# A Case Study of Crop Rotation Analysis of Panipat District & Its Development Blocks Using Geoinformatics

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*Abstract*— Agricultural sustainability requires that the individual farm firm be competitive and profitable while simultaneously enhancing environmental quality and the natural resource base upon which the farm firm and agricultural economy depends. Crop rotation systems are one cropping system alternative that can reduce agriculture's dependence on external inputs through internal nutrient recycling, maintenance of the long-term productivity of the land, and breaking weed and disease cycles. Crop rotation is a time-honored process of planting annual crops. The paper describes methodology and results of crop rotation analysis for Panipat district'(different blocks) of Haryana, climatologically characterized by hot summer, cold winter and dry air except during rainy season. Multi-date & Multi-season IRS LISS-III digital satellite data of 2007-2008 was geo-referenced with the already geo-referenced master image by collecting GCP's using second polynomial order and Nearest Neighborhood (NN) Resampling approach. The Kharif, Rabi and summer cropping pattern maps and statistics were generated using classified images and applying logical combinations. During Kharif season rice is the major crop which occupies 73,700 ha area and in the Rabi season wheat is major crop occupying 82,900 ha area. In the summer season most of the area is lying vacant as fallow and major crops are fodder, vegetables etc. Sugarcane is an annual crop and it is available in all three cropping seasons. Rice-Wheat-Other, and Rice-Wheat-Fallow and the major crop rotations identified in the district. Major crop rotation is Paddy-Wheat-Fallow occupying 18.41 thousand ha area.

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**KEYWORDS-** Remote Sensing, Crop Rotation, Cropping Pattern Accuracy Assessment, Satttelite data.

## 1. INTRODUCTION

Crop rotation is a "system of growing different kinds of crops in recurrent succession on the same land" (Martin, Leonard, and Stamp, Principles of Field Crop Production, 1976). Thus, in the strictest sense, crop rotation is more than just changing crops from year to year based on current economic situations. Rather, it is a long-term plan for soil and farm management. The photo at right shows three crops in a corn-soybean-wheat/red clover rotation. At the farm management level, crop rotations are used to diversify income, spread labor requirements throughout the year, and spread the crop loss risk associated with overall risk management tool. These basic ecological principles still apply today, although advances in technology and marketing have contributed to shorter or no crop rotations and more specialized agricultural systems. Decisions about planting crops are complex. Crop price fluctuation, input costs, rental agreements, government price supports, weather, choice of farming system and on-farm resources such as animal manures, and other factors all contribute to decisions about crop rotations. Market conditions can have a dramatic effect on crop rotation. An example of this was the national corn acreage in 2007, which experienced an unprecedented 19.5% increase compared to 2006 because of increased demand for corn grain for ethanol production. This increase in corn acreage in 2007 shifted a significant portion of the total corn acreage to second year corn. Continuous corn or corn after corn is also still grown on many dairy farms that have a large demand for corn silage and want to utilize manure derived nutrients more efficiently. This same trend is also evident in the upper Midwest dairy systems.

## 1. STUDY AREA

Panipat district first came into existence on November 1, 1989. It was carved out of Karnal district. The district status to Panipat sub division of Karnal was again restored on First of January, 1992. The district has one sub divisions namely Panipat and Five development blocks namely Panipat, Samalkha, Madlauda, Israna and Bapauli. This city has strategic at National Highway No.

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1, just 89 Km. from the national capital. The city has one of the best rail and road connectivity to the state capital Chandigarh and other important commercial hubs of the adjoining states. Panipat is a historical place and was the gateway of India in medieval times. Three battles were fought here and winner of course occupied the Delhi Throne. Panipat is situated in North Eastern Haryana, flanked by River Yamuna on the estern10 border. The Panipat district is surrounded by Karnal in North, Panipat in West and Sonipat district in South and Mujarfarnagar district of Uttar Pradesh in the East. It has a total geographical area of 1267sqkm.

## 3. MATERIALS & METHDOLOGY

### 3.1 DATA USED

Remote sensing data is the basic data source for mapping the cropping system of the Panipat district .Indian sensing satellite resource sat (IRS-P6) LISS-III data was used in the present study 23.5m spatial resolution data in Green, Red, NIR and SWIR bands with 24 days revisit The data was used in to drive Kharif, Rabi, & Summer. Cropping patterns . The IRS LISS-III data was the main source of satellite imageries for cretin the spatial maps of cropping pattern, crop rotation map ect.

