Exploring the feasibility of using remote sensing in the dairy sector (fodder development)

A pilot study in Banaskantha District, Gujarat

Space Application Center, Indian Space Research Organisation (ISRO)

&

National Dairy Development Board (NDDB)

June 2015

50 Years of transforming lives through dairying

राष्ट्रीय डेरी विकास बोर्ड
National Dairy Development Board

CHAIRMAN

July 8, 2015

Foreword

India is the largest producer of milk in the world and about 70 percent of the milk production is contributed by small and marginal farmers, who own about 75 percent of milk producing animals but only about 40 percent of farm land. Less than 5 per cent of the country's farmland is devoted to fodder farming though the livestock sector's contribution to the farm sector's total gross domestic product (GDP) is now higher than that of cereals.

The full potential of interventions in the dairy sector to enhance productivity like breed improvement, efficient livestock husbandry and providing access to organised markets, cannot be fully realised, unless the bovine animals are fed the required nutrients adequately and in scientific proportions.

Thus, the challenge lies in augmenting the availability of feed and fodder in a situation, where there is steady shrinkage of natural pastures and common grazing grounds and vegetative cover. Sufficient emphasis also needs to be given for promoting the cultivation of fodder crops by including them in the cropping sequences.

ISRO has successfully developed the crop production forecasts (FASAL) technology, for major food crops, using remote sensing techniques. This pilot project, which is first of its kind in the country, had been initiated in collaboration with Space Applications Centre, ISRO to explore, whether remote sensing techniques could be utilised in estimating the area under fodder crop and the extent of availability of current fallows and culturable wastelands, with geographical locations.

This pilot project has demonstrated that remote sensing technology can act as an information and decision making tool for monitoring and planning of fodder development activities.

I hope that the finding of this pilot project is useful for all stakeholders in the dairy sector.

(T Nanda Kumar)

तपन मिश्रा
निदेशक
Tapan Misra
Director

भारत सरकार GOVERNMENT OF INDIA
अंतरिक्ष विभाग DEPARTMENT OF SPACE
अंतरिक्ष उपयोग केंद्र
SPACE APPLICATIONS CENTRE
अहमदाबाद AHMEDABAD - 380 015
(भारत) (INDIA)
दूरभाष PHONE : +91-79-26913344, 26928401
फैक्स /FAX : +91-79-26915843
ई-मेल *E-mail : director@sac.isro.gov.in*

FOREWORD

ISRO has been in the forefront of demonstrating the use of space technology for societal good. With the availability of very high spatial resolution satellites in recent years, ISRO has contributed significantly, by ushering in many new applications areas in agriculture and rural development.

National Dairy Development Board (NDDB) had played a pivotal role in the Operation Flood program, which had a significant contribution in making India the largest milk producer in the world today. However, the productivity of the dairy sector is crucially linked to feed and fodder availability for the bovine animals, among other requirements. In this context, NDDB had expressed desire to explore the feasibility of using remote sensing in dairy sector with SAC (ISRO).

Thus, a collaborative pilot project between NDDB & Space Applications Centre (SAC), ISRO was initiated on estimation of fodder crop area and identification of current fallows and culturable wastelands suitable for green fodder cultivation, using remote sensing technology, in Banaskantha district of Gujarat.

Fodder crops are normally grown sparsely and in very small plots by our farmers, typically one hectare or less. This makes the job of discrimination of these crops through our satellite quite challenging. Overcoming these challenges, it has been demonstrated in this pilot project that it is feasible to estimate the area under fodder crops at a district level using this technology.

It is felt that with active participation of all stake holders in the dairy sector, remote sensing technology can be utilised fruitfully for the benefit of the dairy farmers of our country. The pilot project, which is first of its kind in the country, showed the feasibility of attempting this remote sensing technology for estimating fodder crops and the available current fallows and culturable wastelands available during the season.

Tapan Misra

Ahmedabad
29 July 2015

(तपन मिश्रा)
(Tapan Misra)

Project Execution Team

The pilot project was executed by the following team members from SAC, ISRO, Ahmedabad & NDDB, Anand,

Dr. Sujay Dutta, Shri K.N. Chaudhury, Dr. R. Tripathy &
Shri K.R. Manjunath
from
Space Applications Centre (ISRO), Ahmedabad

&

Shri Darsh Worah, Ms. Mena Paghadar &
Shri Subir Mitra
from
National Dairy Development Board, Anand

Acknowledgement

We are grateful to **Shri T. Nandkumar, Chairman, NDDB** and **Shri A S Kiran Kumar, Chairman, ISRO** for taking keen interest, to initiate this pilot study for demonstration of procedure and feasibility of utilising remote sensing in the dairy sector, at the ground level.

The overwhelming support provided by **Shri Tapan Mishra**, **Director, SAC, ISRO** Ahmedabad for carrying out this study is also duly acknowledged.

We also acknowledge the contributions and support provided by the following:

National Dairy Development Board, Anand

1 Dr. T N Datta (General Manager, SA&S)

2 Shri Anil Patel (Manager, SA&S)

3 Dr. N R Ghosh (Manager, AN)

Banaskantha Milk Union, Palanpur

1 Sanjay Karamchandani (Managing Director)

2 Narsinh Gurjar (Fodder Development Officer)

3 Dr. Haribhai M Patel (Manager)

4 Dr. P S Chaudhary (Senior Officer)

5 Dr V S Patel (Senior Officer)

6 Dr M V Prajapati (Assistant Executive)

7 Dr D V Loh (Junior Executive)

Anand Agriculture University

1 Ms. Ashvini Patel (B.tech Agri IT, Final Semester Student)

2 Ms. Devee Odedara (B.tech Agri IT, Final Semester Student)

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(gadh), Tahsil: Palanpur, District: Banaskantha

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Executive Summary

India is the largest producer of milk in the world. The most important aspect of milk production in our country is that it is a major source of livelihood for a large proportion of the rural population, especially small holder farmers. About 80 percent of dairy farmers are small and marginal, typically owning one to three milk producing animals and contribute about 70 percent to the total milk production. Improving productivity in our dairy sector can potentially contribute to improved food security and stability of national milk prices, in addition to improving the incomes of millions of small holder milk producers.

One important way in which the productivity can be improved is to improve availability of feed and fodder for the bovine animals. However, less than 5 per cent of the cultivable land is devoted to growing fodder crops, though the contribution of the livestock sector to the agriculture GDP (at constant prices) is higher than that of cereals (2012-13).

Indian Space Research Organisation (ISRO) has successfully developed the crop production forecasts (FASAL) technology, for major food crops, using remote sensing techniques. *This pilot project, which is first of its kind in the country, had been initiated in collaboration with Space Applications Centre (SAC), ISRO, to explore, whether remote sensing techniques could be utilised in estimating the area under fodder crop and the extent of availability of current fallows and culturable wastelands, with their geographical locations.*

Fodder crops are normally grown sparsely and in very small plots by our farmers, typically one hectare or less. This makes the job of discrimination of these crops through remote sensing quite challenging.

This pilot project could estimate the area under green fodder crops in Banaskantha district (81 thousand hectares) and the fallow areas & culturable wastelands (57 thousand hectares) with 77% accuracy level. It could also demarcate these areas on a GIS platform.

The main learning and possible way forward, which emerges out of this pilot project, can be summarised as below,

a) It is feasible to assess green fodder availability for bovine livestock at disaggregated level (district/sub-district) through remote sensing, which could be an important input to various fodder development programs or program components viz. Accelerated Fodder Development Program (AFDP), National Livestock Mission (NLM), MGNREGA, NDP-I, Watershed, etc.

b) It can act as a decision making tool for monitoring and planning of fodder development activities by all the stakeholders in the dairy sector, particularly as part of drought management in fodder deficit areas.

Department of AH,D&F, Ministry of Agriculture, GOI had been discussing with ISRO to explore the potential of geospatial technology, to evolve a national study on the assessment of feed and fodder for the livestock at disaggregated level e.g., district / tahsil level, to start with and identify the measures for ensuring the availability of fodder on a sustainable basis.

In this effort, ISRO can collaborate with NDDB for getting ground truth (village level data) through its country wide network of Milk Unions, while research organisations like NDRI & IGFRI can be co-opted for developing models for fodder cropping pattern and establish fodder production forecasting.

As an end result, ISRO can provide information on season wise, remote sensing based estimates on area under fodder crop & current fallow & culturable wastelands in a GIS platform, for dissemination to Milk Unions and other stakeholders in the dairy sector.

Introduction

Development and growth of bovine livestock are highly associated with the scope of availability of fodder from cultivable land, forest, pastures and grazing lands. Traditionally, cattle grazed on the pastures and grazing lands are supported by feeding crop residues or straw of jowar, bajra, wheat, maize, paddy etc. supplemented with some green fodder. **The economic viability of bovine animal husbandry heavily depends on sources of feed and fodder, as feed and fodder costs account for around 70 percent of the total cost of milk production.** The feed given to cattle comprises of dry fodder, green fodder and concentrates. The adequate supply of nutritive fodder and feed is a crucial factor impacting the productivity and performance of the animals.

One of the main reasons for the low productivity of our livestock is under-nutrition either due to lack of adequate quantity or lack of balanced rations, beside the low genetic potential of the animals.

From **Table-1** below, it is evident that the country is highly deficient in respect of availability of green fodder, dry fodder and concentrates. The deficit gap of availability vis-à-vis the requirement of green fodder is huge at 665.80 million MT (62.76 %) and 138 million MT (23.46 %) for dry fodder. The deficit of concentrates also found to be more than 30 percent. The fodder and feed deficit varies across states and found more acute and chronic in arid and semi-arid states where farming is highly dependent on rainfall and have large livestock population.

Table-1 : Requirement and availability of fodder in the country – 2010.

Year	Feed Resources	Availability (Million Tons)	Requirement (Million Tons)	Balance (Million Tons)	% Deficit
2012	Dry	375	480	-105	-22
	Green	614	820	-206	-25
	Concentrate	55	82	-27	-33
2025 (Projected)	Dry	433	550	-117	-21
	Green	600	1000	-400	-40
	Concentrate	65	105	-40	-38

Source: National Institute of Animal Nutrition and Physiology (NIANP):ICAR 2012

About 29 Million hectare area in the country falls under the category of open forests with less than 0.4 canopy density, which can be developed with fodder trees. Further use of quality fodder seeds including dual purpose grains like Bajra, Maize and Jowar, etc. could improve the availability of feed and fodder multiple times.

The chronic shortage of feed and fodder resources during the last few decades particularly the shortage has been severe in the Eastern region, as compared to other regions. This could be attributed to the growing livestock population, low productivity and less emphasis on forage cultivation by the livestock owners.

To increase the fodder production, concerted efforts are needed to develop community pastures with improved grasses and cultivation of fodder on current fallows and marginal land areas. Suitable measures to increase bio-mass production on current fallows, wastelands and common grazing lands needs to be taken up expeditiously. Silvi-pastures in wastelands and available degraded forest lands can also be taken up.

In fact, the National Livestock Mission addresses these issues comprehensively, however ground level monitoring and implementation is a challenging task, due to lack of sufficient data on area under fodder crop, varieties of fodder crops grown and fodder production.

The fodder crops as assessed in 2010-11 in major fodder growing states are shown below in **Table-2**.

Table-2 : Area under fodder crops in 2010-11

Sr.	Study States	Area '000 ha
1	Rajasthan	3287
2	Maharashtra	969
3	Uttar Pradesh	831
4	Gujarat	821
5	Punjab	540
6	Madhya Pradesh	462
7	Haryana	408
8	Tamilnadu	195

9	Andhra Pradesh	85
10	Jammu & Kashmir	53
11	Karnataka	35
12	Uttarakhand	35
13	Bihar	18
14	West Bengal	3
15	Others	27
	All India	**7769**

Source: Basic Animal Husbandry Statistics-2014, DAHDF, GOI

Rangeland and pastures have been identified as one of the Societal Benefit Areas (SBA) identified by Group of Earth Observation System of Systems (GEOSS), Headquartered in Geneva, which observed that the fast changing international environment in terms of food supply and climatic change enhances the need for rangeland monitoring in developing countries also.

With the experience gained so far in national level agricultural production forecasting through remote sensing under 'FASAL' project, it was thought prudent to attempt fodder crop assessment and suggests ways for improving fodder production areas, as these are crucial inputs in the dairy sector.

In this project IRS LISS-III multi-date data is used to discriminate food crops and fodder crops in the study area during October 2014 to March 2015. The major fodder crops grown in study area are Pearl Millet, Sorghum, Lucerne, Cowpea, Guinea Grass, Maize, Oats, and Chicory.

