International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2020; 8(1): 494-500

Received: 16-11-2019
Accepted: 18-12-2019

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Cropping pattern changes: A case study in Krishna delta region of Andhra Pradesh

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DOI: https://doi.org/10.22271/chemi.2020.v8.i1g.8306

Abstract
A study was conducted to prepare a cropping pattern changes of Krishna delta region of Andhra Pradesh using satellite data, by following analysis in ERDAS and GIS environment. Sustainability of agriculture can be achieved through optimum cropping pattern or crop rotation in an area. Multi date satellite data of Landsat TM, IRS P6-LISS III and OLI satellite data were used for the generation of cropping pattern and extent of crops in *kharif* and *rabi* seasons. In the present study extent of crop in season wise and cropping pattern has been determined for rice, maize, sugarcane, cotton and rice-rice, rice-maize, respectively. Rice has been the dominant crop of *kharif* in the study area contributing to 59.77, 59.73 and 46.60 per cent followed by sugarcane contributing to 0.72, 1.46 and 1.81 per cent and cotton of 0.63, 0.50 and 1.07 per cent of the total geographical area in 1996, 2005 and 2015, respectively whereas, in *rabi* pulses were dominant crop and contributing of 44.09, 24.39 and 32.57 per cent of the total geographical area in 1996, 2005 and 2015, respectively followed by rice and maize. The extent of maize in the study area was found to be 53.43 and 76.86 (₹ 000 ha) covering 8.56 and 12.32 per cent in 2006 and 2016, respectively. Temporal remote sensing data revealed a drastic reduction in extent of area in rice-pulse pattern with an increase in rice-maize in 2006 and 2016 compared to 1997.

Keywords: Cropping system, remote sensing, IRS-P6 satellite, LISS-III, Rabi, Kharif

Introduction
Cropping pattern is the yearly sequence of crops in a piece of land. In any region cropping pattern depends on the soil, climate, rainfall, market value of commodity etc. Apart from this, it depends on the nature and availability of irrigation facilities. The shrinking of agricultural lands, intensive cropping and over-exploitation of natural resources in recent years without considering the potentialities and limitations for various uses causes deterioration of soil quality/health. Majority of Indian farmers get the major share of income from crop production. Therefore, it is very much important to select the right crop, in the right season so that maximum profit may be achieved. Cropping pattern have significant environmental consequences, namely soil fertility, erosion, soil health/quality. The new technologies like remote sensing and Geographical Information System (GIS) has become very useful tools for the management of dynamic agricultural resource. Remote sensing data provides timely information about present crops, identify crop types and spatial distribution of crops hence, remote sensing is a pre requisite devise for ideal cropping pattern dynamics within an agro-ecological region. In recent years, satellite technology has become extremely important due to its synoptic, repeated collection of data and multi-sensor data availability, which provides a cost-effective, reliable and critical mechanism for cropland mapping and change analysis (Panigraphy *et al.*, 1998) [5]. Cropping pattern identification and changes are essential to know the overall agro-environment and agro-spatial diversity of the area, which helps the planners and policy makers to assess the potential use of agricultural land, suitability analysis of crops and future cropping pattern planning of the area. The objective of the study is to analyze the spatial dynamics of cropland and find out the major cropping pattern and their changes between 1996/97, 2005/06 and 2015/16.

Materials and Methods

Study area

The Krishna delta region is a part of Guntur and Krishna districts of Andhra Pradesh, is falling in the Deccan Plateau Agro-climatic region of India has a geographical area of 6240 sq.km. It lies between 15.75^0 to 16.56^0 N latitude and 80.31^0 to 81.33^0 E longitude. The delta has a semi-arid climatic with annual rainfall ranges from 960 to 1100 mm. The main crops growing is paddy, maize, black gram, green gram, chilli, sugarcane, leafy vegetables etc.

