 37.820 | 37.820 | 0.000 | 37.820 |
| 48 | Dist-34 | 0.940 | 102.56 | 102.56 | 0.940 | 102.560 |
| 49 | DPO-15 | 0.000 | 44.230 | 44.230 | 0.000 | 44.230 |
| 50 | DPO-16 | 0.000 | 38.230 | 38.230 | 0.000 | 38.230 |
| 51 | Dist-35/DPO | 0.833 | 52.110 | 52.110 | 0.833 | 52.110 |
| 52 | Dist-36 | 0.920 | 88.040 | 88.040 | 0.920 | 88.040 |
| 53 | Dist-37 | 1.170 | 108.310 | 0.000 | 1.170 | 0.000 |
| 54 | DPO-17 | 0.000 | 32.330 | 32.330 | 0.000 | 32.330 |
| 55 | Dist-38 | 4.852 | 659.410 | 659.410 | 3.840 | 521.874 |
| 56 | Dist-39 | 1.393 | 92.120 | 92.120 | 0.820 | 54.227 |
| 57 | Dist-40/DPO | 1.333 | 48.210 | 48.210 | 1.333 | 48.210 |
| 58 | Dist-41/DPO | 1.250 | 56.010 | 56.010 | 1.250 | 56.010 |
| 59 | Dist-42 | 1.230 | 104.250 | 104.250 | 0.900 | 76.280 |
| 60 | Dist-43/DPO | 0.720 | 62.490 | 62.490 | 0.720 | 62.490 |
| 61 | Dist-44/DPO | 0.790 | 63.860 | 63.860 | 0.790 | 63.860 |
| 62 | DPO-18 | 0.000 | 47.120 | 47.120 | 0.000 | 47.120 |
| 63 | Dist-45/DPO | 1.380 | 68.990 | 68.990 | 1.380 | 68.990 |
| 64 | Dist-46/DPO | 2.440 | 62.660 | 62.660 | 2.440 | 62.660 |
| | **Total CCA (Balundgi Lift)** | **117.446** | **16723.360** | **9745.540** | **73.231** | **7661.749** |

*Source: Author.*

***Table 3:*** *Google Earth GIS Tools and Features.*

| Google Earth GIS Tools/Features | Utility |
|---|---|
| Path | Mapping/digitization, measurement, change of units and color code |
| Polygon | To identify "breaks" |
| Zoom in and Zoom out | Facilitate mapping finer details of the canal network |
| Save as | Saves the digitzation in .kmz file format |

***Table 4:*** *Color Code of Digitization of Canal Network.*

| | Canal Network | Digitization Color Code |
|---|---|---|
| 1 | Balundgi Main Canal | Pink |
| 2 | Allagi Main Canal | Indigo |
| 3 | Ghattargi | Green |
| 4 | Distributaries | Yellow |
| 5 | Distributaries found with irregularities | Blue |