Objective of the pilot project

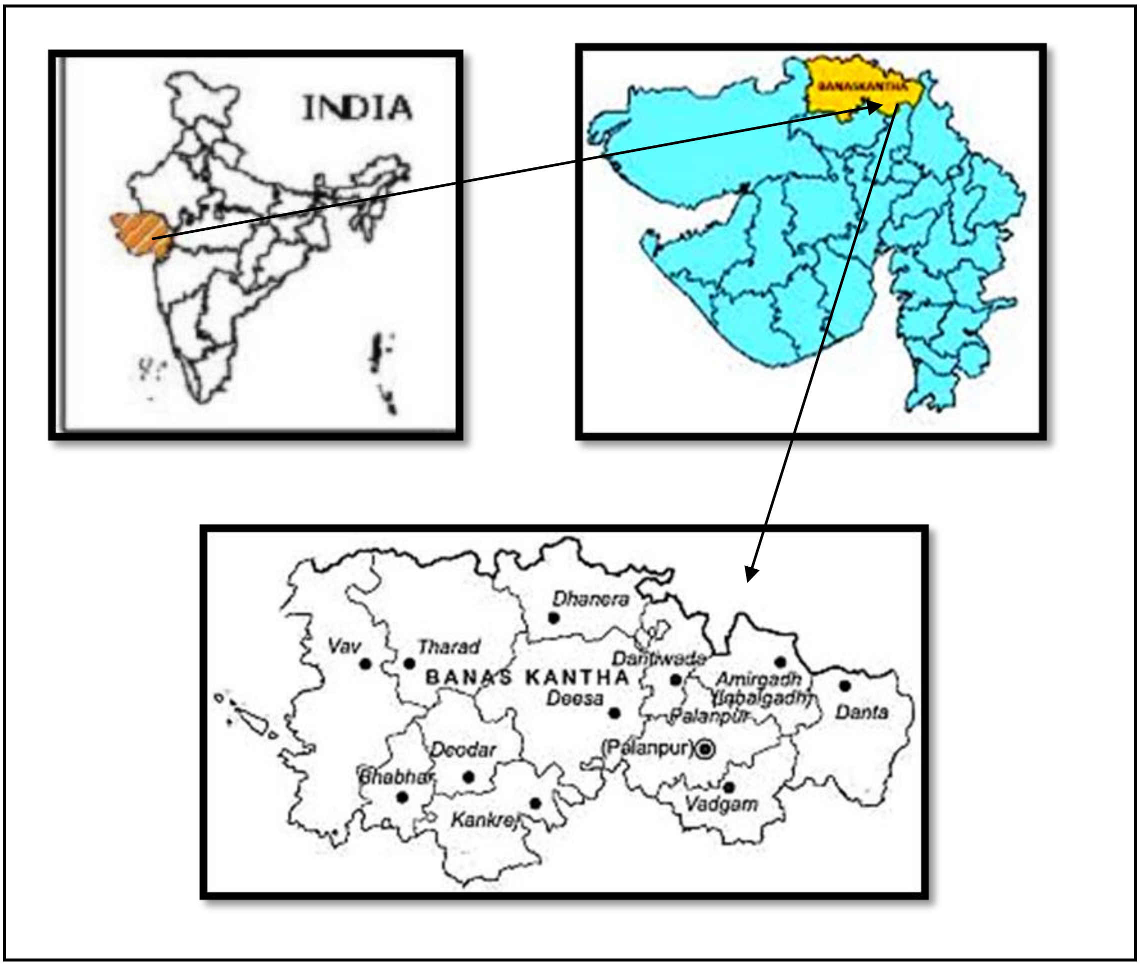
- **Identification/discrimination between food crops and fodder crops at district level.**
- **Identifying suitable areas of current fallows and culturable wastelands at district level, for green fodder cultivation.**

Study Area

Banaskantha district, Gujarat was chosen as a study district for demonstration purpose. It lies between parallels of latitude 23° 49' and 24° 42' and the meridians of longitude 71° 1' and 73° 0' **(Figure-1).** The area covered by the district is 10,757 sq. km. (5.49 %).The district is located in the Northeast of Gujarat and is presumably named after the Banas River which runs through the valley between Mount Abu and Aravalli Range, flowing to the plains of Gujarat in this region and towards the Rann of Kutch. It has twelve tahsils namely Deesa, Dantiwada, Bhabhar, Vav, Kankrej, Deodar, Tharad, Dhanera, Danta, Vadgam, Amirgadh and Palanpur. Deesa is famous for its potato market. Some parts of the district are flat and some are hilly and full of small hills and hillocks.

The district is facing a problem of high incidence of poverty, low employment availabilities in lean agriculture seasons, acute shortage of water resources for both, drinking and irrigating crops, frequent drought and distress migration of big livestock holders along with livestock in summer season. **Livestock and dairying plays the dominant role in the economy of the district**.

Figure-1 : Banaskantha district, Gujarat



Satellite Data

Multi-temporal cloud-free digital data from Indian Remote sensing satellite (IRS-P6) LISS-III was acquired during Rabi Season (October-April). IRS, LISS-III data is provided by SAC-ISRO as shown in **Table-3,** below. The study area lies in two LISS-III scenes of 093-55 and 092-55 (**Figure-2**). The satellite data was imported into ERDAS IMAGINE 9.1 software in an image format for geometric rectification.

Figure-2 : Geo-referenced FCC of Jan.12, 2015, Path: 92 Row: 55

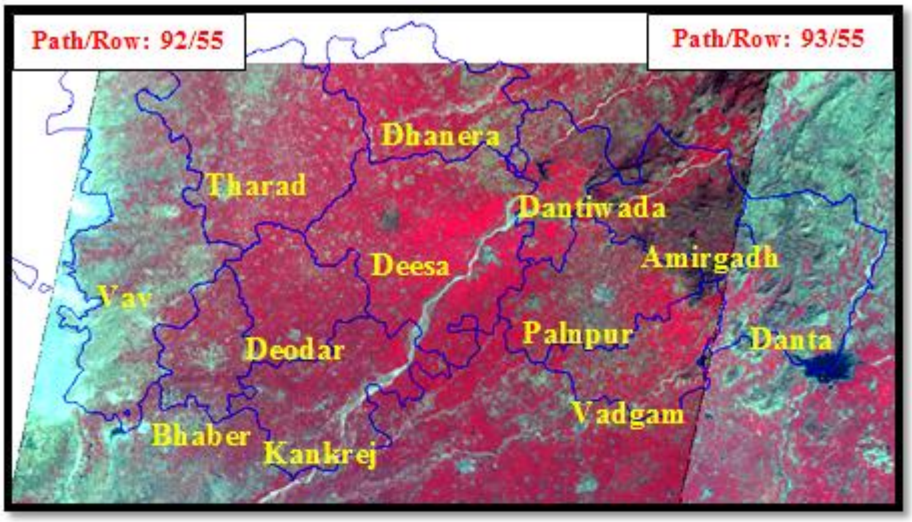


Table-3 : Multi-date LISS-III data information

No	Date	Path/Row
1	Oct.08,2014	92/55
2	Oct.13,2014	93/55
3	Nov.01,2014	92/55
4	Nov.241,2014	93/55
5	Nov.30,2014	93/55
6	Dec.19,2014	92/55
7	Dec.24,2014	93/55
8	Jan.12,2015	92/55
9	Jan.17,2015	93/55
10	Feb.05,2015	92/55
11	Feb.10,2015	93/55
12	Mar.25,2015	92/55
13	Mar.30,2015	93/55
14	Apr.18,2015	92/55

Field Survey Data (Ground Truth)

Field surveys were carried out three times, in the duration, as shown below,

1st: 12-13 February 2015,

2nd: 17-19 February 2015

3rd: 16-17 April 2015

The project team visited 69 villages to collect 169 Ground Truth (GT) points across the district. Villages were selected in consultation with Banaskantha Milk Union, based on their knowledge about villages growing fodder in significant amount.

The third field survey was carried out for **verification** of fodder growing areas. **These points were preselected randomly from the classified imagery and the project team navigated to the exact point using GPS and Google Maps.** Ground Truth (GT) was done by matching the pattern, shape and size of the field from the FCC for a particular topographic feature using GPS locations.

To illustrate, ground truth sheet **(Figure-3)**, zoomed view **(Figure-4a)** and synoptic view **(Figure-4b)** of a fodder growing plot in **Village**: Dhedhal **Tahsil** : Deesa, is presented below.

Figure-3 : Ground truth sheet of fodder crop [Village: Dhedhal, Tahsil: Deesa]

S. No.	Heading of Information	Values / Detail
1	Date of Observation	13/2/2015
2	Crop Name	Lucern
3	Farmers name/contact no	9428196325 Desai Tejabhai Pirabhai
4	District name	Banaskantha
5	Taluka name	Deesa
6	Village name	Dhedhal
7	Field size	1 ha
8	Crop growth stage	Peak vegetative
9	Irrigated/unirrigated field or Any crop stress	irrigated
10	Geographic latitude	24.25803°
11	Geographic longitude	72.06919°
12	Field GT photograph no.	5353
13	Name of GT collector	Mr. Darsh
14	Name of adjacent crop grown	mustard
15	Remarks if any	

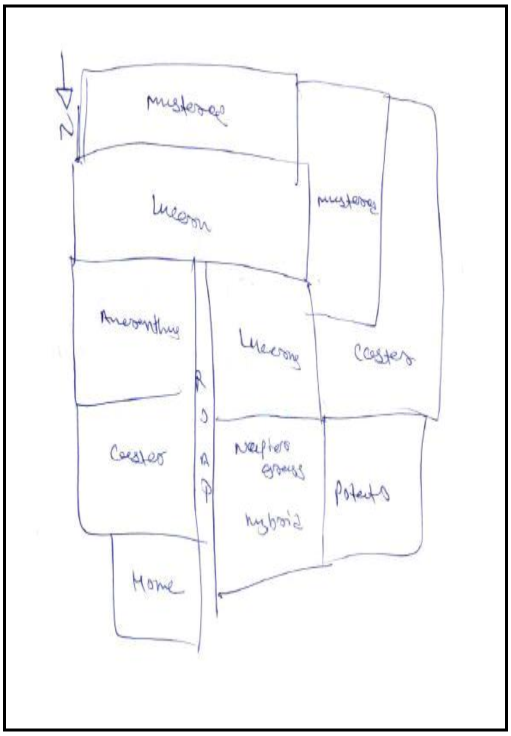


Figure 4a : Zoomed view of the GT survey

Figure 4b : Synoptic view of the GT

The field location of fodder growing areas were recorded in term of their geographic position using hand held GPS. Along with this ancillary information such as village name, crop condition, farmer's name, soil moisture, date of sowing and harvesting were collected. From the location details, a point map with attribute information was prepared in GIS, which was used to collect different crop signatures for the spatial assessment of fodder crops in the study area.

Methodology

1 Calculation of NDVI and LSWI mean value

NDVI (Normalised Difference Vegetation Index) and LSWI (Land Surface Water Index) images were made and analysed to see the vegetation profile changes at different time duration. SWIR, NIR and Red bands are important for NDVI, LSWI calculation as per the formula given below:

$$NDVI = \frac{\rho_{nir} - \rho_{red}}{\rho_{nir} + \rho_{red}}$$

Where, ρ_{nir} = radiance in near infrared band (LISS band 3)

ρ_{red} = radiance in Red band (LISS band 2)

For LSWI, SWIR and NIR bands are important, as per its formula

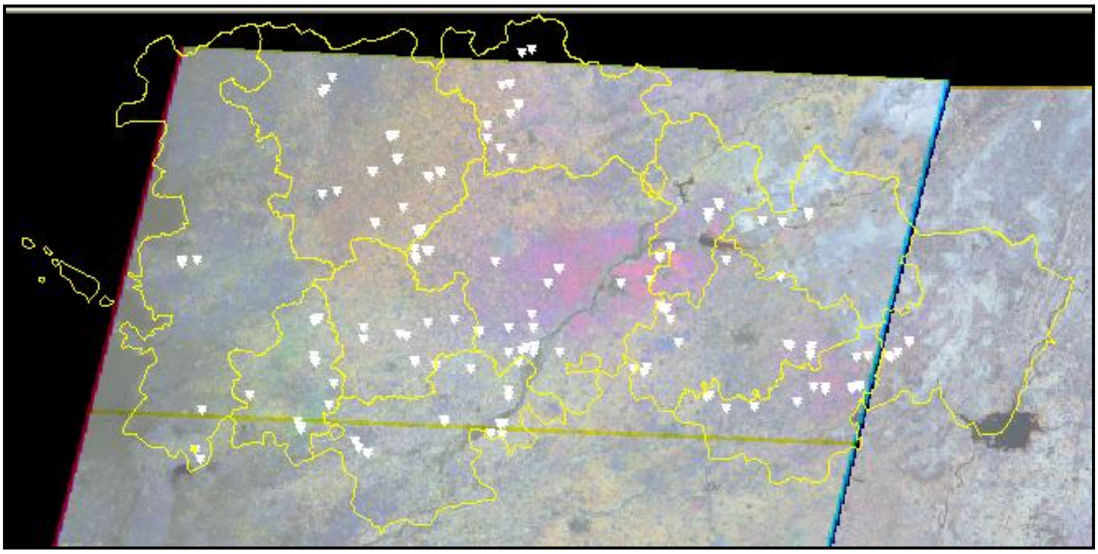
$$LSWI = \frac{(\rho_{nir} - \rho_{swir})}{(\rho_{nir} + \rho_{swir})}$$

Where, ρ_{nir} = radiance in near infrared band (LISS band 3)

ρ_{red} = radiance in SWIR (LISS band 4)

Next, date wise layer stack of all NDVI and LSWI image were made and overlaid on the Banaskantha district boundary and GT points (fig.5).