Data

Remote sensing data is the basic data source for mapping the cropping pattern of the Krishna delta region. In this study Landsat TM, IRS P6-LISS III and OLI satellite data were used. The Landsat TM images were acquired for the year 1996 and 1997; LISS III data of 2005 and 2006; LANDSAT 8 data of 2015 and 2016 imageries were used for studying cropping pattern changes (Table 1). The collateral data used are toposheets, boundary of Krishna delta region, crop statistics at district and block level from Department of Agriculture and ground truth data in the form of GPS points. It may be mentioned here that in the study area *kharif* season starts at September, but due to unavailability of cloud free optical images before November of the area was another reason to acquire satellite data for November. LISS-III has a spatial resolution of 23.5 m, four spectral bands (green, red, blue and near infrared) and a temporal resolution of 25 days with a swath of width. OLI has a spatial resolution of 30 m, nine spectral bands and temporal resolution of 16 days. The data in the months of October/November is used for *kharif* season and January/Febraury is used as *rabi* season were used for identification of different crops.

Table1: The multi temporal satellite data used for studying cropping pattern changes

Satellite	Sensor	Path/orbit	Row/sector	Date of pass
Landsat 5	Landsat Thematic Mapper	142	49	November 10th, 1996
				Febraury 14th, 1997
IRS P6	LISS-III	102	61 & 62	November 14th, 2005
				January 25th, 2006
Landsat 8	Operational Land Imager (OLI)	142	49	October 15th, 2015
				Febraury 19th, 2016

ERADAS Imagine 9.3 software was used for importing, image geo-referencing and rectification for studying cropping pattern changes. ARC GIS 10.2 was used for map composition and Microsoft office was used for database preparation.