### 3.2 METHDOLOGY

Multi-date and multi-season LISS-III digital satellite data was geo-referenced with the master images by collecting GCP's using second polynomial order and NN Resampling approach. The geo-referenced images were used for further analysis using complete enumeration approach. In complete enumeration approach the administrative boundary of the districts was digitized, a mask generated and superimposed on the geo-referenced image. All the data elements (pixels) within this were extracted for further classification etc. Unsupervised classification approach Iso-Data Clustering classifier was used and class of interest was using ground truth information provided by HARSAC in the form of GPS location.

The Kharif, Rabi and summer cropping pattern maps were generated using classified images and logical combination. The crop rotation maps were generated using Kharif, Rabi and summer cropping pattern maps.

## 4. RESULTS & DISCUSSION

### 4.1 Crop Rotation of Panipat District

The crop rotation shows sequential planting of crops in time. Analysis indicate that Panipat district has the major crop rotations of Paddy/Bajra/Jowar/Othercrops Mustard/Wheat-Other crops/Fallow, Paddy-Wheat- Fallow, Bajra-Mustard /Wheat-Other crops, Fallow-Mustard-Fallow and Sugarcane based of three seasons kharif, Rabi and summer in 2007-08

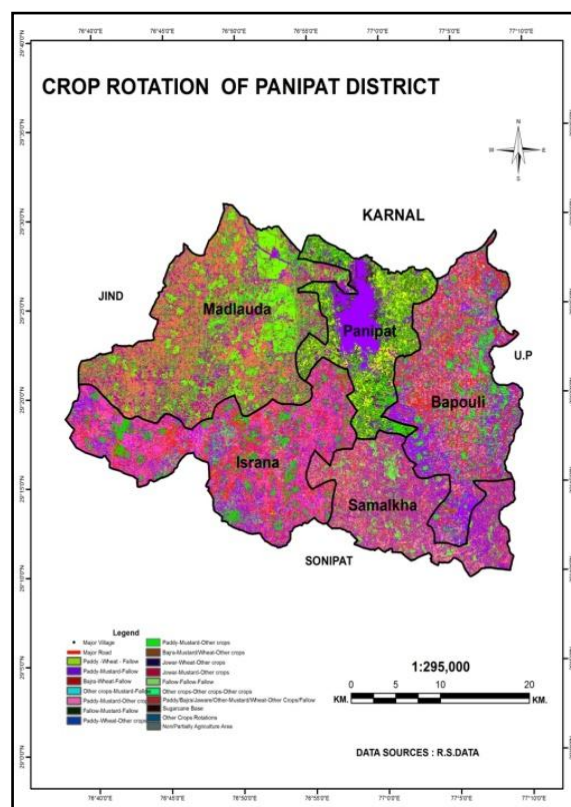**Map 1: Crop Rotation statistics of Panipat District derived from RS data**



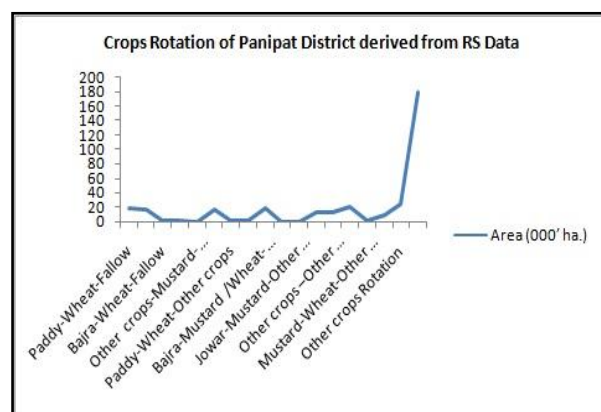**Fig. 1: Crop Rotation of Panipat District derived from RS Data**



