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Mapping Irrigation Infrastructure and Potential of the Upstream Penganga Irrigation Project Using Cartosat Satellite Data

Grace Laltlinzo, Teresia Kathure Murungi

Abstract: ***The present study has been conducted with an aim of assessing irrigation potential created in Accelerated Irrigation Benefit Program through mapping of irrigation infrastructure using Cartosat (2.5 m resolution) satellite data. This study deals with results of satellite data analysis of Upper Penganga irrigation project. The original satellite data in Geo - tiff format were converted into ERDAS Imagine image format In addition to the canal network, the associated irrigation and drainage structures were also identified and inventoried. The digital map base for the study area with rivers/streams, roads/rail, and villages, etc. using high resolution data is prepared and used further for preparing map outputs. The shortage in length is mostly due to pending gaps in middle and tail reaches. It is observed that the majority of the pending canals and canal gaps with pending reaches were found among Chalgani Branch Canal and Bramhangaon distributary under ILBC and Bhategaon Branch Canal under IRBC. The irrigation potential has been assessed using the irrigation infrastructure derived from the Cartosat data analysis. Based on the assessment of physical progress, the overall irrigation potential created in the Upper Penganga project assessed as 13, 198 ha. as against the proposed irrigation potential of 24, 622 ha. Thus, the balance irrigation potential yet to be created is estimated as 11, 424 ha. The balance irrigation potential yet to be created under ILBC is 7, 054 ha and under IRBC is 4, 369 ha. The irrigation potential balance which is to be created is distributed mostly among Chalgani branch canal (5, 227 ha), Bramhangaon distributary (1, 042 ha) under ILBC and Kayadhu branch canal (2, 233 ha), Bhategaon branch canal (1, 361 ha) under IRBC. The field reported irrigation potential created and balance irrigation potential are 14, 543 ha. and 10, 072 ha. respectively. The total balance irrigation potential assessed from Cartosat study is lower (1, 351 ha.) than reported by field reported. This is mainly due to pending reaches and their offtake connectivity to parent canals in spite of majority of the canal lengths being physically completed.***

Keywords: Irrigation, Agriculture, Geospatial Techniques, Remote Sensing, GIS, Cartosat - 1

1. Introduction

Accelerated Irrigation Benefit Program (AIBP) launched by Government of India during 1996 - 97 aims at speeding up the implementation of on - going irrigation / multi - purpose water resources projects. The projects in which substantial progress has been made and which are beyond the resource capability of the respective State Governments and the projects which are in advanced stage of construction and could yield irrigation benefits in the next few agricultural seasons have been taken up under this project. Accelerated Irrigation Benefit Program was aimed at twin benefits of accelerating the ongoing irrigation projects and realization of bulk benefits from completed irrigation projects. The recent advent of high resolution remote sensing satellites providing information over relatively small areas with greater details has opened new era of remote sensing applications. The meter to sub - meter pixel resolution dramatically improved the feature identification. High resolution satellite imagery can provide a rapid, high quality data source for capturing the topographic details more accurately and with less geometric distortion. There is immense potential for use of high resolution satellite data for inventory of irrigation infrastructure (canal network, conveyance and distribution system), assessment of progress of irrigation works, closer visualisation of spatial irrigation utilisation patterns, assessing the impact of irrigation developmental programmes.

Identification of existence of a gap between supply of irrigation water and its demand in a particular year, and looking for the factors responsible for, if such a gap really exists, are fraught with several difficulties. While some are conceptual, some result from lack of appropriate quantitative information that could have settled the issue. A simple rudimentary way to resolve the puzzle has been developed that compares the irrigation potential created and irrigation potential utilized.

2. Methodology

The basic approach for the assessment of irrigation potential creation in a project is through identification and mapping of irrigation canal network and providing the status (w. r. t. the completion / incompletion / pending) of the entire conveyance and distribution system, various irrigation and drainage structures, etc. Project command area maps and relevant ground / field information has been used for precise boundary delineation of the study area. This area mask were used for Cartosat satellite data acquisition planning and procurement. The individual ortho corrected Cartosat pan scenes were mosaiced to create area satellite database.

