# Mapping & Monitoring of Long-Term Spatial-Temporal Transpose of Crop Rotation of North-Western Haryana (1990-91 to 2021-22): Using Remote Sensing and GIS Approach

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**Abstract**

Crop rotations are becoming more popular as a tool to keep sustainable crop production as awareness of the need to produce high-quality food with little negative effect on the environment grows. The dearth of agricultural knowledge severely hinders efforts to develop effective policies and carry out research to attain food security. In North-Western Haryana, a research was carried out for mapping and monitoring long-term changes of crop rotation using satellite-based remote sensing data along with other spatial and non-spatial collateral data. The primary source of data for this research is derived from Landsat-5 and Sentinel-2 and were processed digitally using the ARC GIS and ERDAS imagine software packages. The information was evaluated using the supervised classification approach. The crop rotation change map was generated for the years of 1990-91 to 2021-22.

**Keywords:** Geospatial technology, Supervised Classification, spatial-temporal changes, North-Western Haryana, Crop rotation changes

## 1. Introduction

A holistic view of crop rotation is necessary for issues involving to food security, crop monitoring, and sustainable agricultural management. The present study used Geospatial technology to examine the long-term performance of crop rotation in north-western Haryana. Crop rotation is a universal phenomenon which is practiced by the famers world-wide. For the better understanding of cropping pattern of an area, it become necessary to study the area under individual crop coverage and the crop rotation followed by the farmers. Increasing farming profits, reduce the incidence of diseases, pests or weeds that are difficult to control with pesticides and preserving the fertility of the earth are the some of the major objectives of crop rotation. The practice of crop rotation, which involves the sequential production of different plant species on the same land, has been in existence for thousands of years (Karlen & et al., 1994).

Remote sensing is an effective tool for delivering precise and up-to-date information on the performance of farming systems (N J Singh & et al., 2010) and it provides tools for managing advanced cropping systems (Panigraphy & et al., 2002). The accuracy of area statistics is frequently impacted by cloud cover during monsoon season, despite the fact that high spatial resolution (HSR) satellite data

provides a more accurate depiction of the ground. HSR satellite data also has a smaller spatial coverage and very coarse temporal resolution (Kumar, P., & et al. 2016). In a recent report on crop monitoring for better food security, the Food and Agriculture Organization (FAO) emphasised the need for local governments to adopt advanced crop monitoring based on remote sensing in order to provide accurate agricultural statistics (Srivastava., 2015). According to reports, the net sown area statistics provided by the government appear to be much lower than the area provided by researchers (Biradar and Xiao 2011; NRSC 2014).

## 2. Study Area-Location and Extent

Haryana is an agricultural state situated in north-western part of India with less than 1.4% of India's land area and carved out of the former state of Punjab on 1 November 1966, is one of the 28 states in India. To the total geographical area of Haryana 85% of it is available for agricultural use and rest of 15% is covered for non-agricultural purposes say built up, barren land or forests etc (Vinod & et al., 2021). Haryana is a landlocked state surrounded by Punjab and Himachal Pradesh from north and north-west, Rajasthan in the south and south-west, Uttar Pradesh & Delhi in the east. Haryana state surrounded by Shivalik hills & Aravali range from north & south and drained by two major rivers Ghaggar and Yammuna.

North-western Haryana, which is a part of the Indo-Gangetic alluvial plain, was the subject of a research. The North-western Haryana comprises of three major districts of state Haryana are Sirsa, Fatehabad & Hisar as shown in Figure 1 and accounts for 24.42 percent of Haryana's total geographical area. North-western Haryana is located between 28°54'N and 29°59'N latitudes and 74°28'E to 76°19'E longitudes (as shown in Fig.1). North-western Haryana lies in the humid to semi-arid type climatic conditions and receive less rainfall as compare to the eastern part of Haryana. The major crops grown in North-western Haryana are Cotton, paddy, wheat, sugarcane, bajra, gram and mustard in the Rabi and Kharif seasons. The introduction of new agriculture technology brought about changes in the traditional cropping pattern particularly - wheat-rice rotation, which replaced cotton-mustard crop rotation in north-western Haryana.