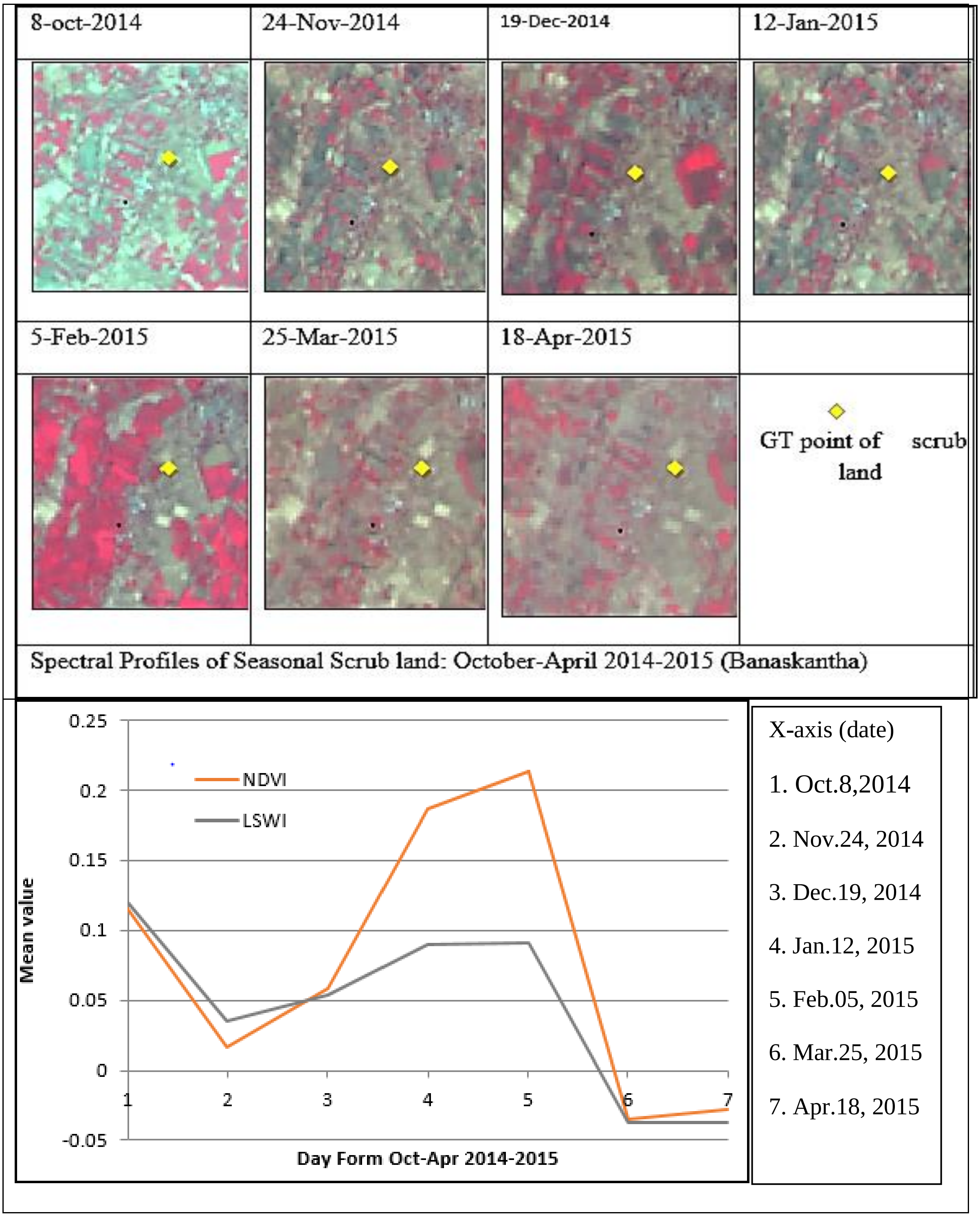
Figure-5 : Layer stack of NDVI images for all date with GT coverage and Tahsil boundaries



The spectral profiles of all the pixels of both LSWI and NDVI images will differ as per its vegetation stages and reflectance.

To illustrate, **Figure-6** below, represents the NDVI and LSWI spectral profiles for the **current fallow** land of **Village**: Ujjanvada, **Tahsil** :Bhabhar Similar spectral profiles were created for all GT points.

Figure-6: NDVI and LSWI Spectral profiles

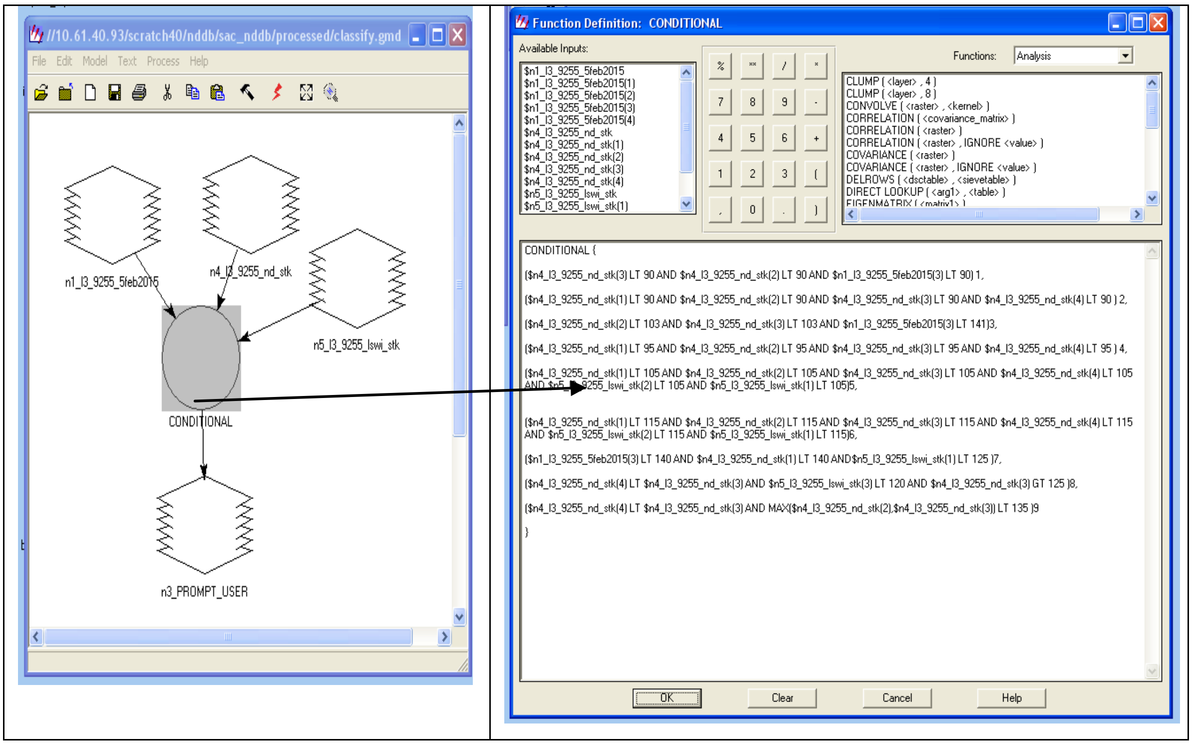


2 Hierarchical Decision Rule

Hierarchical decision rule was used to mask classes of non-agricultural area i.e. Forest, Scrubland, Water, Sand, Wet soil, and

Fallow land. NDVI and LSWI stack file are used to mask non-agricultural area. Classes were defined based on different values of NDVI. Sometimes, when the mean NDVI values were not sufficient, at that time LSWI mean values were used. Conditional functions were defined in the model for generating mask of non-agricultural areas currently not under cultivation as shown in **Figure-7** below.

Figure-7 : Model development for generating mask image of non-agriculture area



3 Image Classification

The automatic classification process in ERDAS IMAGINE uses the colours or spectral patterns of raster cells in a multi spectral image to automatically categorize all cells into a specified number of spectral classes. The relationship between spectral classes and different surface material or land cover type may be known before hand or determined after classification by analysis of the spectral properties of each class. The automatic classification process offers a variety of classification method as well as tools to aid in the analysis of the classified result. In Automatic Classification process it combines classes of raster cells and produces a classification raster. This process is designed for using a coregistered set of rasters, which represents a multispectral image. The basic requirement for the Automatic Classification process is that input raster represent continuous (non-categorical) data, and have the same extent, map projection, and cell size.

The Automatic Classification process provides several classification methods; each method uses numerical methods to compare the spectral patterns of all cells and assigns cells with similar patterns to the same class. The process automatically categorizes cells in an image into spectral classes, which can be related by the interpreter to specific surface materials or land cover types. The success of the unsupervised methods is based on the premise that the input raster dataset includes natural statistical groups of spectral patterns that represent particular types of physical features. All of the unsupervised classification methods, except simple One-Pass Clustering, use an interactive process to analyse a set of sample input cells and determine a set of class centre and associated statistical properties. The entire input raster set is then processed, and a classification rule is used to assign each raster cell to one of the defined classes.

An unsupervised classification (ISODATA Clustering) technique was performed using combination of all NDVI dates to create a mask of non-agriculture and fallow and forest area area. Second iteration of unsupervised classification (ISODATA Clustering) technique was applied to segregate fodder growing areas in the district.

The ISODATA algorithm analyses a sample of the input to determine a specified number of initial class centres. Cells are assigned to classes by determining the closest class centre (minimum Euclidean distance). After each classification step, the process calculates a new centre for each class by finding the mean vector for each class. At the beginning of each iteration the process evaluates the set of classes produced by the previous steps. Large classes may be split on the basis of a combination of factors, including the maximum standard deviation for the class, average distance of class samples from the class centre, and number of sample cells in the class. If the distance between the centres of a pair of classes falls below a user-defined threshold, the classes are combined. If the number of cells in a class falls below a user-defined threshold, the class is discarded, and its cells are reassigned to other classes. Iterations continue until there is little change in the location of class centres in successive iterations, or until the maximum allowed number of iterations is reached.