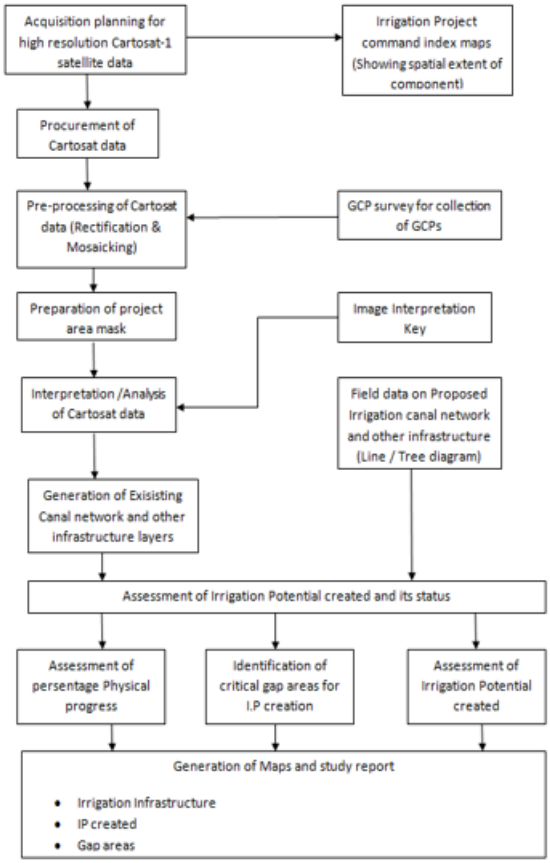


Figure 3.1: Flowchart of Methodology followed in the study

2.1 Assessment of Irrigation Infrastructure

Identification and mapping of existing irrigation canal network with Main canal/Branch canal/Distributaries/Minors & Sub - minors done from the satellite image through onscreen digitisation using ERDAS IMAGINE image processing software and ArcGIS software by displaying the image at 1: 4, 000 to 1: 2, 000 scales. In addition to the canal network, irrigation and other structures including cross drainage structures viz. aqueducts etc. were identified and marked on to the digital database.

2.2 Assessment of Irrigation Potential created

The details of irrigation potential proposed under each canal as per the field data is available to us and is provided in table designed for presenting irrigation potential information. Satellite based assessment of irrigation potential is done based on the physical status of canal: i. e. completed; gaps existing in various canal stretches; pending cross drainage structures; pending irrigation structures such as regulators, etc. causing hydraulic discontinuity. The process for the assessment of irrigation potential is described in this section along with a case study.

2.3 Overview of Online Monitoring

The basic processes involved in this study are collection of field data, accessing of Bhuvan website through authorised login, creation of field database, digitisation of canal network, editing of canal network, field visit for ground truth, etc. The following figure shows the flowchart of methodology for online monitoring of this projects.

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.

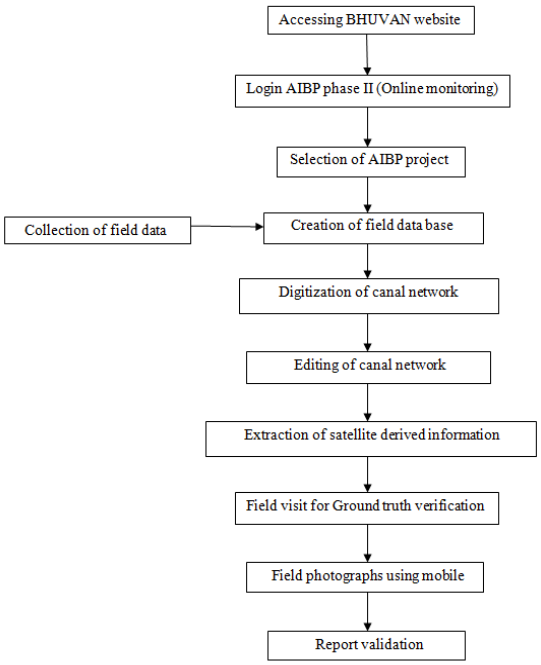
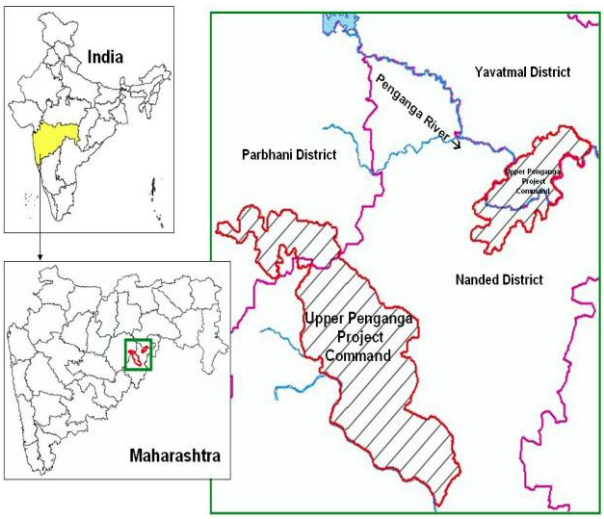