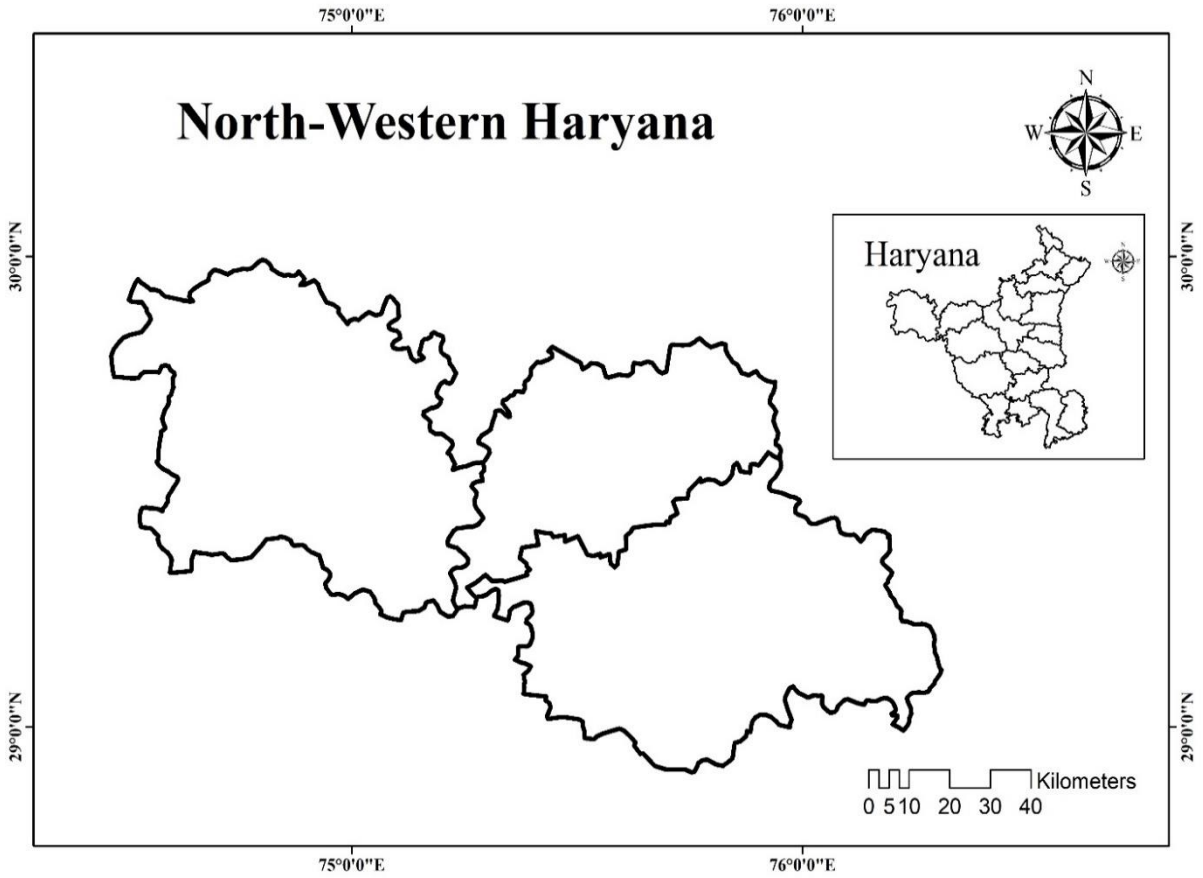


Figure:-1 Study area Location map and its districts (North-western Haryana).

## 3. Aim and Objective of the study

- To examine the Long-term crop rotation changes in the agriculture of north-western Haryana during reference period of 1990-91 to 2021-22.

## 4. Database

The present study is based on primary source of data and make the study more effective & meaningful.