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**Table 1: Crop Rotation of Panipat district derived from RS Data**

| Crop rotation | Area (000' ha.) |
|---|---|
| Paddy-Wheat-Fallow | 18.41 |
| Paddy-Mustard-Fallow | 16.99 |
| Bajra-Wheat-Fallow | 2.21 |
| Bajra-Mustard/Wheat-Fallow | 2.21 |
| Other crops-Mustard-Fallow | 0.07 |
| Fallow-Mustard-Fallow | 17.20 |
| Paddy-Wheat-Other crops | 1.57 |
| Paddy-Mustard-Other crops | 1.53 |
| Bajra-Mustard /Wheat-Other crops | 18.14 |
| Jowar-Wheat-Other crops | 0.44 |
| Jowar-Mustard-Other crops | 0.06 |
| Fallow-Fallow-Fallow | 14 |
| Other crops –Other crops –Other crops | 14 |
| Paddy/Bajra/Jowar/Other crops -Mustard/Wheat-Other crops/Fallow | 21.50 |
| Mustard-Wheat-Other crops | 2.4 |
| Sugarcane Base | 8.8 |
| Other crops Rotation | 25.58 |
| Non/Partially Agriculture Area | 178.76 |

**Crop Rotation of Panipat Block**

The Paddy-wheat-mustard-Fallow rotation dominates the western and northern part of the district while the Sugarcane Based rotation dominates the eastern part of the block.

**Fig. 2: Crop Rotation of Panipat Block derived from RS Data**
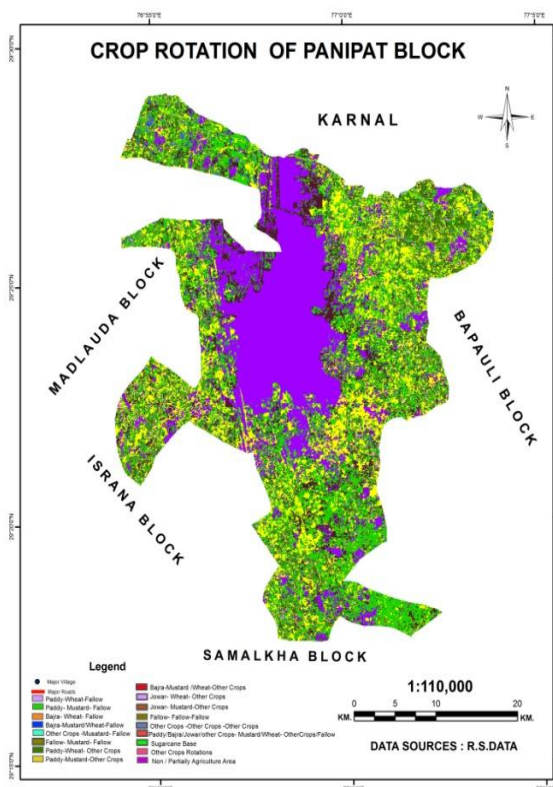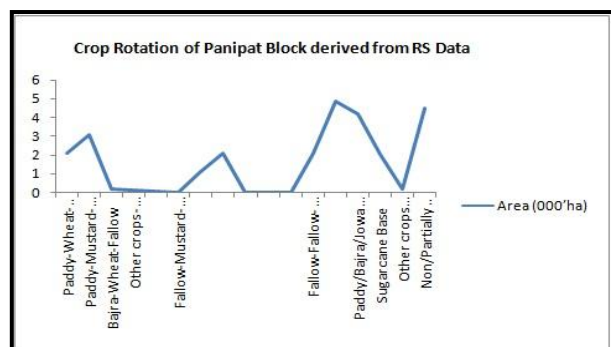