Figure 3.3: Flowchart of methodology for online monitoring

3. Study Area

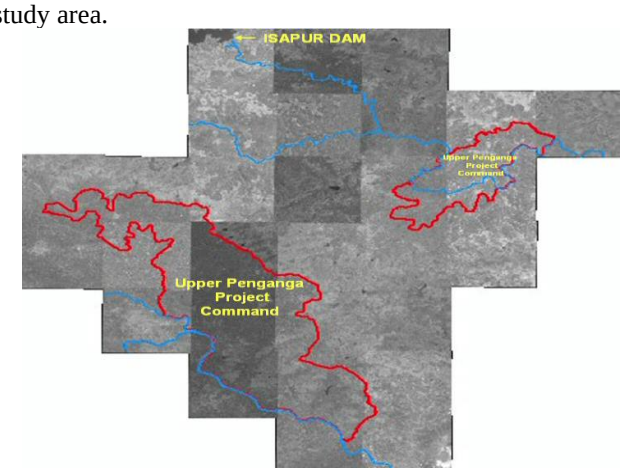
The Upper Penganga Major is being constructed in the Godavari Basin in Maharashtra state. The project envisages construction of two Dams viz. Isapur Dam across River Penganga, near village Isapur, district Yavatmal and Sapli Dam across River Kayadhu, near village Sapli, district Hingoli. Two main canals i. e. Isapur Left Bank Canal (ILBC) & Isapur Right Bank Canal (IRBC) taking off from the Isapur Dam and a feeder canal Kayadhu feeder canal (KFC) taking off from the Sapli Dam are envisaged for creating an ultimate irrigation potential of 1, 34, 280 ha (ICA 1, 07, 090 ha) in Yavatmal, Parbhani and Nanded districts of Maharashtra State. The geographical extent of the project is between 770 09' 35" E – 770 54' 14" E longitude and 180 56' 48" N – 190 34' 27" N latitude.



4. Data Collection and Field Surveys

As briefly mentioned in above chapter, the project activities were broadly divided into the following steps:
a) Secondary data and analysis leading to selection of sample projects for primary data collection.
b) Data on selected main canals/ distributaries from field offices

Satellite Data Used
Cartosat - 1 (IRS - P5) PAN sensor data was used which has a spatial resolution of 2.5 m and 10 bit radiometric resolution. Figure - 2 shows the satellite data coverage over the study area. Each scene is ortho corrected (7.5'X7.5') product and the entire study area was covered by 29 scenes. Figure - shows the mosaic of satellite image covering the study area.