Some classes presenting profile like fodder are mixed with other crops, while some of the fallow land classes are covered in forest, hilly area, road, etc. To overcome these problems, LSWI image were used for unsupervised classification in second iteration with 20 classes and 30 iterations. Each class was identified based on the signature profile of collected GT points. Histogram of classified fodder classes were generated to account for the number of fodder pixels within the district. The flow diagram of the procedure is shown in **Figure-8a** and **Figure-8b** below,

Figure-8a: Remote Sensing Data Analysis Procedure

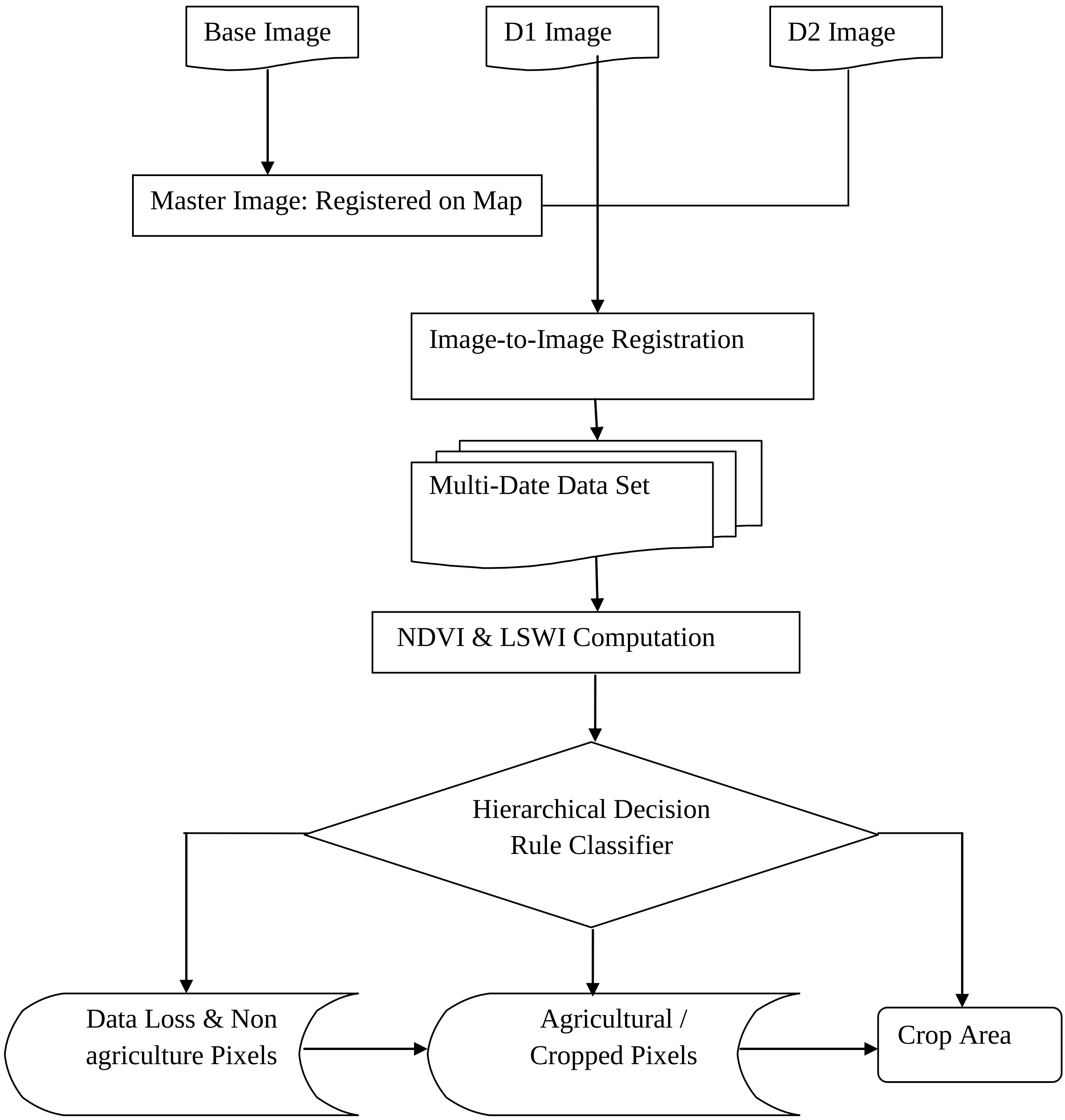
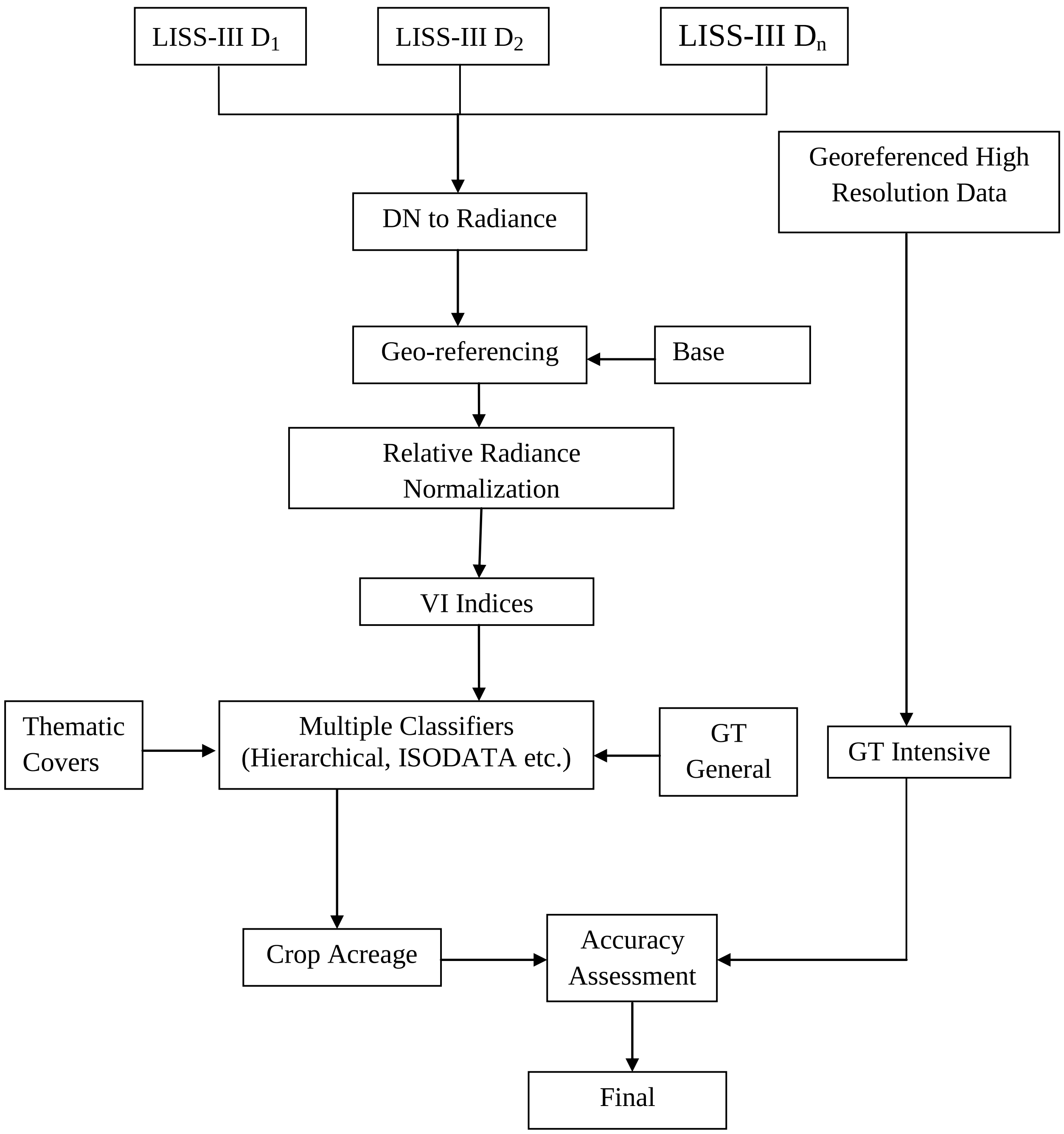


Figure-8b : Methodology for Fodder Area Estimation



Results & Outputs

Classification of signatures play important role in crop identification. Classification was applied separately on both LISS-III scenes (92/55 and 93/55) and a mosaic of these scenes were prepared. Identification of agricultural and non-agriculture land-use like canals, water bodies, railway lines, roads, forest area, etc. was done using hierarchical decision rule analysis. Agriculture area was extracted for further analysis after masking out the non-agricultural areas. Fodder crops and other competitive crops, scrub lands and fallow lands formed part of the derived agricultural areas. The agricultural areas were classified using ISO-DATA clustering. **Figure-9** shows a GT point of fodder crop overlaid on satellite imagery of different dates. data different classes were marked based on different temporal spectral profile of various fodder crops like lucerne, oats, chicory, maize, etc. as shown in **Figure-10** as an illustration ,

Figure-9 : GT point of fodder crop overlaid on satellite imagery of different dates

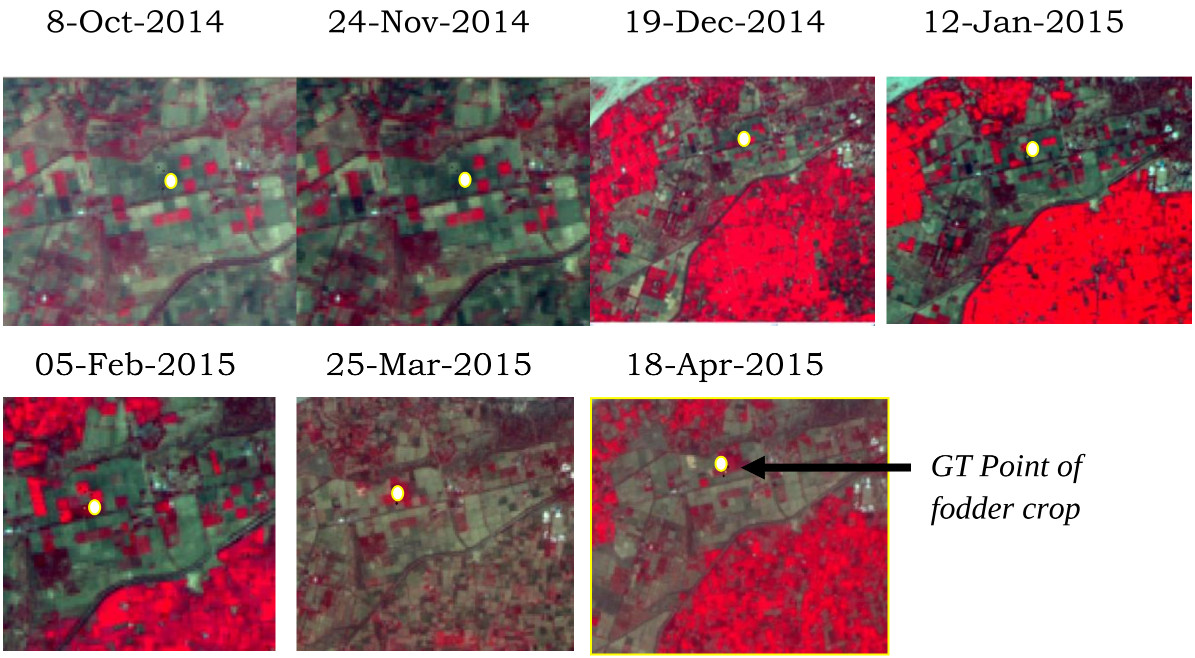
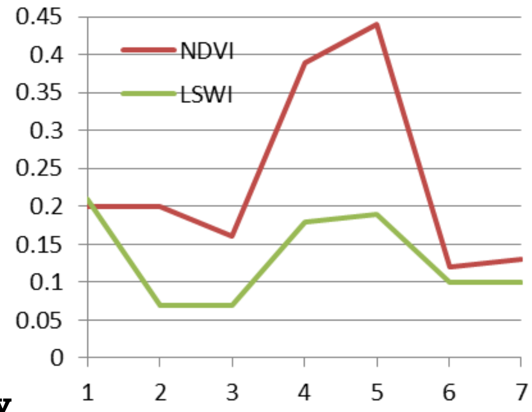


Figure-10 : Spectral signatures of different crops.