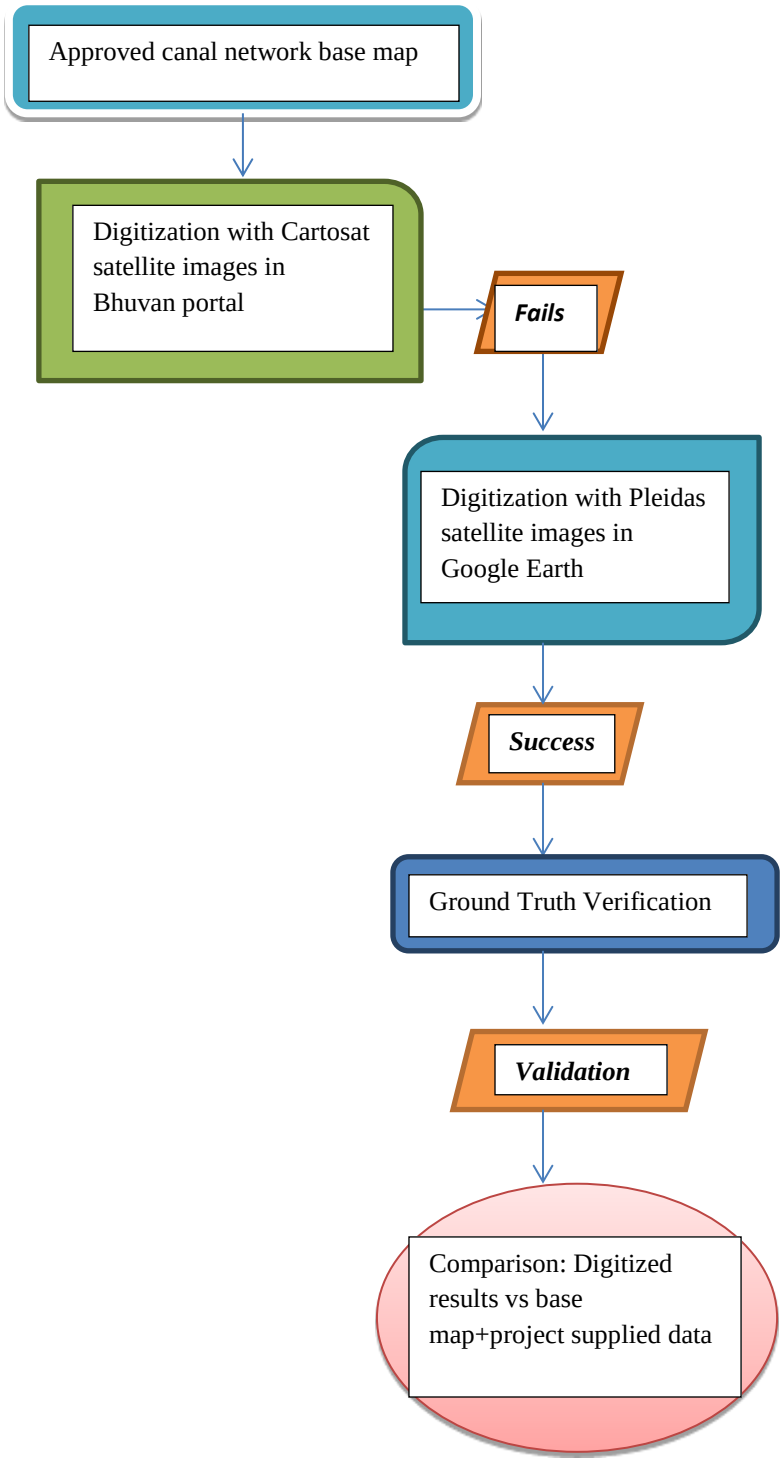



***Plate 2:*** *Methodology.*

## DISCUSSION

### Use of India's Cartosat Satellite Image

Cartosat-2B is the India's latest remote sensing satellite equipped with single band panchromatic camera that has capability of providing earth surface image with a spatial resolution of better than 1 m [5]. This is the highest spatial resolution available with any Indian remote sensing satellite. Cartosat-2 launched in 2007 possesses capabilities similar to that of Cartosat-2B. Initially, both Cartosat-1 and Cartosat-2 were chosen for the present study. NRSC uploaded Cartosat-1 and Cartosat-2 panchromatic image covering the entire project area of Bhima LIS in Bhuvan portal [6].

The panchromatic image of Cartosat-2 satellite possesses spatial resolution of 1 m which means that a pixel in the image represents an area of 1 m x 1 m on the earth surface. During the present study, it was cumbersome to discern features that are less than 1 m wide. Not every section of canal network in Bhima LIS possesses uniform width greater than 1 m. Sections of main canal near tail end possess less width than at the beginning.

Distributaries and minors that branch out from main canal, possess width even less than main canal of about 1.5–2.0 m. In Bhima LIS, the width of distributaries range from 1 m to less than 1 m (upto even half a meter at tail end).

The shortcoming in Cartosat pan-chromatic satellite image is conspicuous because canals are linear features with distinct reflectance due to concrete lining whereas in contrast, "breaks" are small gaps across canals or discontinuity in canal lining or in earth excavation or both. Combined with cross-drainage structures like super-passage or cart track crossings, the pitfalls in clear identification of gaps distinct from cross-drainage structures was a greater challenge with gray scale panchromatic images of Cartosat. This limitation of Cartosat-1 and 2 became constraint for the present study while undertaking digitization/mapping of the Balundgi main canal as well as its distributaries and minors. Several times, the cross-drainage structures executed across the main canal were misconstrued for "breaks". The coarse resolution and comparison with Google Earth image is shown in Figure 2.

Procurement of high resolution satellite images from global satellite market was ruled out due to the maze of government procedures involved in such a process as well as the national pride involved in rejecting "home grown" space prowess. The only alternative available was Pleidas satellite image uploaded in Google Earth. Pleidas IA and IB satellite series belong to Astrium, Europe's leading space agency and CNES, France that offer high spatial resolution satellite images of about 50 cm with better quality and neater contours using new algorithm [7]. Google Earth proved to be a better alternative than Bhuwan portal for the present study. The GIS tools of Google Earth are shown in Figure 3 and outlined in Table 3. Google Earth uploaded latest satellite images for the dates 28.03.2014, 29.03.2014 and 10.04.2014 covering the entire project area of Bhima lift irrigation scheme. Google Earth then facilitated direct digitization of canal network thereby precluding digitization of canal network in base map first using GIS software and then the shape file was transferred to Google Earth. The present method of digitization therefore has been faster, versatile and betterment of any earlier studies of satellite based monitoring such as that conducted by NRSC [4].

During the study, it was found that Google Earth had inherent advantages that Bhuwan portal lacked.

1. Google Earth possessed Pleidas satellite image with a spatial resolution of up to 50 cm.
2. Google Earth uploaded true colour composite satellite images unlike the panchromatic images of Cartosat images in Bhuvan portal.
3. Google Earth is in possession of GIS tools with digitization/mapping/location/measurement/marker/placemark/zoom capabilities.
4. Google Earth is free of cost and it possesses, relatively, faster servers.
5. Google Earth facilitates conversion of entire digitization of canal network into shapefile or a .kmz file format that could be communicated in email or storage

device that could be used in another computer platform.