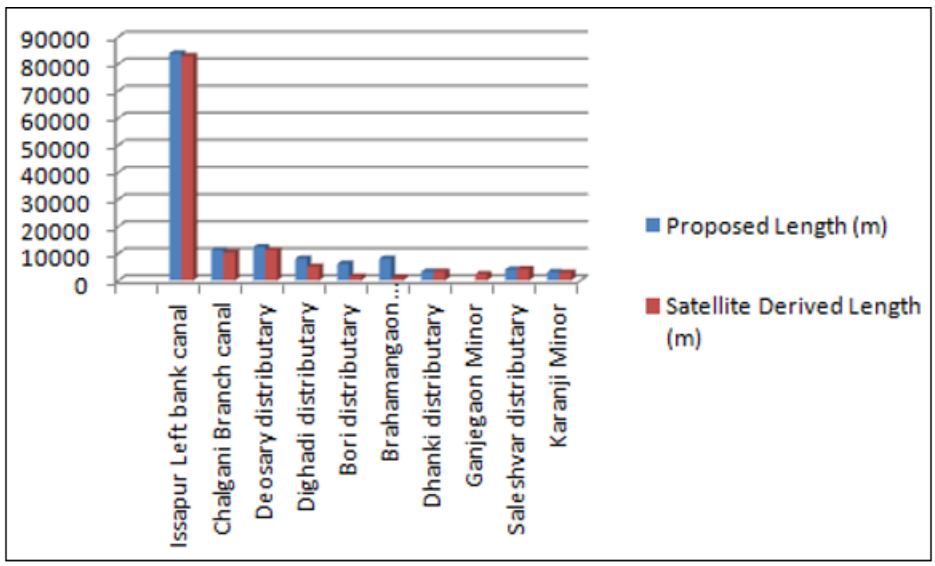


5. Result and Discussion

5.1 Irrigation Infrastructure

The inventory and mapping of canal network using cartosat data has been done in Isapur Left Bank Canal (ILBC) and Isapur Right Bank Canal (IRBC) under Upper Penganga Project. The details of the satellite derived existing canal network are shown in Table - 5.1. From the table it is observed that majority of the pending canals and canal gaps with pending reaches were found among Chalgani Branch Canal and Bramhangaon distributary under ILBC and Bhategaon Branch Canal under IRBC. Also different cross - drainage structures like aqueducts, other cross drainage structures and others were found to be completed on ILBC and IRBC except an aqueduct on IRBC at chainage 108.35 km.

Sr. No	Name of the canal	Proposed Length (m)	Satellite Derived Length (m)
1	Issapur Left bank canal	84000	82900
2	Chalgani Branch canal	11350	10457
3	Deosary distributary	12390	11273.97
4	Dighadi distributary	8140	5255.62
5	Bori distributary	6240	1541.48
6	Brahamangaon distributary	8150	1085.92
7	Dhanki distributary	3360	3366
8	Ganjegaon Minor		2416.19
9	Saleshvar distributary	4160	4337.93
10	Karanji Minor	3140	3080.69



Sr. No	Name of the canal	Proposed Length (m)	Satellite Derived Length (m)
1	Issapur Right bank canal	115	115.92
2	Kayadhu Branch canal	90000	89338.21
3	Bhategaon Branch canal	31375	31039.09
4	Bhogaon distributary	5960	8058.39
5	Wadgaon distributary	6700	6483.69
6	Kurunda Minor	2300	2207.04
7	Tail distributary	11230	9385.36
8	Nimagaon branch canal	21000	21395.86
9	Chenapur Branch canal	21000	19212.28
10	Tirkaswadi branch canal	37000	35278.18
11	Shindi Rahati	11397	11135.54
12	Manur distributary	4760	4800.14
13	Hangarga distributary	6940	6818.84
14	Mudhkhed distributary	9540	9591.24