**Map 2: Crop Rotation statistics of Panipat Block derived from RS data**

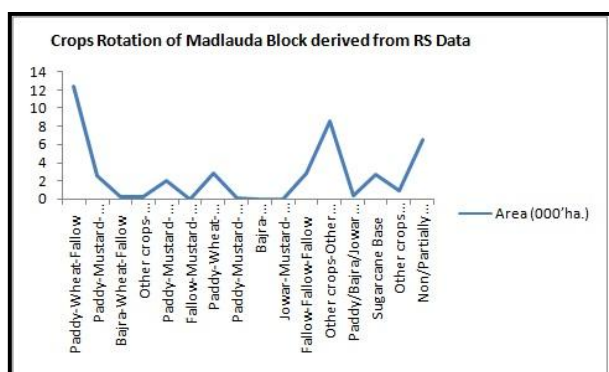| Crop Rotation | Area (000'ha) |
|---|---|
| Paddy-Wheat-Fallow | 2.1 |
| Paddy-Mustard-Fallow | 3.1 |
| Bajra-Wheat-Fallow | 0.19 |
| Other crops -Mustard-Fallow | 0.12 |
| Paddy-Mustard-Other crops | 0.04 |
| Fallow-Mustard-Fallow | 0 |
| Paddy-Wheat-Other crops | 1.1 |
| Paddy-Mustard-Other crops | 2.1 |
| Bajra-Mustard /Wheat-Other crops | 0.02 |
| Jowar-Wheat-Other crops | 0 |
| Jowar-Mustard-Other crops | 0 |
| Fallow-Fallow-Fallow | 2.1 |
| Other crops -Other crops -Other crops | 4.86 |
| Paddy/Bajra/Jowar/Other crops -Mustard/Wheat-Other crops/Fallow | 4.2 |
| Sugarcane Base | 2.03 |
| Other crops Rotation | 0.16 |
| Non/Partially Agriculture Area | 4.47 |

**Crop Rotation of Madlauda Block**

Analysis indicates that the block has four major rotation namely Paddy-Wheat-Fallow, Paddy-Wheat-Other crops, Sugarcane Base, Paddy-Mustard-Other crops based on Kharif, Rabi and summer cropping pattern. The area of crop rotation given in Table 3, Figure 3 spatial distribution depicted Map 3

**Map 3: Crop Rotation statistics of Madlauda Block derived from RS data**



Fig. 3: Crop Rotation of Madlauda block derived from RS Data
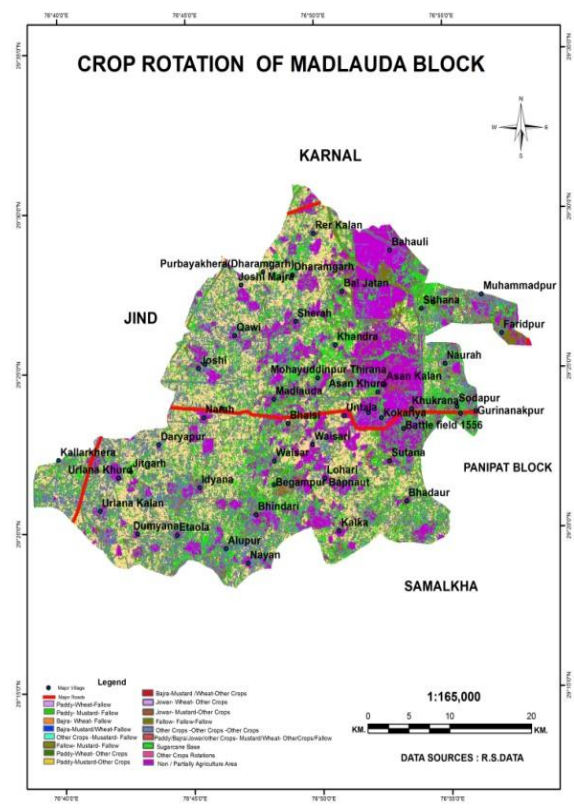


| Crop Rotation | Area (000'ha.) |
|---|---|
| Paddy-Wheat-Fallow | 12.4 |
| Paddy-Mustard-Fallow | 2.6 |
| Bajra-Wheat-Fallow | 0.3 |
| Other crops-Mustard-Fallow | 0.3 |
| Paddy-Mustard-Other crops | 2.1 |
| Fallow-Mustard-Fallow | 0.0 |
| Paddy-Wheat-Other crops | 2.8 |
| Paddy-Mustard-Other crops | 0.1 |
| Bajra-Mustard/Wheat-Other crops | 0.0 |
| Jowar-Mustard-Other crops | 0.0 |
| Fallow-Fallow-Fallow | 2.8 |
| Other crops-Other crops-Other crops | 8.6 |
| Paddy/Bajra/Jowar/Other crops Mustard/Wheat Other crops/Fallow | 0.4 |
| Sugarcane Base | 2.7 |
| Other crops Rotations | 0.9 |
| Non/Partially Agriculture Area | 6.5 |