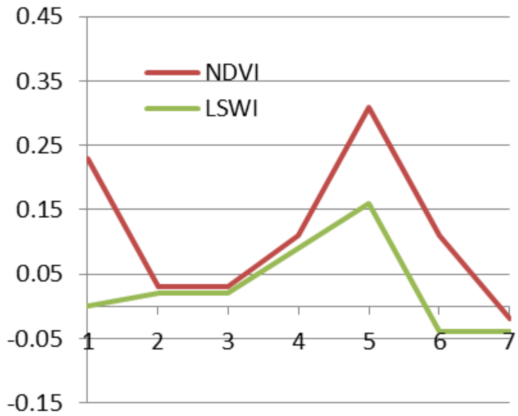


Chicory

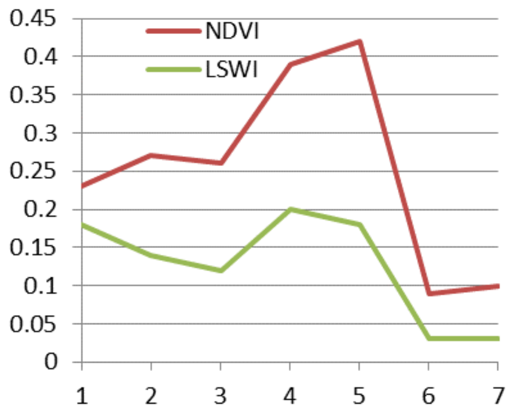
Here, X-axis (dates)

1. Oct. 08, 2014
2. Nov.24, 2014
3. Dec.19, 2014
4. Jan.12, 2015
5. Feb.05, 2015
6. Mar.25, 2015
7. Apr.18, 2015

Maize

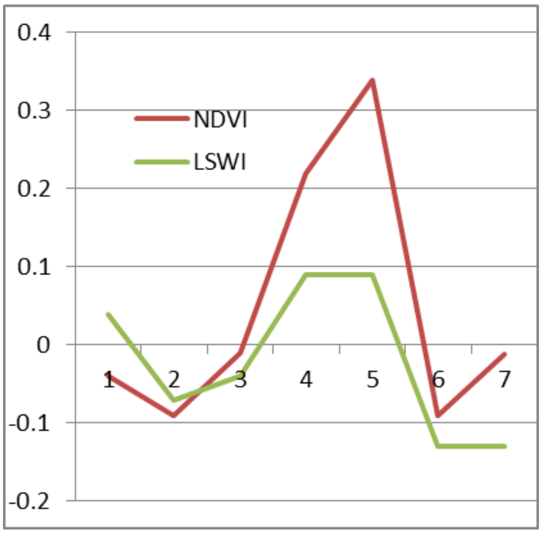


Lucerne + Oats



Oats

Wheat



Based on the above spectral profile fodder crops were identified. Some fodder classes were mixed with other crops like cumin and mustard and castor. To overcome these problems, stack of LSWI images along with NDVI images were used for better results. Each class was identified based on the signature and profile of GT point.

As Banaskantha district is covered in two different Path/Row, same procedure is followed for another adjacent path/row image. Single mosaic image was created after classifying both the adjacent path images. Then total fodder area was calculated from mosaic image by overlaying Banaskantha shapefile based on histogram of classified image.

Figure-11 below shows the tahsil boundary and classified image of fodder crops while **Figure-12** shows its comparison with False Colour Composite (FCC) image. *The distribution of fodder crops is shown in yellow colour.*

<u>Figure-11 : Classified image for fodder crops</u>

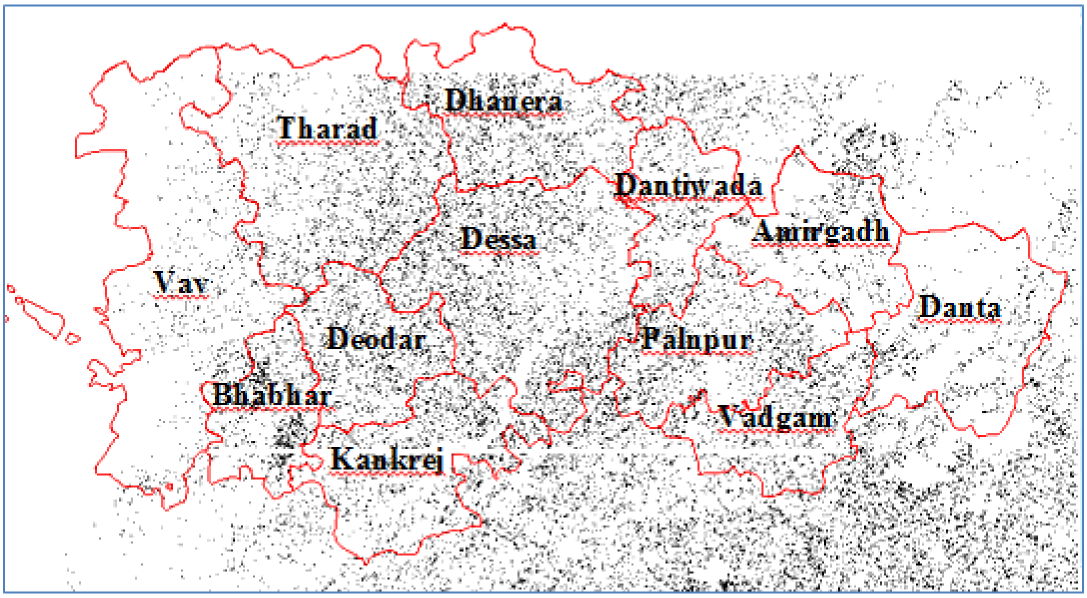
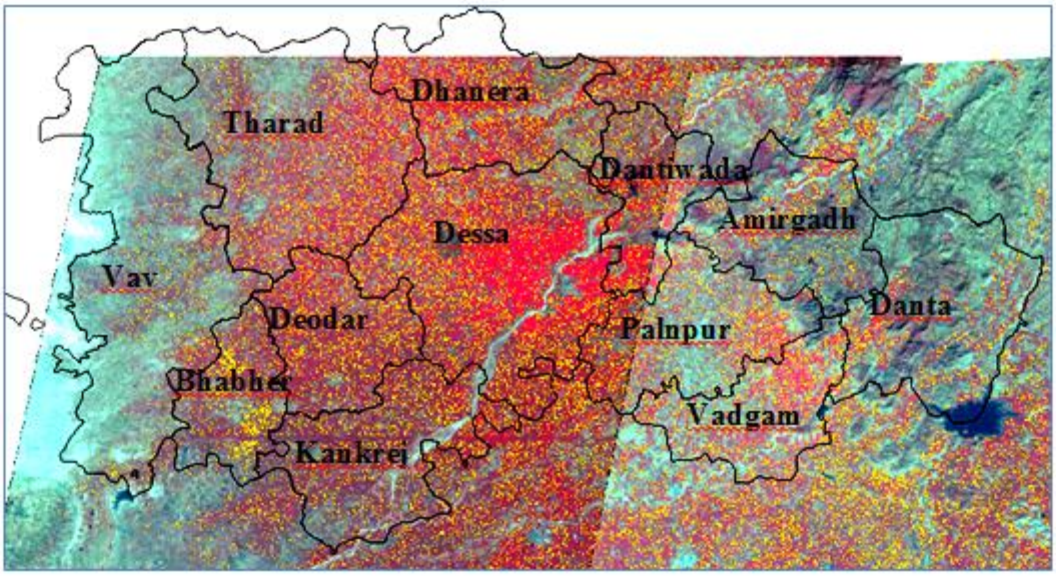

Dhanera
Tharad
Dantiwada
Amirgadh
Dessa
Vav
Danta
Deodar
Palnpur
Bhabhar
Vadgam
Kankrej

Figure-12 : FCC overlaid on classified image of fodder crops



This image shows the different fodder crops pixel marked in yellow colour. **Total area under fodder crop is estimated to be 81 thousand hectare for rabi season.**

1 Accuracy assessment

The accuracy assessment involves the comparison of a site on a map against reference information (GT) for the same site. Accuracy assessment is essential for comparison between classified imagery and ground truth data to evaluate how well the classification represents the real world.

Table-4, below, presents the contingency table for accuracy assessment.

Overall Accuracy: Number of correct plots / total number of plots.

Table-4 : Contingency table for accuracy assessment

Plots	Fodder	Mustard	Castor	Potato	Scrub land	Others	Total
Fodder	85	7	1	0	18	7	118
Mustard	1	3	0	0	0	0	4
Castor	1	0	4	0	0	1	6
Potato	0	0	0	4	0	0	4
Scrub Land	0	0	0	0	14	0	14
Others	2	0	0	0	0	18	20

Total	89	10	5	4	32	26	166

Total accuracy = $\frac{\mathbf{128}}{\mathbf{166}} \times 100$ = **77 %**

Here, diagonals represent sites classified correctly according to reference data and off-diagonals represent misclassified sites.

2 Kappa coefficient

Kappa coefficient (represented as $\hat{K}$) reflects the difference between actual agreement and the agreement expected by chance. For example, $\hat{K}$ of 0.85 means there is 85% better agreement than by chance alone. $\hat{K}$ is useful to compare two error matrices, cells in error matrix according to severity of misclassification provide error bounds on accuracy.

Table-5 below provides the contingency table for the Kappa coefficient

Table-5 : Contingency table for kappa coefficient

	Class types determined from reference source								User Accuracy (%)
Class types determined from classified map	Plot Size	**Fodder**	**Mustard**	**Castor**	**Potato**	**Scrub land**	**Others**	**Total**	
	Fodder	**85**	7	1	0	18	7	**118**	**72**
	Mustard	1	**3**	0	0	0	0	**4**	**75**
	Castor	1	0	**4**	0	0	1	**6**	**66**
	Potato	0	0	0	**4**	0	0	**4**	**100**
	Scrub Land	0	0	0	0	**14**	0	**14**	**100**
	Others	2	0	0	0	0	**18**	**20**	**90**
	Total	**89**	**10**	**5**	**4**	**32**	**26**	**166**	
Producer Accuracy (%)		**95**	**30**	**80**	**100**	**44**	**69**		**77**

Computation of $\hat{K}$ Coefficent of Agreement

$$\hat{K} = \frac{N\sum_{i=1}^{k} x_{ii} - \sum_{i=1}^{k}(x_{i+} \times x_{+i})}{N^2 - \sum_{i=1}^{k}(x_{i+} \times x_{+i})}$$

$\sum_{i=1}^{k} x_{ii}$= (85+3+4+4+14+18) = 128

$\sum_{i=1}^{k}(x_{i+} \times x_{+i})$= (118 x 89) + (4 x 10) + (6 x 5) + (4 x 4) + (14 x 32) + (20 x 26)

=11556

$\hat{K} = \frac{166(128) - 11556}{166^2 - 11556}$ = **60.57%**

While the accuracy level was 77%, the Kappa coefficient was found to be 60.57%.

3 Identification of current fallows and culturable wastelands

The spatio-temporal analysis of the region was done using multi-date IRS Resourcesat2 satellite data of LISS-III sensor of 24 m resolution to determine the region within the district. The data were geo-referenced and converted to radiance values using radiometric calibration. After these pre-processing, the NDVI and LSWI of all the multi-date images were generated and stacked together. An unsupervised classification (ISODATA Clustering) technique was performed using combination of all NDVI and LSWI dates to create a mask of non-agriculture and fallow and forest area . Classification was carried out using Classifier Module of ERDAS Imagine Software. Non-agriculture areas were delineated through clustering by their typical NDVI values throughout the season. Discrimination of clusters of fodder crops and other rabi crops were done through their growth pattern as seen in spectral-temporal profiles.

Initially large classes of permanent fallow that are saline soil, hilly area, water bodies and other forest were eliminated from the images using hierarchical decision rule classification . The permanent fallow lands have very low NDVI values throught the season. Profile rarely changes in case of saline soil because it remains permanently fallow during the entire season and its spectral reflectance remains below 0.2 NDVI values. Same is the case of road, railway, canal and water bodies having similar permanent spectral profiles every time. One the other hand, the profile of forest peak at the some specific period. Thus depending upon profiles these non-agricultural area were discriminated from agricultural area using Hierarchical decision rule.

To classify remaining agricultural classes (like fodder and other competitive crop signature according to Ground Truth (GT) data) ISO-DATA clustering technique were used. Current fallow land and fodder crops signatures were identified using this technique. The signature reflecting low NDVI for maximum duration, were considered as fallow land or wastelands. Then total current fallow land and wasteland area was calculated from histogram of classified pixels of fallow land.

Figure-13 below shows the distribution of fallow land within tahsil boundary and **Figure-14** shows its comparison with FCC image to ascertain the location of fallow and wastelands in the rabi season.