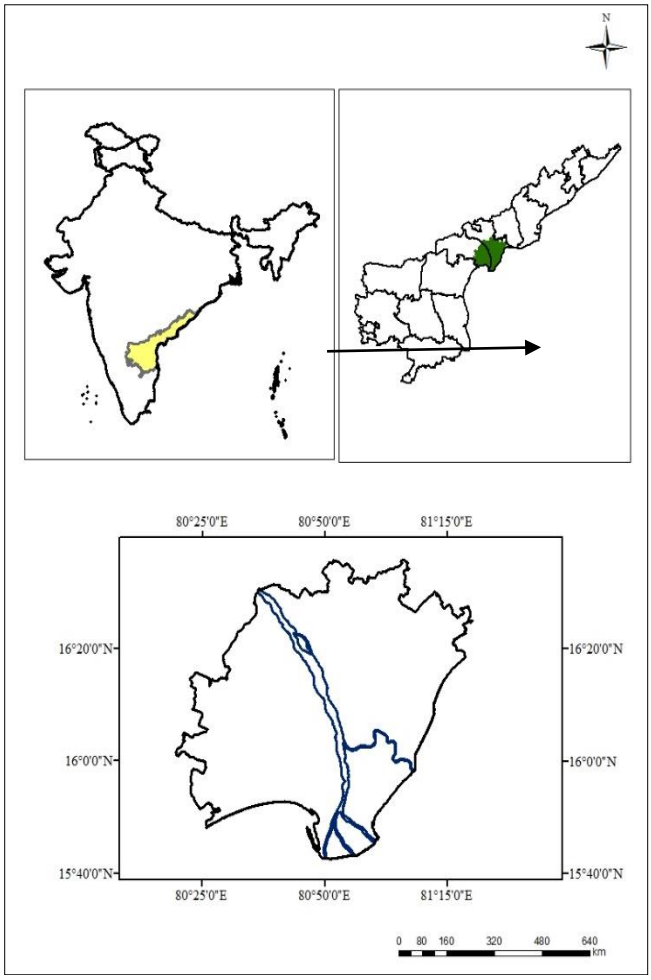

Fig 1: Location map of the Krishna delta area

Methodology

For studying changes in cropping pattern the cloud free data of LANDSAT 5 and 8 for the *kharif* and *rabi* seasons were downloaded from USGS Earth Explorer, NASA http://earthexplorer.usgs.gov/in TIFF format. The multispectral images of November 14th 2005 and January 25th, 2006 of LISS-III were acquired from National Remote Sensing Centre, Balanagar, Hyderabad. The green, red and near infrared wavelengths representing bands 2, 3 and 4 in Landsat TM and LISS-III whereas 3, 4 and 5 of OLI were stacked together to obtain respective final false colour composites. ERDAS (Earth Resource Data Analysis System) software package was used for radiometric correction, georeferencing, classification and spatial modelling of cropping pattern. The information in the false colour composite was not related to the real world. Hence geometric correction was performed through georeferencing, which established the relation between row/column numbers and real-world coordinates using UTM projection with WGS-84 spheroid datum. Thus, all the data sets were brought to a common projection. This ensured the satellite imagery to have a spatial reference with the real world. The LANDSAT and LISS III images were covering large area. However, the study area was only a part of the image, hence generated a subset for the area of interest. The schematic diagram showing the methodology followed for cropping pattern changes were depicted in fig 1. In order to classify the data, supervised classification was followed. The principle of image classification is that a pixel was assigned to a specific class based on feature vector by comparing it to predefined clusters in the feature space. The supervised Maximum Likelihood classifier was used and the supervised classification for the images was done. The training signatures were defined for various crops and other permanent features based on ground truth information. Multiple training sites for each class were identified in order to represent the variability within same class. The signature seperability between different classes were ensured before the image was classified using maximum likelihood algorithm. The procedure was repeated for each dataset and finally classification was done for each dataset.

Results and Discussion

Analysis by remote sensing techniques pertaining to the temporal variation in cropping pattern during three time periods *viz.*, 1996-97, 2005-06 and 2015-16 for *kharif* and *rabi* seasons obtained using remote sensing data are presented in tables 2 to 4 and figures 2 to 10. Understanding the cropping pattern of a given area requires information about the crops that are grown in *kharif* and *rabi* season.

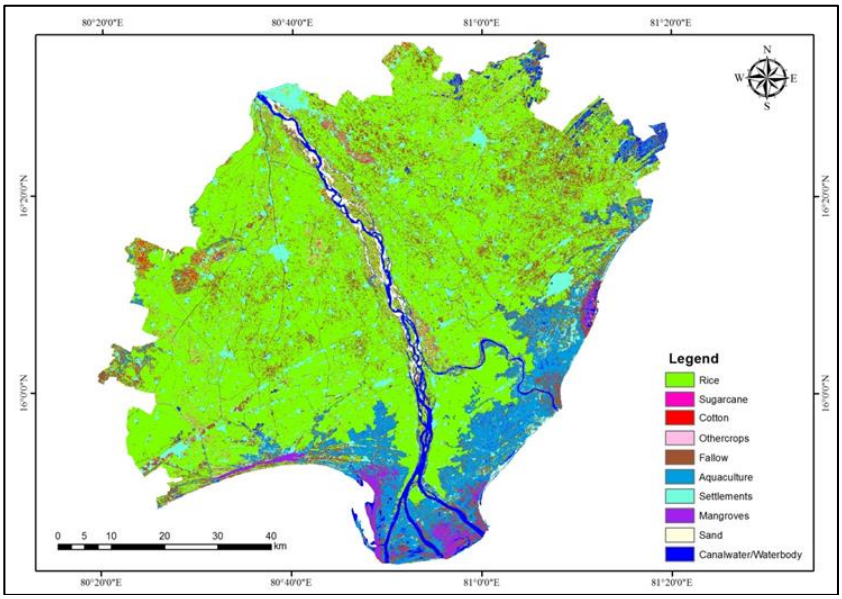

Fig 2: Extent of different land uses during *kharif* 1996 in Krishna delta region