**Crop Rotation of Samalkha Block**

The major Crop Rotation in the block observed Paddy-Wheat-Fallow, Sugarcane based, and Paddy Mustard-Other crops. Statistics of various rotations given in Table-4, Figure4 and Map No.4

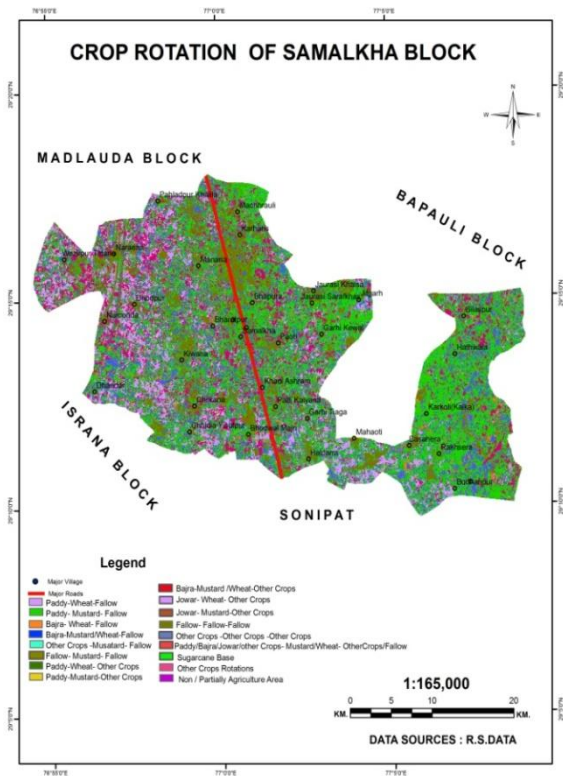**Map 4: Crop Rotation Map of Samalkha Block derived from RS Data**



**Fig. 4: Crop Rotation of Samalkha Block derived from RS Data**



| Crop Rotation | Area (000'ha.) |
|---|---|
| Paddy-Wheat-Fallow | 6.7 |
| Paddy-Mustard-Fallow | 2.7 |
| Bajra-Wheat-Fallow | 0.30 |
| Bajra-Mustard/Wheat-Fallow | 0.49 |
| Other crops-Mustard-Fallow | 0.04 |
| Paddy-Mustard-Other crops | 1.2 |
| Fallow-Mustard-Fallow | 0.10 |
| Paddy-Wheat-Other crops | 1.3 |
| Paddy-Mustard-Other crops | 1.1 |
| Bajra-Mustard /Wheat-Other crops | 0.01 |
| Jowar-Wheat-Other crops | 0.00 |
| Fallow-Fallow-Fallow | 2.08 |
| Other crops-Other crops-Other crops | 7.51 |
| Paddy-Bajra/ Jowar /Other crops-Mustard/Wheat- Other crops /Fallow | 2.3 |
| Sugarcane Base | 2.8 |
| Other crops Rotations | 0.25 |
| Non/Partially Agriculture Area | 1.52 |
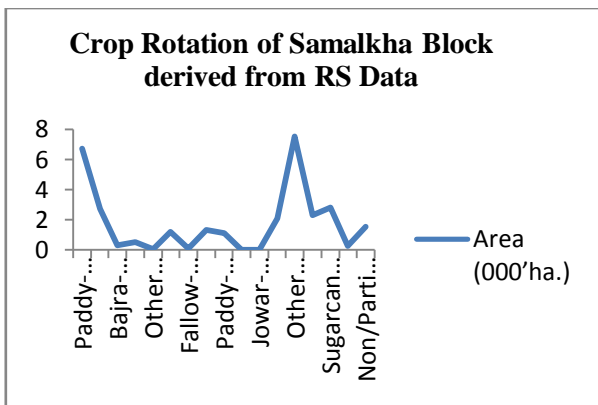
**Table 4: Crop Rotation of Samalkha Block derived from RS Data**

**Crop Rotation of Israna Block**

Based on three season cropping pattern major crops rotation derived in the block namely Fallow- Mustard-fallow, other crops-Other crops–Other crops, Paddy- Wheat-Fallow and Paddy-Mustard-Fallow. Crop rotations are given Table 5, Figure 5 and spatial distribution depicted in Map-5.