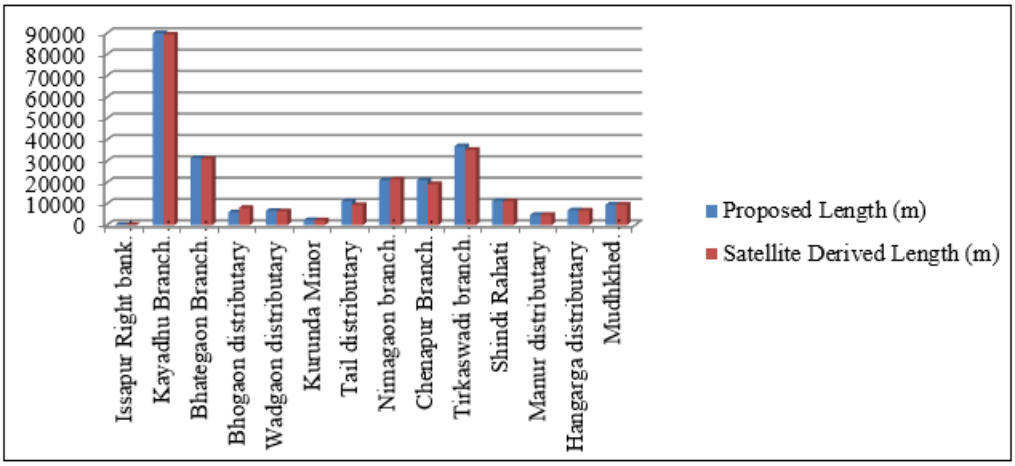
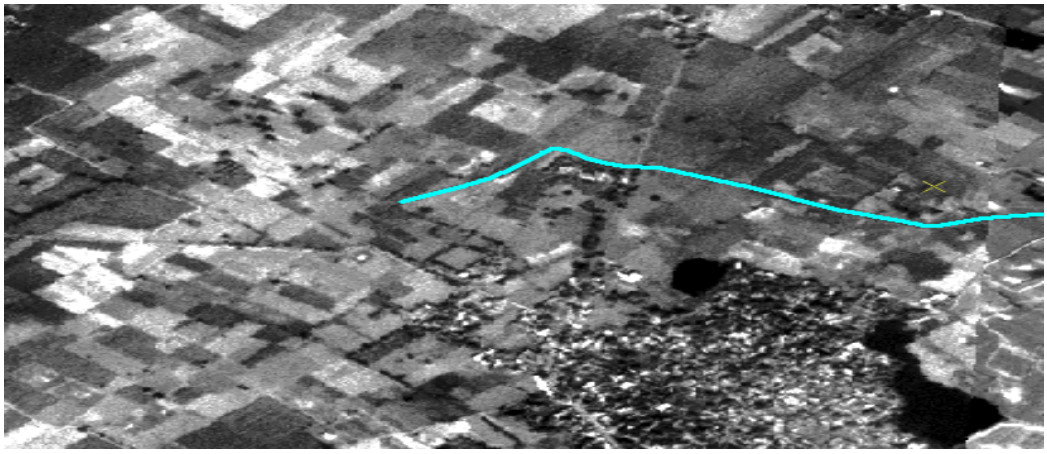


Table 5.1: Comparison of field reported and satellite derived offtake chainges and lengths of canal network