Figure-13 : Classified image for Current Fallow land

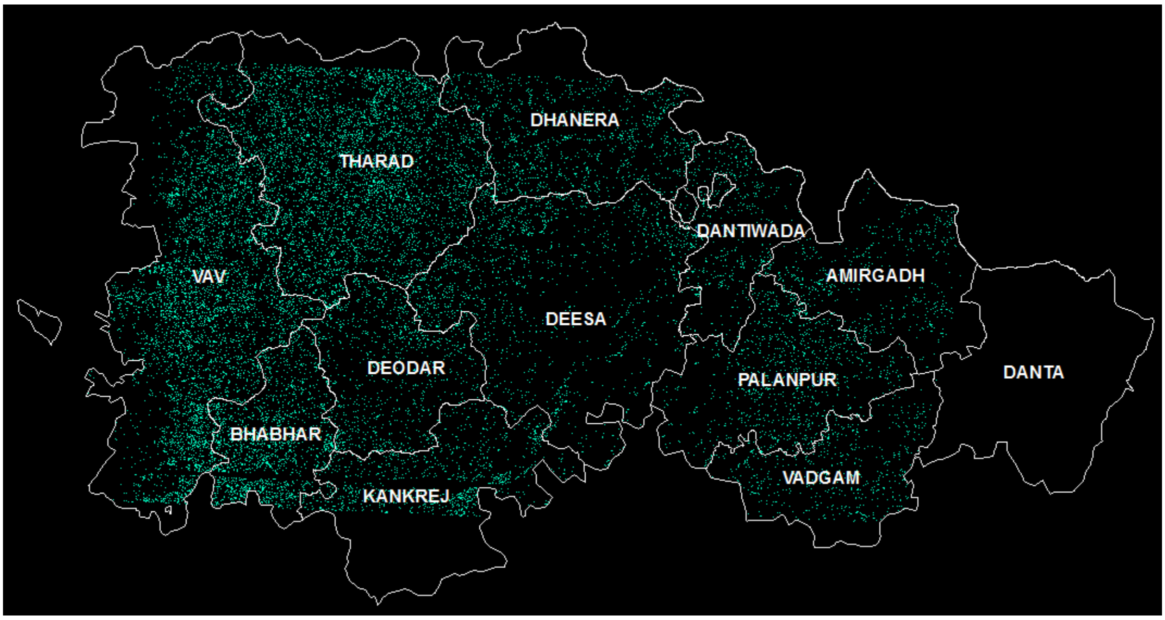
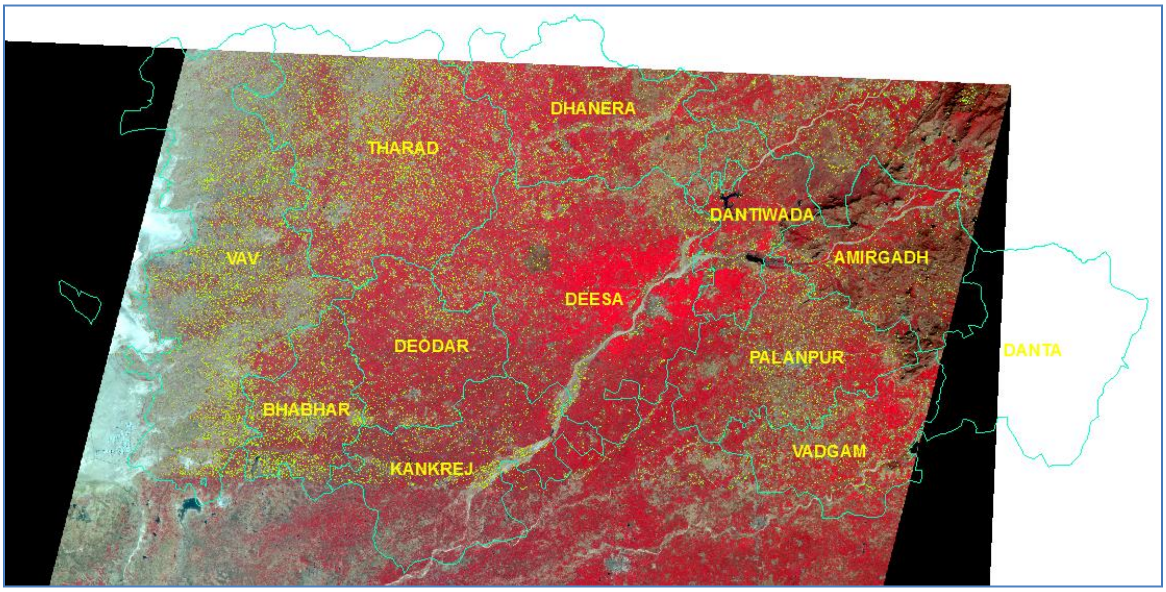


Figure-14 : Classified image for Current Fallow land with FCC



Using the classified image analysis shows that the entire central belt shows high proportion of cultivable land under fodder crop in the category (12-20% of the cultivable land as fodder crop) underlying the importance of bovine livestock & dairying in Banaskantha district as shown in **Figure-15**.

Figure-15 : Proportion of fodder crop area out of cultivable land

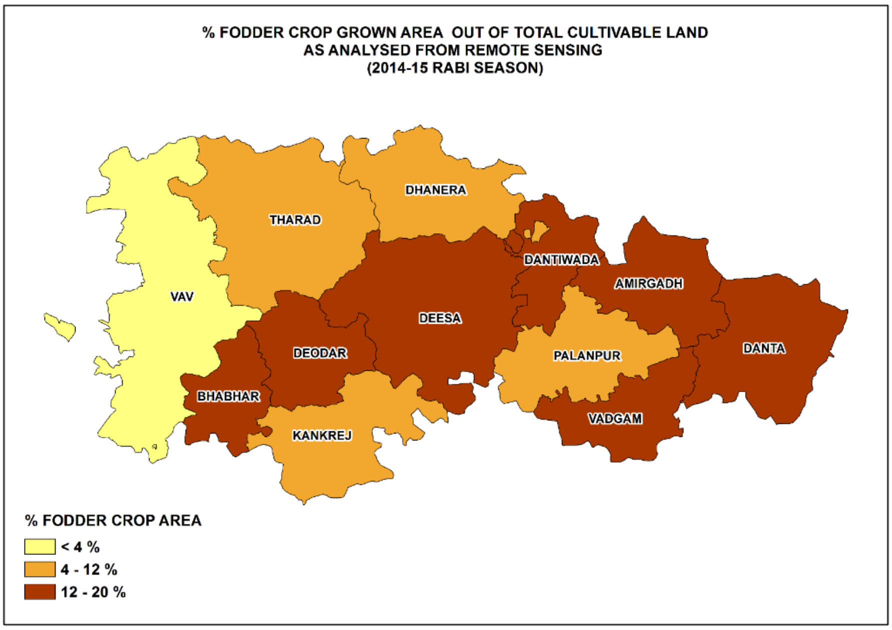
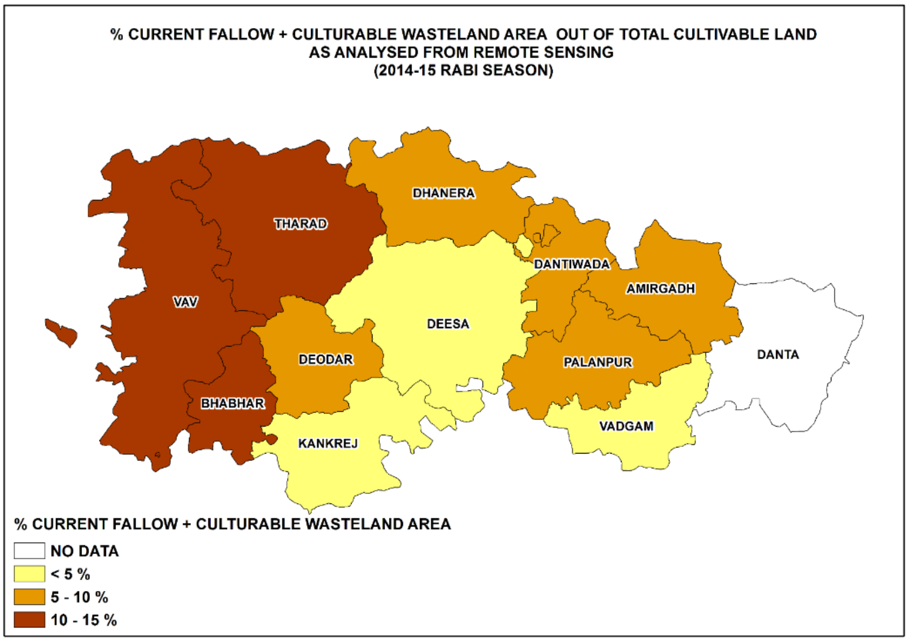


Figure-16 below shows that Vav, Tharad & Bhabar tahsils have the highest amount of current fallow & culturable wastelands. About 10-15 percent of the current fallow and culturable wastelands fall in the western part of the district which are mostly drought prone. Fortunately, these tahsils are now getting irrigation from the "Sujalam Sufalam" schemes, thus it is expected that area under fodder crops would increase substantially with increase in bovine livestock population. Similar observations have been shown by Govt. of Gujarat District Statistics Abstract of 2013 given in **Annexure C**.

Figure-16 : Proportion of current fallow & culturable wastelands out of cultivable land


% CURRENT FALLOW + CULTURABLE WASTELAND AREA OUT OF TOTAL CULTIVABLE LAND
AS ANALYSED FROM REMOTE SENSING
(2014-15 RABI SEASON)
DHANERA
THARAD
DANTIWADA
AMIRGADH
VAV
DEESA
DANTA
DEODAR
PALANPUR
BHABHAR
VADGAM
KANKREJ
% CURRENT FALLOW + CULTURABLE WASTELAND AREA
NO DATA
< 5 %
5 - 10 %
10 - 15 %

Discussions

The salient objective of this pilot project was to explore whether remote sensing technology has any utility in the context of the development of dairy sector, particularly in fodder development.

It is observed that the availability and reliability of statistics related to districtwise or tahsil wise area under fodder crops is not up to the standards desired. Further, no statistics or maps are available on segregation of area under major fodder crops, which is important in planning for feed and fodder development.

National Livestock Mission under its sub-mission (component 7.3.1) on Feed & Fodder Development calls for fodder production from non-forest wasteland/ rangeland/ grassland/ non-arable land with 75% Central assistance and 25% State share**.** The funding support consists of maximum per hectare ceiling of Rs. 1 Lakh for CPR, Gochar land /community land / waste land, which need treatment of soil and Rs. 0.85 Lakhs per hectare, which does not need such treatment. Further, an amount of Rs. 30,000 per hectare has been provided for individual farmer, who will cultivate fodder crops in own/leased land for a minimum of 3 years. Implementing agencies designated are: Department of Animal Husbandry/ Agriculture of the States. States may also involve NGOs, SHGs, Corporations, Milk Cooperatives/ Federation / Central and State Agriculture or Veterinary Colleges / Universities.

However, statistics of grasslands available with the implementing agency and present status of requirement and availability of green and dry fodder are not readily available. Many village dairy co-operatives have on their own initiative are engaged in green fodder production for their member milk producers. These institutions can take the benefit of the funding support available under National Livestock Mission, as mentioned above **(Annexure-A).**

1 Salient achievements of the project

This pilot project (duration Jan-May 2015), which was first of its kind in the country, was able to achieve the following,

(a) Estimation of area under fodder crop for a particular season in a particular sub-district (tahsil) also mapping it on a digital GIS platform, whereas secondary sources may provide only annual data district wise, that too only in some States.

(b) Estimation of the current fallow & culturable wastelands and also mapping it on a digital GIS platform.

(c) With the active support of Milk Union and village dairy co-operative societies, individual farmer/ plot level data could be collected with ease and accuracy in different phases.

(d) Methodology for assessment of the aforesaid was developed and tested using remote sensing technology with an accuracy level of 77%.

(e) The most important way forward maybe that the aforesaid information can be analysed periodically and shared over a GIS platform with the stakeholders, particularly the Milk Unions for their programs on feed and fodder development in deficit areas. The Milk Unions and village dairy co-ops may provide this information to various GOI/State level schemes like AFDP, MGNREGA, Watershed, NLM for initiating programs for fodder development in identified villages.

(f) For example, in this pilot project, it was found that in Banaskantha district, Gujarat, 46% of the villages are cultivating fodder crops in more than 10% of the cultivable land available in their village, underlying the importance of fodder crops in the agricultural economy of the district (At the national level , 4.6% of the cultivable land is utilised for growing fodder crops and the Working Group on Livestock for 12th FYP had suggested a norm of atleast 10%). Further, there is considerable scope in improving fodder production in atleast 35% of the villages, where the current fallows & culturable wastelands constitute more than 5% of the cultivable land **(Annexure-A).**

(g) Observing at the sub-district (tahsil) level, we find that **there is a strong correlation between area under fodder crops and the population of bovines (correlation coefficient is 0.9)**. Palanpur tahsil was analysed in detail, as a case example, juxtaposing the remote sensing image analysis with the LULC (Land Use Land Cover) sourced from NRSC. Due to improvement in irrigation facilities (between 2011-12 & 2005-06), the area under double/triple cropping has increased by around 25% while current fallow decreased by 15% and scrublands & other wastelands have decreased marginally. Significantly, fodder crops are predominantly grown in the southwest and southeast portions interspersed with main crops, while large tracts of current fallow & culturable wastelands exists in the central part of the tahsil **(Annexure-B)**.