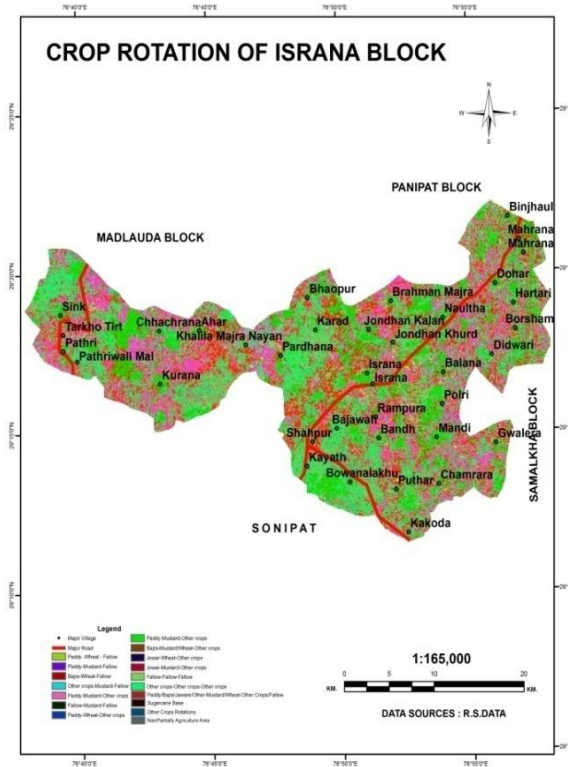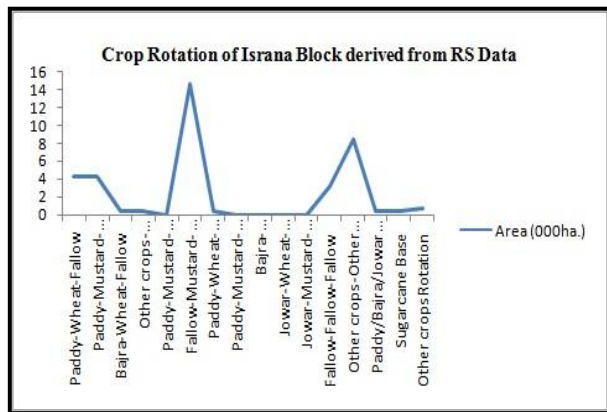**Map 5: Crop Rotation of statistics Israna Block derived from RS data**



**Fig. 5: Crop Rotation of Israna Block derived from RS Data**



**Table 5: Crop Rotation of Israna Block derived from RS Data**

| Crop Rotations | Area (000ha.) |
|---|---|
| Paddy-Wheat-Fallow | 4.38 |
| Paddy-Mustard-Fallow | 4.38 |
| Bajra-Wheat-Fallow | 0.44 |
| Other crops -Mustard-Fallow | 0.43 |
| Paddy-Mustard-Other crops | 0.04 |
| Fallow-Mustard-Fallow | 14.7 |
| Paddy-Wheat-Other crops | 0.4 |
| Paddy-Mustard-Other crops | 0.04 |
| Bajra-Mustard/Wheat-Other crops | 0.04 |
| Jowar-Wheat-Other crops | 0.01 |
| Jowar-Mustard-Other crops | 0.00 |
| Fallow-Fallow-Fallow | 3.29 |
| Other crops -Other crops – Other crops | 8.49 |
| Paddy/Bajra/Jowar/Other crops -Mustard/Wheat-Other crops /Fallow | 0.53 |
| Sugarcane Base | 0.45 |
| Other crops Rotation | 0.75 |
| Non/Partially Agriculture Area | 3.18 |

**Crop Rotation of Bapauli block**

Based on the analysis of three seasons (Kharif, Rabi, summer) rotations observed in the block are Paddy-Wheat-Fallow, Bajra-Wheat-Fallow, Other crops-Mustard-Fallow and Paddy-Mustard-Fallow. Statistics of various Crop rotation derived given in Table-6, Figure 6 and special distribution depicted in Map 6.