5.2 View of Critical Gap in Canal Network Capture from Cartosat Satellite Data

Upper penganga Left bank canal

Bramhangaon distributary branch canal pending off - take and reaches

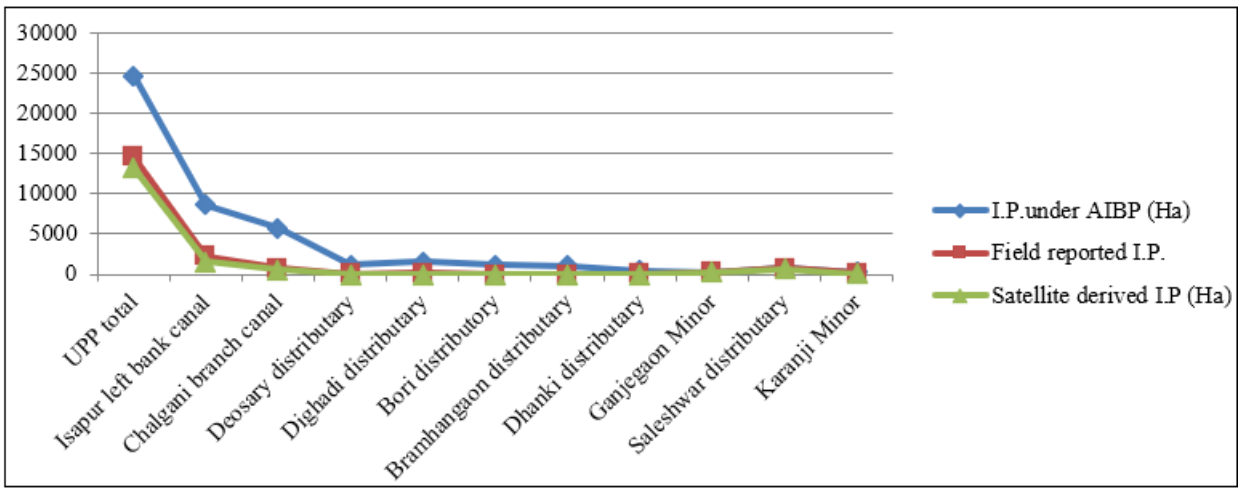


Chalgani branch canal pending reaches

5.3 Irrigation Potential

The irrigation potential was assessed using the irrigation infrastructure derived from the satellite data. The details of proposed irrigation potential, field reported & satellite based irrigation potential created the project are given in Table - 5.3. The overall Irrigation Potential created in the Upper Penganga project based on Cartosat data analysis is assessed as 13, 198 ha. as against the proposed Irrigation Potential of 24, 622 ha. Thus, the balance Irrigation Potential yet to be created is estimated as 11, 424 ha. The balance Irrigation Potential yet to be created under ILBC is 7, 054 ha and under IRBC is 4, 369 ha. The I. P balance which is yet to be created is distributed mostly among Chalgani branch canal (5, 223 ha), Bramhangaon distributary (1, 043 ha) under ILBC and Kayadhu branch canal (2, 237 ha), Bhategaon branch canal (1, 360 ha) under IRBC. Out of 2, 237 ha of balance Irrigation Potential under Kayadhu Branch Canal 1, 297 ha of area is not available for Irrigation Potential creation as mentioned by project officials during field visit. The field reported irrigation potential created and balance irrigation potential are 14, 549 ha. and 10, 073 ha. respectively. The total balance Irrigation Potential assessed from Cartosat study is lower (1, 351 ha.) than reported by field authorities. This is mainly due to pending reaches and their offtake connectivity to parent canals inspite of majority of the canal lengths being physically completed.

Name of the canal	Proposed I. P. under AIBP (Ha)	Field reported I. P.	Satellite derived I. P.	Remark
UPP total	24622	14549	13198	I. P=11, 424
Isapur left bank canal	8638	2219	1583.64	I. P=7056.36 Ha
Chalgani branch canal	5741.28	749.22	517.6	I. P=5223.68 Ha
Deosary distributary	1109	72.14	0	Pending
Dighadi distributary	1523	144.65	0	Pending
Bori distributory	1120	0	0	Pending
Bramhangaon distributary	1042.78	0	0	I. P=1042.78 Ha
Dhanki distributary	434	107.09	0	I. P=434 Ha
Ganjegaon Minor	220.94	220.94	220.94	Completed
Saleshwar distributary	769	719.96	702	I. P=67Ha
Karanji Minor	215	160.27	68.86	I. P=146.14 Ha



Name of the canal	Proposed I. P. under AIBP (Ha)	Field reported I. P.	Satellite derived I. P.	Remark
Isapur right bank canal	15984	12330.42	11614.82	I. P=4369.13 Ha
Kayadhu branch canal	5945	4543.42	3708.02	I. P=2236 Ha
Bhategaon branch canal	2340	1144	979.52	I. P =1360.48 Ha
Bhogaon distributary	280	0	64	Pending
Wadgaon distributary	33	0	0	Pending
Girgaon distributary	150	79	150	completed
Nimagaon branch canal	27	27	27	completed
Chenapur branch canal	0	0	0	completed
Tirkaswadi branch canal	356	33	33	I. P=323 Ha
Shindi rahathi branch canal	2557	2164	2286.32	I. P=270.68 Ha
jamgaon branch canal	2474	2196	2357.97	I. P =116.03 Ha
Mudkhed distributary	700	700	700	completed
Dongaon distributary	1203	1203	1203	Completed
Bolsa distributary	262	262	262	Completed