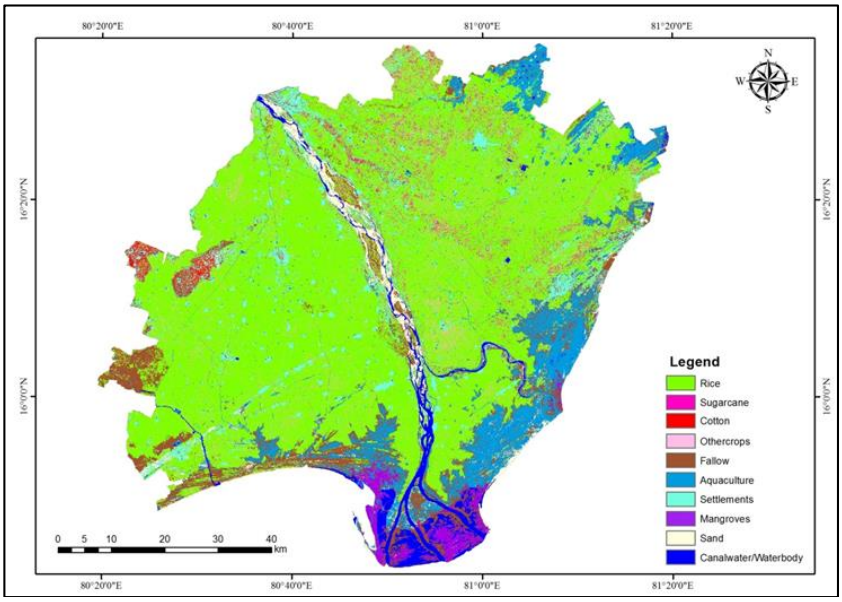

Fig 3: Extent of different land uses during *kharif* 2005 in Krishna delta region

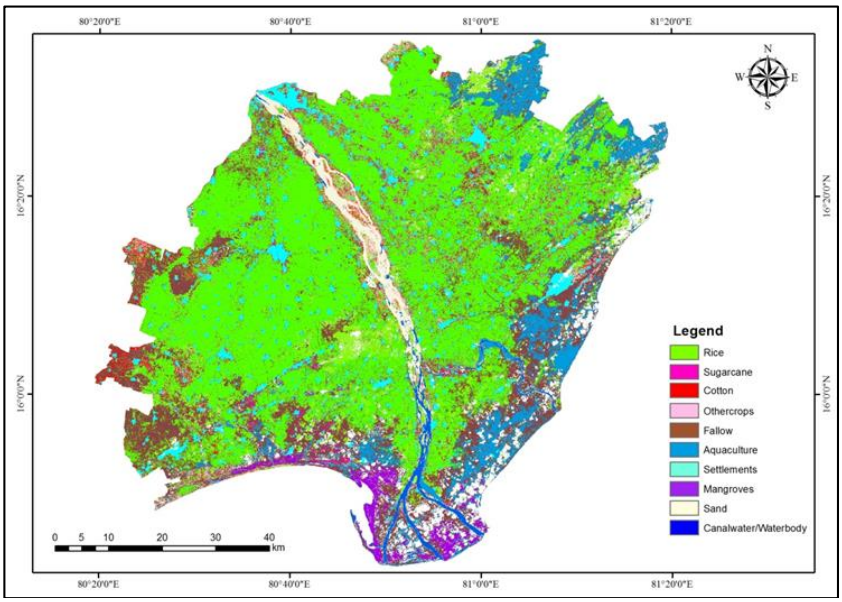

Fig 4: Extent of different land uses during *kharif* 2015 in Krishna delta region