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**Map 6: Crop Rotation of Bapauli Block derived from RS data**

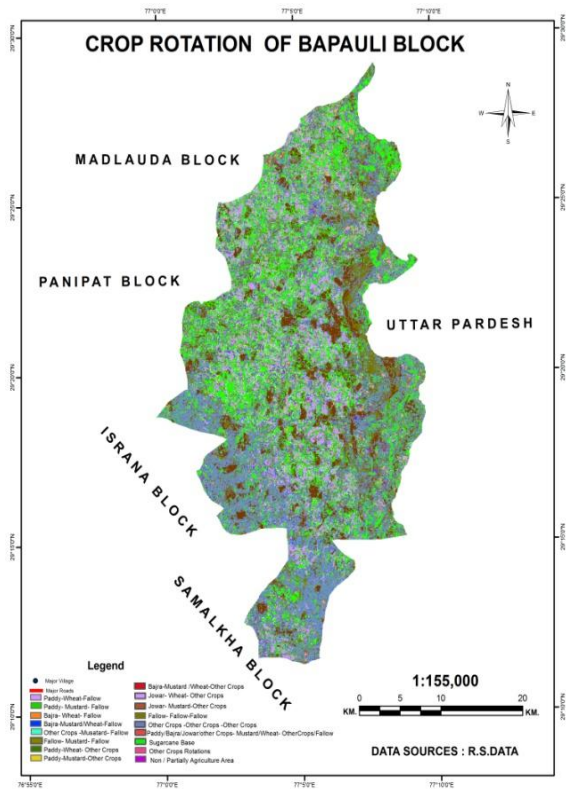**Table 6: Crop Rotation of Bapauli block derived from RS Data**



Fig. 6: Crop Rotation of Bapauli block derived from RS Data



| Crops Rotations | Area (000'ha.) |
|---|---|
| Paddy-Wheat-fallow | 5.15 |
| Paddy-Mustard-Fallow | 2.56 |
| Bajra-Wheat-Fallow | 4.86 |
| Other crops-Mustard-Fallow | 4.57 |
| Paddy-Mustard-Other crops | 0.80 |
| Fallow-Mustard-Fallow | 2.48 |
| Paddy-Wheat-Other crops | 0.03 |
| Bajra-Mustard/Wheat-Other crops | 0.35 |
| Jowar-Wheat-Other crops | 0.52 |
| Jowar-Mustard-Other crops | 0.37 |
| Fallow-Fallow-Fallow | 3.5 |
| Other crops-Other crops-Other crops | 0.96 |
| Paddy/Bajra/Jowar/Other crops-Mustard/Wheat-Other crops/Fallow | 4.00 |
| Sugarcane base | 1.82 |
| Other crops rotation | 29.93 |
| Non/partially agriculture area | 21.29 |
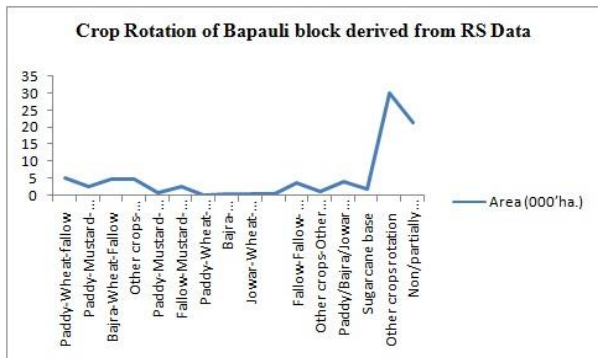
**Conclusion**

- Crop rotation is a "system of growing different kinds of crops in recurrent succession on the same land .

- Multi-date and multi season optical remote was used to generate seasonal cropping patterns and then crop rotation map of Panipat District and its development blocks using Geomatica 10.3 and Arc GIS software Package

- RS data analysis showed that Paddy-Wheat-Fallow, Paddy-Mustard-Fallow, Fallow-Mustard-Fallow and Sugarcane based are the major rotation.

- Multi-date and multi-season optical data with spatial resolution of 23.5m from Indian Remote sensing Satellites is formed to be useful for the cropping system analysis of major and contiguous minor crops at block-level. For cropping system analysis of minor and non-contiguous crops high resolution multi-date multispectral data is required.

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