(h) The proportion of fodder crop areas as well as current fallow & culturable wastelands determined through remote sensing when compared with District Statistical Abstract (DSA), Govt. of Gujarat show somewhat similar results. Though both the sources are not strictly comparable, since the remote sensing duration refers to rabi season only for the FY 2014-15, whereas the DSA refers to the complete FY 2013-14 (which was the latest data available with us) **(Annexure-C).**

(i) It was also possible to categorise and locate and map within the tahsil (a) the fodder crop areas and (b) current fallows & culturable wastelands, on a digital GIS platform. Thus, these can act as decision support tools at the Milk Union level. **The identified tahsils (sub-districts) which have relatively higher area under fodder crops, can be an important input for promoting intensive fodder cultivation by providing good quality fodder seeds to dairy farmers in these places.**

ISRO has already developed the crop production forecasts (FASAL) technology, for major food crops, however looking at dairy sector, which in terms of contribution to GDP in the economy exceeds cereal crops, it is important that a similar technology is developed and put in place for fodder crops.

2 Linkages

Use of remote sensing technology in the dairy sector can also provide technical inputs in following areas to important stakeholders, as below,

(a) Input to dairy sector on bovine carrying capacities of the milkshed area and managing fodder scarcity during droughts.

(b) Input to dairy sector on location of fodder crops, fodder crop production levels (in terms of biomass) /fodder crop area area estimates in rabi & summer seasons (zaid)

(c) Input to Farming Systems Analysis program (ICAR Modipuram)

(d) Input for societal benefit areas on global rangeland assessment, as identified by the GEOGLAM project. *Global Earth Observation System of Systems (GEOSS) through a coordination of remote sensing activities around the globe has launched the "Global Agricultural Geo-Monitoring" (GEOGLAM) project for advancement of sustainable agriculture.*

Conclusions

Department of AH,D&F had been discussing with ISRO to explore the potential of geospatial technology to evolve a national study on the assessment of feed and fodder for the livestock at disaggregated level e.g., district / tahsil level, to start with and identify the measures for ensuring the availability of fodder on a sustainable basis.

Indian Grassland & Fodder Research Institute (IGFRI), Jhansi has been instrumental in fostering research, training and extension programmes on all aspects of forage production and utilization through inter-disciplinary approach. It has been generating and disseminating technologies for enhanced quality of forage and livestock productivity in socio-economic and environmental perspectives.

In view of the growing importance of the dairy sector in the agricultural economy and as it is forecasted that there would be significant shortage of feed & fodder in the years to come, it may be prudent to scale up the current pilot project to the State and district level to begin with.

In this context, the participation in fodder crop monitoring through interaction with NDDB, Anand (National Dairy Development Board), NDRI, Karnal (National Dairy Research Institute) and Indian Grasslands & Fodder Research Institute (IGFRI), Jhansi would enable getting in-situ ground truth data required for in-season fodder assessment. In return, ISRO can provide remote sensing data for these sites during the crop growing period. **This will be mutually beneficial for all the stakeholders to know the developing cropping pattern and establishing procedures for fodder production forecasting.**

Further the assessment of feed and fodder for livestock at disaggregated (district/sub-district) level could be an important input to various fodder development programs or program components viz. Accelerated Fodder Development Program (AFDP), National Livestock Mission (NLM), MGNREGA etc as well as for important stakeholders like co-operative Milk Unions, Livestock Boards and DAHDF. This would also meet a much awaited requirement in the dairy sector as currently there are hardly any regular and reliable statistics on fodder production in the country.

ANNEXURE-A : Village level Analysis

Table-6 : Proportion of villages having significant fallow & culturable wastelands

Number of Villages *	% of Villages	% Current Fallow + Culturable Wasteland Area out of available cultivable land #
187	23	0-2%
329	41	2-5%
203	25	5-8%
83	10	> 8%

*Around **35%** of villages have more than 5% of the cultivable land which are lying as current fallow and/or culturable wastelands.*

Table-7 : Proportion of villages having significant land under fodder crops

Number of Villages *	% of Villages	% Fodder Crop Area out of available cultivable land
251	22	0-5%
369	32	5-10%
297	26	10-15%
141	12	15-20%
97	8	> 20%

*Around **46%** of villages are cultivating fodder crops which are more than 10% of the cultivable land available in their village*

**** Excludes villages which are outliers or do not have sufficient data for analysis***

 # Excludes Danta tahsil

ANNEXURE-B: Tahsil level analysis

Figure-17 : Current fallows & Culturable Wastelands and Fodder growing areas in Banaskantha district shown tahsilwise, as analysed by remote sensing during Rabi season 2014-15.

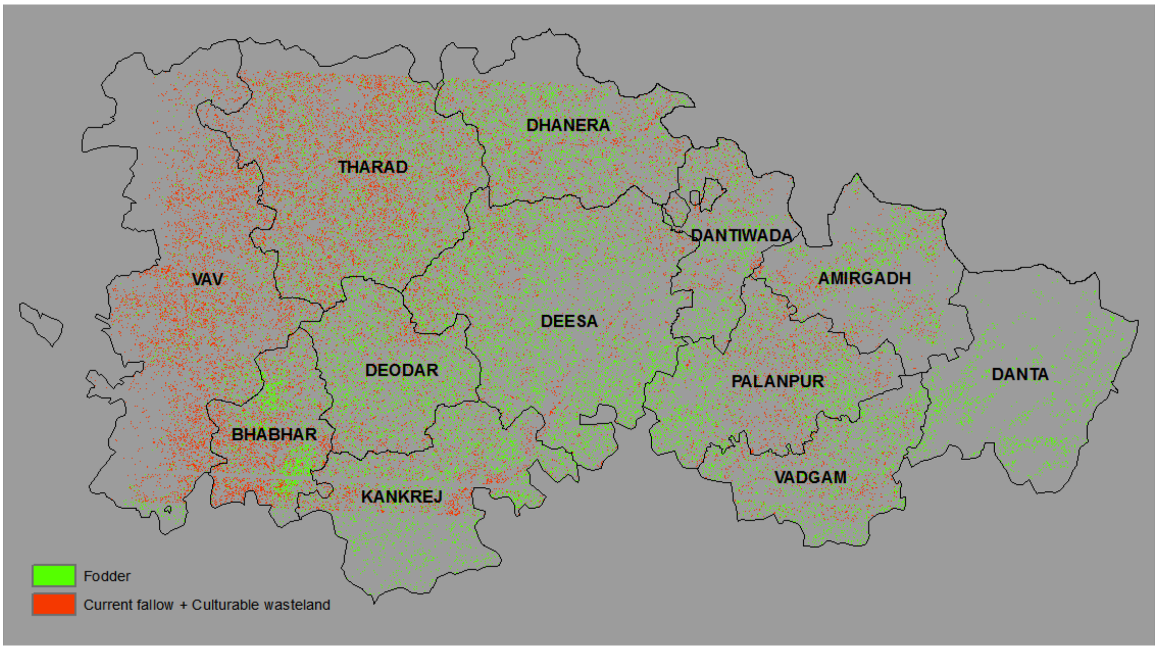


Table-8 : Tahsilwise information on land, bovine livestock & dairying

TAHSIL	Cultivable land (Ha) 1	CURRENT FALLOW + CULTURABLE WASTELANDS (Ha.)	% CURRENT FALLOW + CULTURABLE WASTELANDS 1	FODDER GROWN (Ha.)	% FODDER AREA 1	PROCUREMENT (TLPD) 2	COWS 3	BUFFALO3	TOTAL BOVINES
AMIRGADH	18389	1787	9.7	3663	19.9	35	32463	29214	61677
BHABHAR	36198	5261	14.5	5011	13.8	39	26469	44325	70794
DANTA	27453	5	0.0	4130	15.0	120	64158	59200	123358
DANTIWADA	26980	1365	5.1	3331	12.3	119	27271	39564	66835
DEESA	118495	5002	4.2	17156	14.5	442	131878	128344	260222
DEODAR	51691	3067	5.9	7282	14.1	152	45079	88514	133593
DHANERA	71754	3596	5.0	7704	10.7	394	47211	106602	153813
KANKREJ	70733	3065	4.3	7556	10.7	144	38772	118979	157751
PALANPUR	61994	3176	5.1	7036	11.3	391	56621	83620	140241
THARAD	120428	14333	11.9	10372	8.6	248	67794	96337	164131
VADGAM	43896	2019	4.6	5300	12.1	436	56289	81655	137944
VAV	137109	14101	10.3	4242	3.1	102	60162	68992	129154
BANASKANTHA	785120	56777	6.7	82782	12.2	2621	654167	945346	1599513

1. Percentage of total cultivable land as per District Statistical Abstract 2013-14, Cultivable land is defined as ***Reported Area - Forests - Barren and Unculturable land - Non Agricultural land - Permanent Pastures and Grazing lands***
2. Source District Statistical Abstract 2013-14
3.Source : http://banaskanthadp.gujarat.gov.in/banaskantha/shakhao/pasupalan/pasudhan.htm (Livestock Census 2007)

The correlation coefficient between green fodder grown area and bovine livestock population (assuming growth rate for all tahsils are same between 2007 & 2012) is observed to be very high, around 0.9.

Land under fodder crop is more than 10% of the cultivable land except in Tharad & Vav tahsil, which however (along with Bhabar tahsil) have more than 10% of the cultivable land as current fallow & culturable wastelands. ***Efforts can be made in developing these areas utilising the funding support under National Livestock Mission, by the village level dairy co-operatives.***

Figure-18 : Current fallows & Culturable Wastelands and Fodder growing areas in Palanpur tahsil , as analysed by remote sensing during Rabi season 2014-15