### 4.1. Satellite Data

Landsat-5 has a spatial resolution of 30 m, three spectral channels (green (0.52–0.60 µm), red (0.63–0.69 µm), near infrared (NIR: 0.76–0.90 µm) and a temporal resolution of 16 days with a 185 km swath width while sentinel-2 has a spatial resolution of 10 m, three spectral channels (green (0.543–0.578 µm), red (0.650–0.680 µm), near infrared (NIR: 0.785–0.900 µm) and a temporal resolution of 10 days with a 290 km swath width.

For identifying various crops and researching the long-term crop rotation changes in North-western Haryana from the reference periods to 1990–91 to 2021–22, research used Landsat-5 images acquired in 1991 during February (rabi season), 1989 August, 1991 September (kharif season), and sentinel-2 images acquired in 2022 during February (rabi season), 2021 August (kharif season).

Table:- 1

The detail of input remote sensing data for analysis is given in table

| Satellite | Band | Spatial resolution | Temporal resolution | Description | Swath |
|---|---|---|---|---|---|
| landsat-5 | B2 | 30m | 16 days | Green | 185km |
| | B3 | 30m | | Red | |
| | B4 | 30m | | Near infrared | |
| sentinel-2 | B3 | 10m | 10 days | Green | 290 km |
| | B4 | 10m | | Red | |
| | B8 | 10m | | Near infrared | |

### 4.2. Ancillary Data

The use of ancillary data layers to update historical maps and improve the information gleaned from satellite imagery has been proven in multiple research projects. The ancillary data has been layered with the high-resolution remote sensing data to exhibit the geospatial database for crops across a large spatial extent. The derived agricultural area was stratified by logical modelling of ancillary data sets into two major crop growing seasons of North-western Haryana. Ancillary data sets mainly rainfall data, elevation data, irrigation data, soil data, flood data, crop reports, census data, road network are collected from various govt reports such as statistical Abstract of Haryana, District census handbook, central ground water board. As well as ground truth points and administrative boundaries data are gathered from Haryana Space Application centre, (HARSAC) Hisar, Haryana.

### 4.3. Software Used

Arc GIS and ERDAS IMAGINE (Earth Resource Data Analysis System), a commercial image processing software package was used for radiometric corrections, georeferencing, classification and spatial modelling of the crop rotation changes in North-western Haryana.

## 5. Research Methodology

The information from the two major seasons of rabi and kharif has been evaluated using satellite-based remote sensing data from landsat-5 (band 2 green, band 3 red, band 4 near infrared) and sentinel-2 (band 3 green, band 4 red, band 8 near infrared). These data were further processed for layer stacking and subset data from interest area. For enhancing accuracy, Masking of non-agriculture classes are excluded from maps, such as roads, built-up regions etc. The region of the image that is designated as indicating a class type was used to pick multiple training samples for each desired class, and the samples for each class were then integrated.

The supervised classification approach was used to evaluate the information for long-term crop rotation changes during reference period of 1990-91 to 2021-22. Intersect tool is implemented on the crop rotation satellite data of both years (1990-91 to 2021-22). Thus, the change detection maps of north-western Haryana is generated.