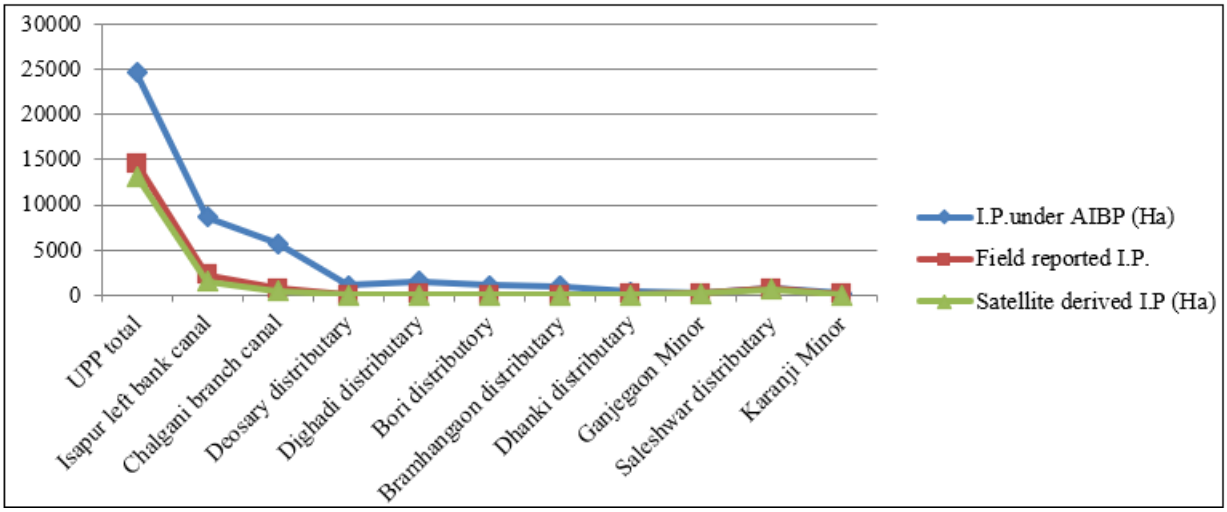


Table 5.3: Comparison of field reported and satellite derived Irrigation potential of canal network

6. Conclusion

1) Identification and mapping of existing irrigation network with main canal / branch canal/ distributaries/ minor & sub minors has been done from the satellite image through onscreen digitization using ERDAS IMAGINE image processing software and Arc GIS software by displaying the image at 1: 4000 to 1: 2000 scales. The above irrigation infrastructures were identified and mapped using the image interpretation key. Then random ground checks were made for verification and confirmation of image interpretation details.
2) In this study it has been seen that most of the distributaries and minors are complete. But, The canal lengths and their offtake chainages from parent canals derived from satellite data were found to be comparable with proposed field reported statistics except in the case of those canals which are either pending totally or having pending reaches yet to be taken up.
3) The shortage in length is mostly due to pending gaps in middle and tail reaches. It is observed that majority of the pending canals and canal gaps with pending reaches were found among Chalgani Branch Canal and Bramhangaon distributary under ILBC and Bhategaon Branch Canal under IRBC. The irrigation potential was assessed using the irrigation infrastructure derived from the Cartosat data analysis.
4) Based on the assessment of physical progress, the overall irrigation potential created in the Upper Penganga project under is assessed as 13, 198 ha. as against the proposed irrigation potential of 24, 622 ha. Thus, the balance Irrigation Potential yet to be created is estimated as 11, 424 ha. The balance Irrigation Potential yet to be created under ILBC is 7, 054 ha and under IRBC is 4, 369 ha. The Irrigation Potential balance which is yet to be created is distributed mostly among Chalgani branch canal (5, 223 ha), Bramhangaon distributary (1, 043 ha) under ILBC and Kayadhu branch canal (2, 237 ha), Bhategaon branch canal (1, 360 ha) under IRBC.
5) The field reported irrigation potential created and balance Irrigation Potential are 14, 549 ha. and 10, 073 ha. respectively. This is mainly due to pending reaches and their offtake connectivity to parent canals inspite of majority of the canal lengths being physically completed. The modern geospatial techniques of Remote Sensing and GIS with high spatial resolution data are useful to check the infrastructure development of canal.
6) Remote sensing and GIS techniques have been very effective. It consumes less time and it is the cheapest and accurate tool for mapping of canal infrastructure development.
7) Apart from all the advantage of remote sensing and GIS for infrastructure development of canal it has also some limitation. In case of very minor changes in canal structure might not be identified. To come out with

these problems one has to do very extensive field visit and using high spatial resolution data to minimize error.

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