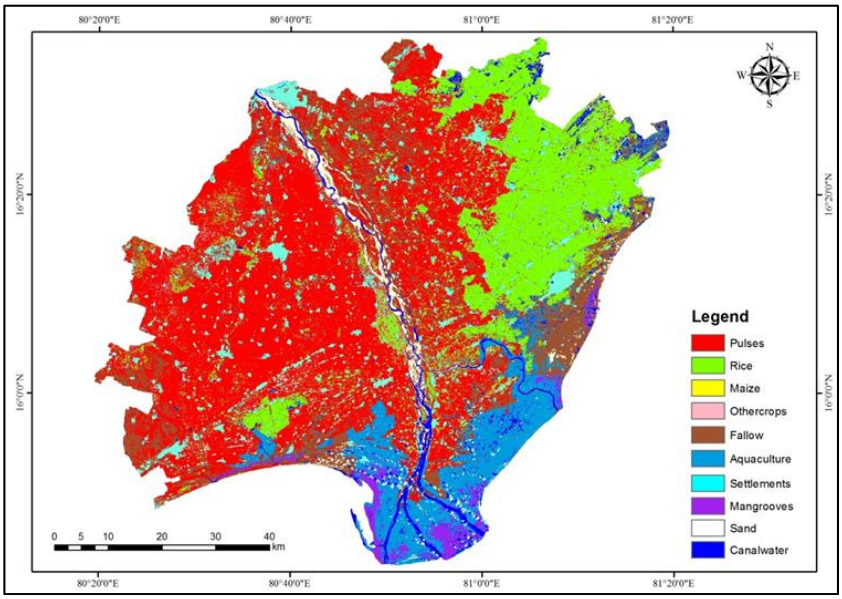

Fig 5: Extent of different land uses during *rabi* 1997 in Krishna delta region

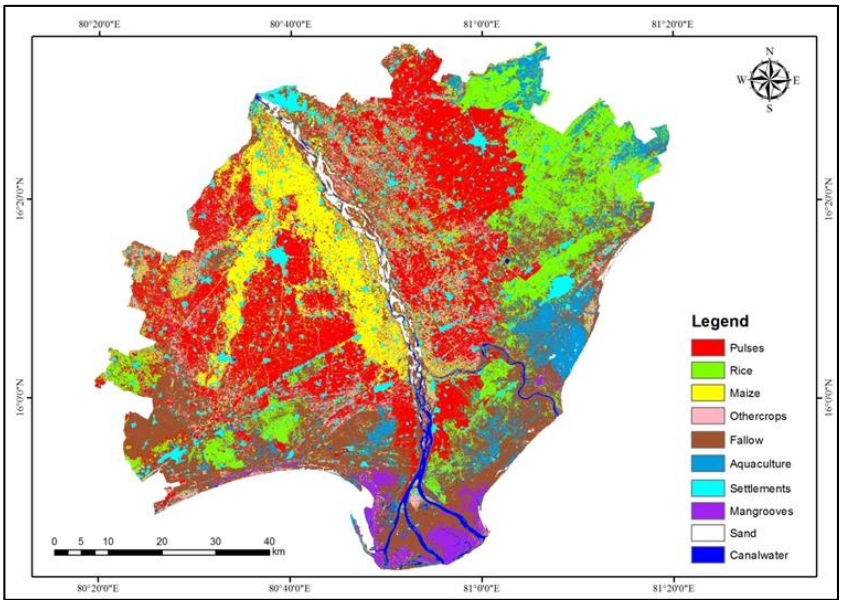

Fig 6: Extent of different land uses during *rabi* 2005 in Krishna delta region

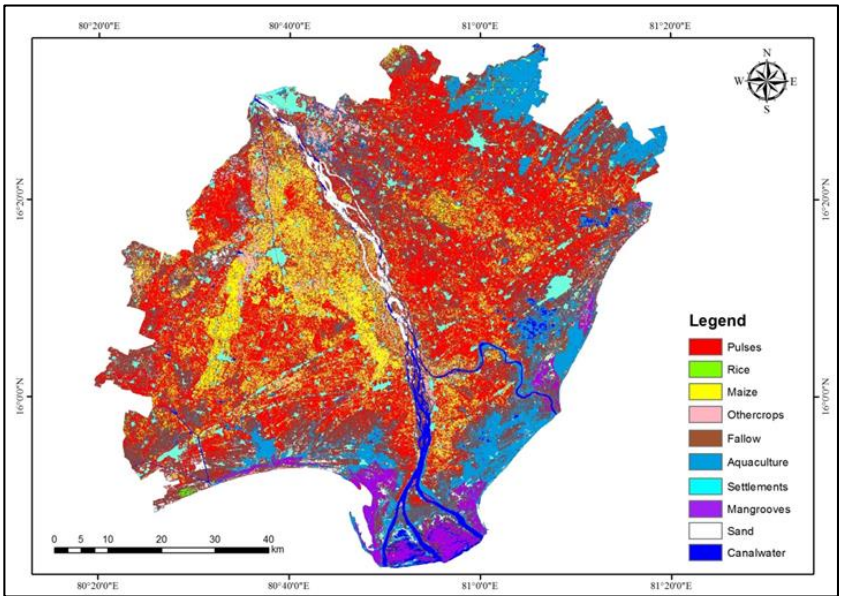