**Methodology Flow Chart**

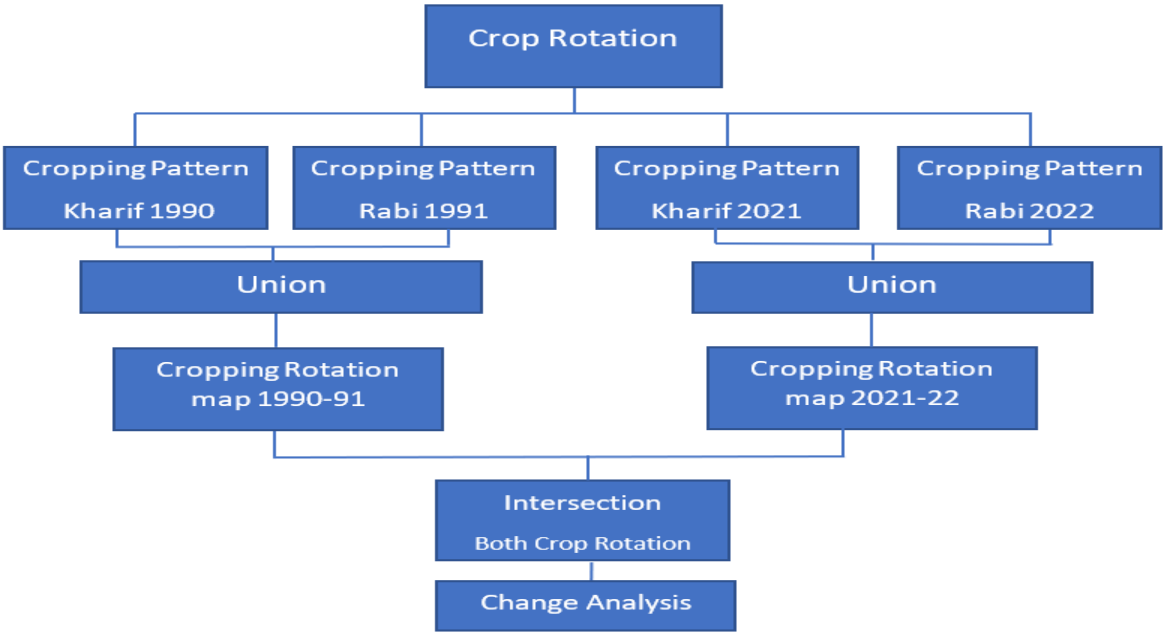


**Fig: 2 Flow chart of research methodology**

## 6. Result & Discussion

The Long-Term changes in North-western Haryana were studied using the satellite data and the period of data used is 1990-91 to 2021-22. Satellite data reveals that 81.73 % of crop rotation area in agricultural of North-western Haryana has been shifted from one major rotation to another as shown in figure 2 and Table 2. About 18.27 % of the crop rotation area has been recorded no change in the agricultural statistics of north-western Haryana as shown in table 2. The annual major crop rotation change has been shifted from Cotton-mustard to Rice-Wheat was accounting about 5.83% and Bajra-Mustard to cotton-Wheat annual minor change has been recorded is about 1.44% as shown in figure 2 and table 2. Major Crop Rotation Change during Kharif Season, shifted from cotton-Wheat to Rice-Wheat was estimated about 10.06 % and major crop Rotation change during Rabi Season, shifted from Cotton-Mustard to Cotton-Wheat Was estimated about 5.99% as shown in table 2 and figure 2.