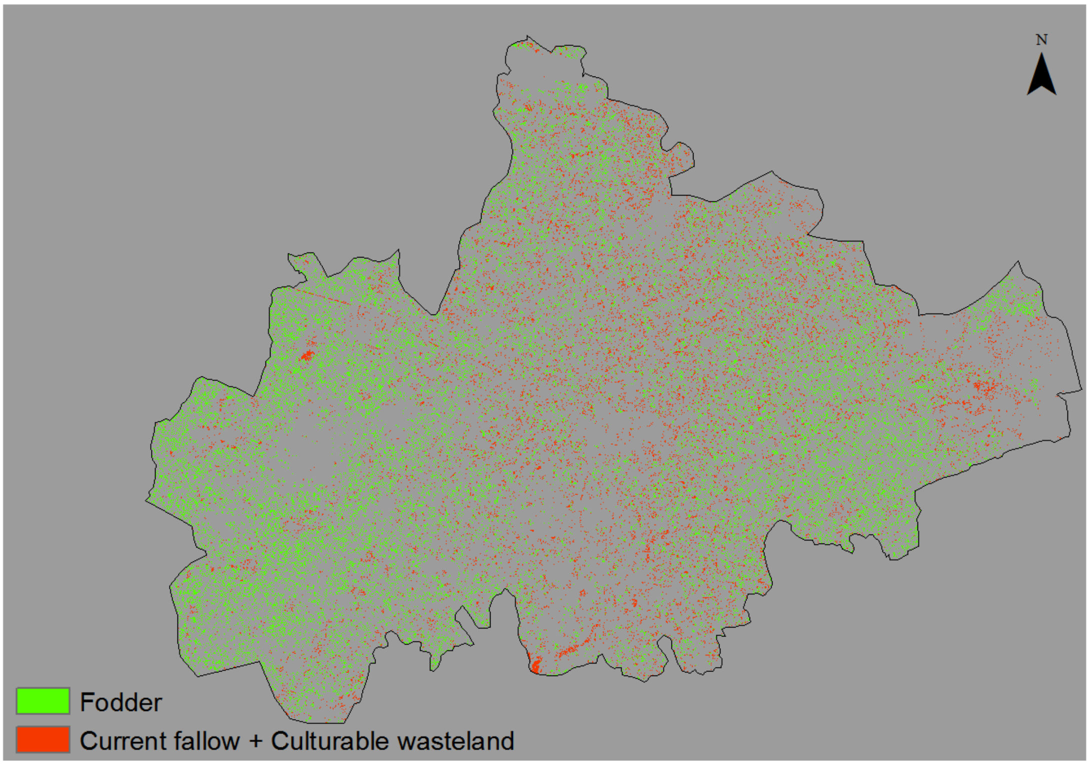


Figure-19 : Land Use Land Cover (LULC) Map of Palanpur Tahsil 2005-06

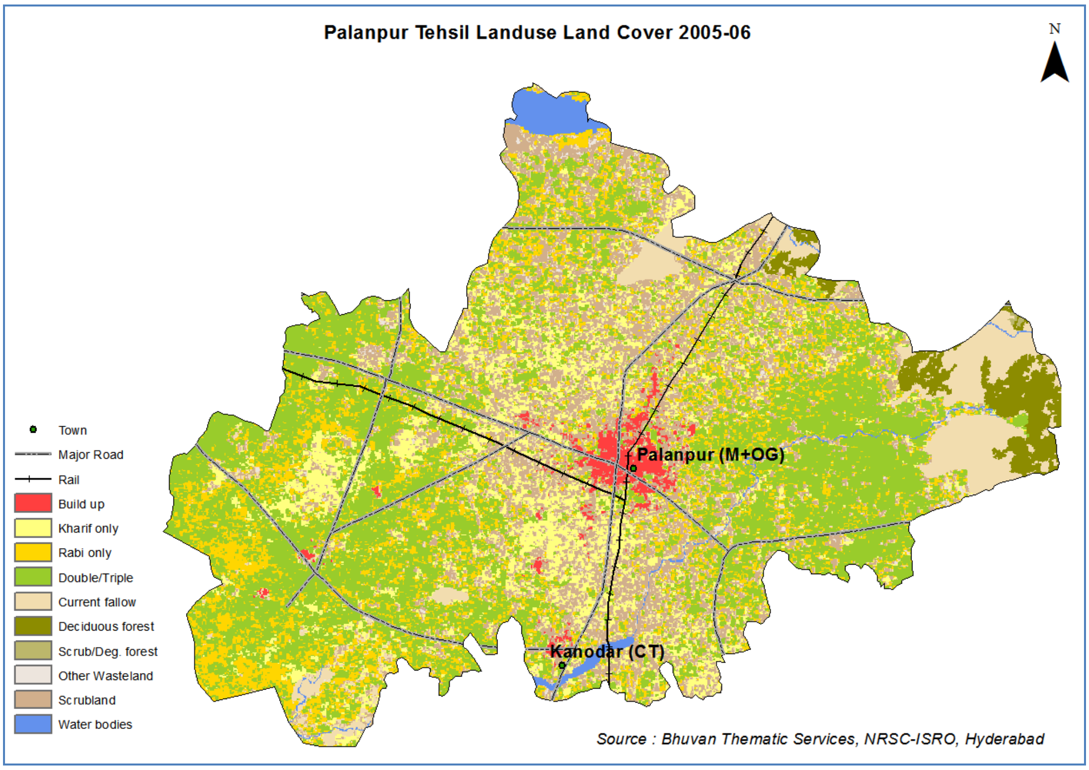


Figure-20 : Land Use Land Cover (LULC) Map of Palanpur Tahsil 2011-12

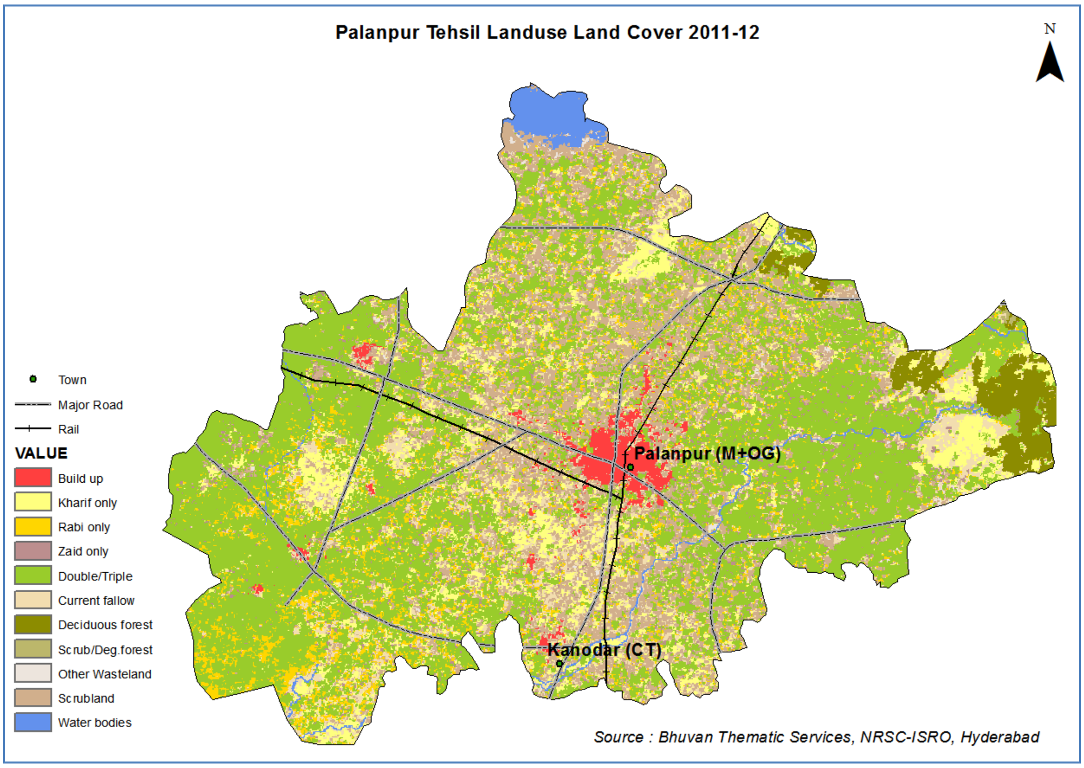


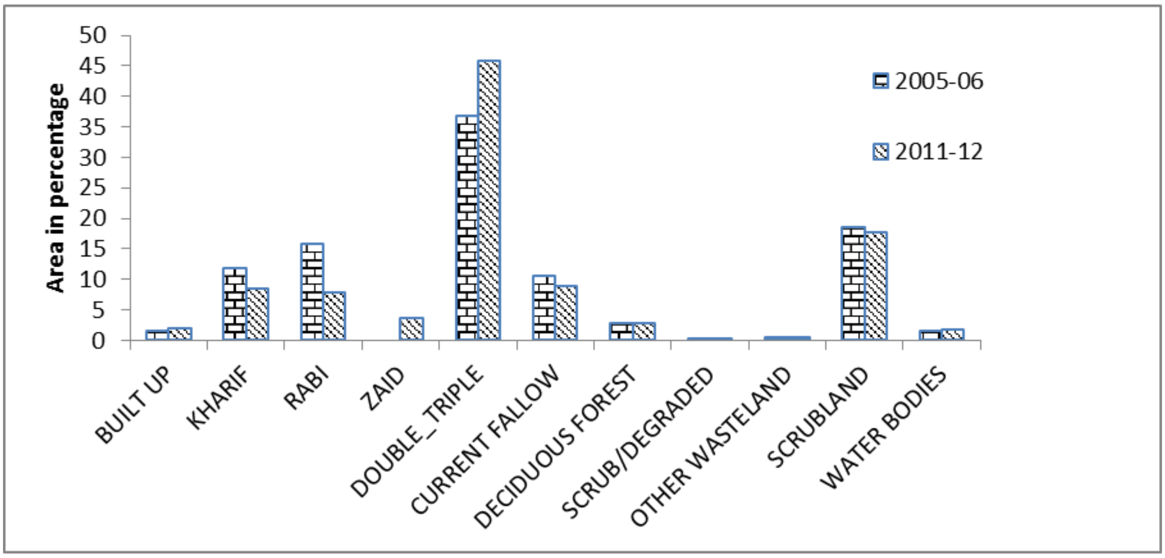
Table-9 : Comparison of changes in Land Use Land Cover (LULC) between 2005-06 and 2011-12 for Palanpur tahsil

Landuse Landcover Category	2005-06	2011-12	Area change (2011_12 - 2005_06) (hectares)	% change in area
BUILT UP	1209	1442	234	**19**
KHARIF	8598	6252	-2346	**-27**
RABI	11516	5755	-5761	**-50**
ZAID	0	2634	2634	**NA**
DOUBLE_TRIPLE	26879	33507	6628	**25**
CURRENT FALLOW	7706	6576	-1131	**-15**
DECIDUOUS FOREST	2010	2109	99	**5**
SCRUB/DEGRADED	25	29	4	**16**
OTHER WASTELAND	406	388	-18	**-4**
SCRUBLAND	13520	12927	-594	**-4**
WATER BODIES	1109	1360	250	**23**
Area in Hectares				

Area under double/triple cropping has increased by around 25% (as single season crop area e.g. Kharif & Rabi reduces and Zaid season crops are introduced).

The current fallow decreased by 15% and scrublands & other wastelands have decreased marginally, showing more and more of such areas are being brought under cultivation .

Figure-21 : Land Use Land Cover (LULC) change in Palanpur tahsil (2005-06 & 2011-12)



ANNEXURE-C: Comparison of results from remote sensing with secondary sources

Table-10 : Tahsilwise % area of total cultivable land under (a) current fallow & culturable wastelands & (b) fodder crop from Remote Sensing (2014-15 Rabi Season)

TAHSIL	CURRENT FALLOW & CULTURABLE WASTELANDS	FODDER CROP
AMIRGADH	9.7	19.9
BHABHAR	14.5	13.8
DANTA	*	15.0
DANTIWADA	5.1	12.3
DEESA	4.2	14.5
DEODAR	5.9	14.1
DHANERA	5.0	10.7
KANKREJ	4.3	10.7
PALANPUR	5.1	11.3
THARAD	11.9	8.6
VADGAM	4.6	12.1
VAV	10.3	3.1
TAHSIL AVERAGE	**6.7**	**12.2**
BANASKANTHA	7.2	10.5

**Excluded from analysis due to data problems*

Table-11 : Tahsilwise % area of total cultivable land under (a) current fallow & culturable wastelands & (b) fodder crop from District Statistical Abstract, Govt.of Gujarat (2013-14)

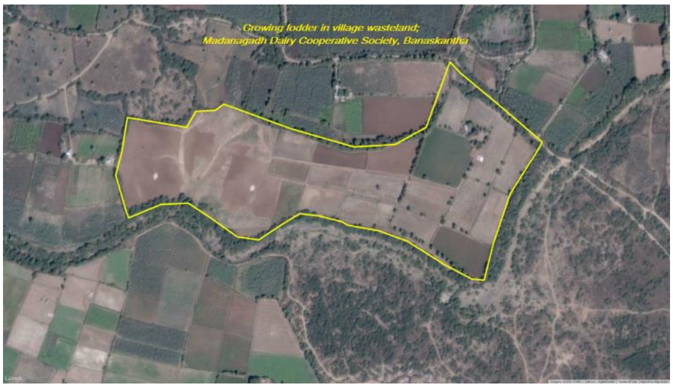
TAHSIL	CURRENT FALLOW & CULTIVABLE WASTELAND	FODDER CROP
AMIRGADH	4.5	17.5
BHABHAR	1.9	13.8
DANTA	17.3	32.6
DANTIWADA	3.8	26.3
DEESA	4.0	11.4
DEODAR	2.2	14.5
DHANERA	6.1	13.7
KANKREJ	6.8	13.3
PALANPUR	4.7	23.5
THARAD	2.9	12.5
VADGAM	4.2	19.1
VAV	7.6	5.1

TAHSIL AVERAGE	**5.5**	**16.9**
BANASKANTHA	5.2	13.9

ANNEXURE-D: Growing fodder on village wastelands : Case Study of Madanagadh Village

The village level Dairy Co-operative Society (DCS) in Madanagadh Village, Palanpur Tahsil in Banaskantha district, on their own initiative, had acquired 25 acres (around 10 hectares) of wastelands on lease from Gram Panchayat and has developed it for forage production.

Figure -22 : Growing fodder in village culturable wasteland by Madanagadh Dairy Co-operative Society, Village : Madana (gadh), Tahsil: Palanpur, District: Banaskantha



This is managed profitably by the DCS and the green fodder grown here is provided to the dairy farmers of the village especially the landless. **Around 100 DCS members, who are the beneficiaries of this green fodder development project, belong to the socio-economically backward classes and supply milk around 500 litres/day to the society**.

There are many such unutilised wastelands available in the village, which can be developed further for forage production thus meeting the green fodder deficit in the village.

The DCS can avail funding support for further fodder development under National Livestock Mission through co-ordination of the Banaskantha Milk Union.

Preliminary results under the NDDB-ISRO pilot project, indicate that it is possible to identify and demarcate such wastelands/ fallow lands in villages, which can be utilised by the DCSs in the village for meeting the green fodder shortages. The above example can be a model for other DCSs to emulate with requisite support.

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