6. Above all, the mapping/digitization/measurement using Google Earth does not infringe upon its terms and conditions as long as it is for civilian use.

**Ground Truth Verification of Bhima LIS**

Ground truth verification is a continuous process and inalienable part of the satellite based monitoring of water resource projects. Ground truth verification was conducted on 10.06.2015 to verify the findings from satellite images. The findings of ground truth verification are shown in Table 3.

## CONCLUSIONS

Before the advent of remote sensing and GIS, monitoring of Bhima LIS was conducted solely by field visits to those areas of the project where progress of works was to be verified. These field visits had a serious limitation such as:

1. Limited access to terrain,
2. Time constraints, and
3. Lack of freedom for monitoring agencies to choose the location and access the same.

Remote sensing and GIS techniques were attempted using India's Cartosat satellite images in the present study, but objectives could not be achieved due to constraints in satellite resolution. Hence, remote sensing and GIS techniques using Pleidas satellite images in Google Earth were adopted. Using GIS tools in Google Earth, the entire canal network of Bhima LIS could be digitized successfully. The breaks in distributaries that remained "blind", due to drawbacks of field visits and limitations of Cartosat images, were now "visible" and identified in Google Earth.

The change in alignment of the distributary network of Allagi lift is the surprising find of this study as completely new alignment of distributaries were found. The change in alignment has implications for the very irrigation potential of 24292 ha conceived for the Bhima LIS project. The change in alignment changes the scope of the project because it changes the dimensions of the canals and distributaries which in turn change the quantities of items involved. The outcome is the change in the approved estimated cost and change in irrigation potential.

The RS and GIS techniques and Google Earth in the present study have enabled change in the paradigm of monitoring because,

1. The command area is now "visible" in satellite image;
2. Absence of time constraints to analyse satellite images; and
3. Freedom for monitoring agency to choose the location for ground truth verification.

## RECOMMENDATIONS

As on date, India does not possess indigenous pan-sharpened true colour composite image of up to 50 cm. Therefore, Google Earth satellite images, being in possession of true colour composite with high resolution images is recommended as a better alternative for satellite based monitoring of water resources projects at least until such a high resolution Indian satellite image is available for civilian use (Currently, even Cartosat satellite images of requisite area of interest and time are not offered free of cost by NRSC). Therefore, as Google Earth uploads high resolution satellite images at the area of interest, it serves a better alternative for satellite based monitoring of water resources projects. It is an alternative technique for satellite based monitoring of physical progress of water resources projects particularly for those which are constrained by Indian remote sensing satellites as on date. The technique elaborated in the article offers promise for similar exercises in future.

## DISCLAIMER

Views expressed in the paper are authors' own interpretation.

## REFERENCES

1. MoWR, RD and GR. *Monitoring of AIBP Projects*. New Delhi: Government of India; 2016. Available from http://wrmin.nic.in/forms/list.aspx?lid=402&Id=4
2. Bhuvan. *Satellite based AIBP Project Monitoring.* Indian Geo-Platform of ISRO. Government of India; 2016. Available from

http://bhuvan3.nrsc.gov.in/applications/aibp/aibp.php
3. Monitoring Report. *Accelerated Irrigation Benefit Scheme, 2013–14: Bhima Lift Irrigation Scheme (Major), Karnataka State.* New Delhi: Government of India; 2016. Available from http://wrmin.nic.in/writereaddata/aibp_mr_201403_bhimaLIS-karnataka.pdf
4. NRSC. *Monitoring of Irrigation Projects using High Resolution Cartosat Satellite*. Hyderabad: Department of Space, Government of India; 2013.
5. Indian Space Research Organization. *Cartosat 2B and Resourcesat-2*. Bangalore: Brochure, Publications and Public Relations, ISRO HQ; 2016. Available from http://www.isro.gov.in/sites/default/files/pdf/pslv-brochures/PSLVC15.pdfhttp://www.isro.gov.in/Spacecraft/resourcesat-2
6. SATAIBP. *Satellite based Monitoring of Irrigation Projects.* Hyderabad: Bhuvan Portal, National Remote Sensing Agency, Government of India; 2016. Available from http://bhuvan3.nrsc.gov.in/applications/aibp/aibphome/aibp.html
7. UN-SPIDER. Knowledge Portal. *Office for Outer Space Affairs.* United Nations; 2015. Available from http://www.un-spider.org/news-and-events/news/astrium-and-cnes-improve-pl%C3%A9iades-image-quality

**Cite this Article**

Harsha J, Pandian R, Thulasidharan M *et al.* Satellite based Monitoring of Water Resource Project using Google Earth: A Case Study of Bhima LIS. *Journal of Remote Sensing & GIS.* 2016; 7(3): 10–21p.