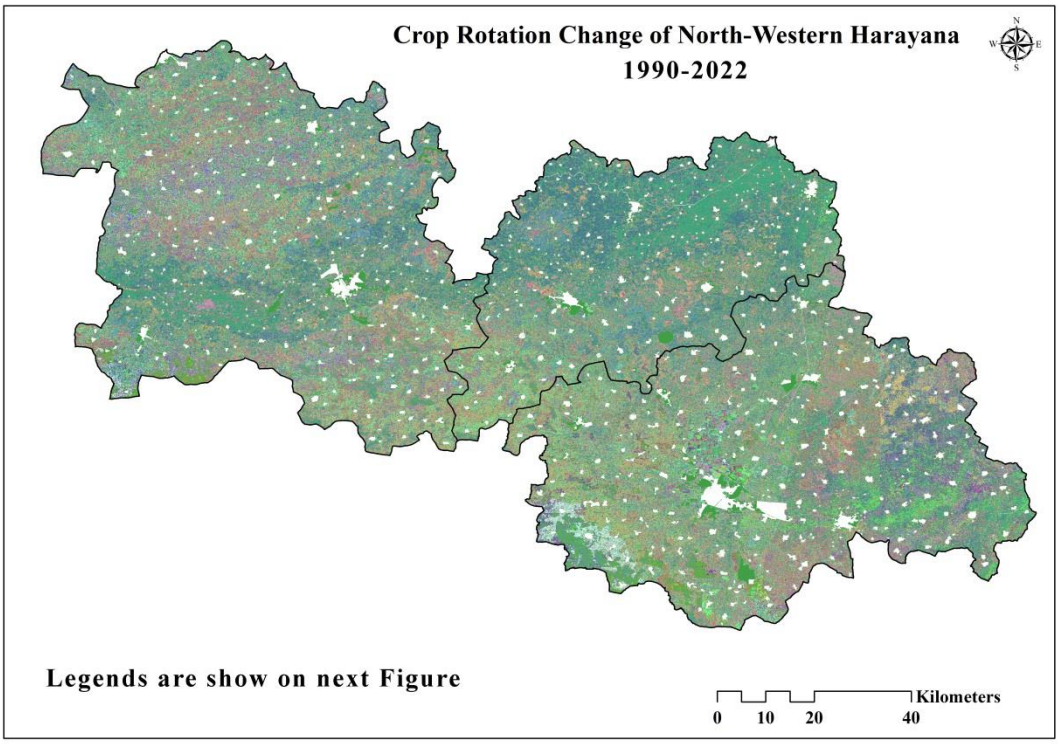


Figure:- 3 Crops rotation change and other classes in north-western Haryana (1990-91 to 2021-22).

The crop rotation shift during kharif season has also been seen in bajra-mustard to Cotton-mustard accounting about 1.98% and Rice-Mustard to Rice-Wheat is accounted 2.05% during Rabi season as shown in Fig 2 & table 2. The annual area under fallow has been transform under the Cotton-Mustard and cotton-wheat crop rotation in the North-western Haryana is estimated about 3.47% & 2.17% as shown in table 2 from the reference period of 1990-91 to 2021-22. The other-other category constitute approx. 6.43 percent of its total share in north-western Haryana (as shown in Table 2)

Table:- 2

**Long term crop rotation changes in Agriculture Statistics of North-western Haryana From 1990-91 to 2021-22**

| categories | Area in percentage |
|---|---|
| **Change** | **81.73** |
| **No change** | **18.27** |
| Annual major C. R. change | |
| **Cotton-Mustard to Rice-Wheat** | 5.83 |
| **Bajra-Mustard To Cotton-Wheat** | 1.44 |
| Major Kharif C. R. change | |
| **Cotton-Wheat to Rice-Wheat** | 10.06 |
| **Bajra-Mustard to Cotton-Mustard** | 1.98 |
| Major Rabi C. R. change | |
| **Cotton-mustad to cotton-Wheat** | 5.99 |
| **Rice-Mustard to Rice-Wheat** | 2.05 |
| Fallow to area under cultivation | |
| **Fallow-Fallow to Cotton-Mustard** | 3.47 |
| **Fallow-Fallow to Cotton-Wheat** | 2.17 |
| **Other** | 6.43 |

*C.R.- Crop Rotation

## 7. Conclusions

The following Conclusions could be derived from the above study that North-Western Haryana, like others part of Haryana, is progressing towards rice-wheat cropping system. This study provides the spatial and temporal information about the crop rotation changes in north-western Haryana during 1990-91 and 2021-22.

we draw the conclusion that landsat-5 and sentinel-2, with moderate to high temporal and spatial resolution, are acceptable for describing the long-term crop rotation changes and managing agricultural systems of North-western Haryana. From these

results it was clear that the major cropping sequence followed by cotton-mustard, cotton-wheat in 1990-91 and rice-wheat, cotton-wheat in 2020-21 in north-western Haryana.

Crop Rotation and Need for Future

- To react to market demands, farmers of North-western Haryana need rotations that are adaptable and cost-effective. The farmer must monitor development, assess crop success, and adjust management as necessary in order to manage the rotation.
- We can create systems in the future with enhanced environmental, agronomic, and economic performance if future study is focused on a better understanding of the effects of crop rotation on soil and plant responses.
- Therefore, it's imperative that we have the right resources to assess the effects of modifying rotation design in terms of the associated financial risks and benefits.
- Rotations have the potential to fix structural issues in the subsoil, but as of yet, we don't fully understand how a root's capacity to exit macropores is influenced by its physical characteristics or how much species differ in this regard.

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