Fig 7: Extent of different land uses during *rabi* 2016 in Krishna delta region

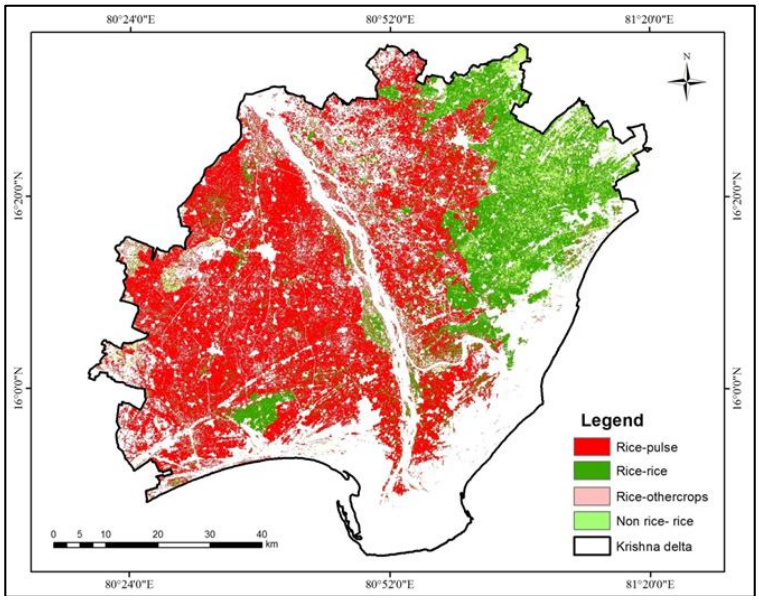

Fig 8: Cropping pattern of Krishna delta region during 1996-97

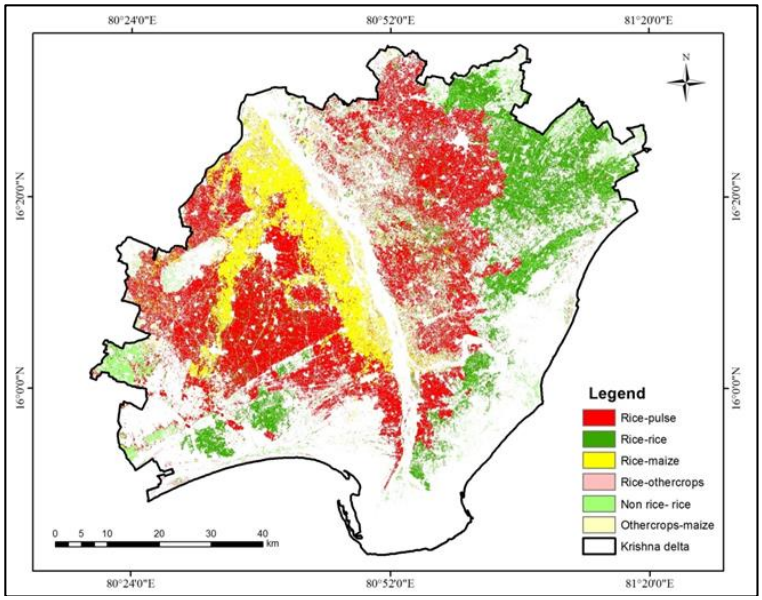

Fig 9: Cropping pattern of Krishna delta during 2006-07

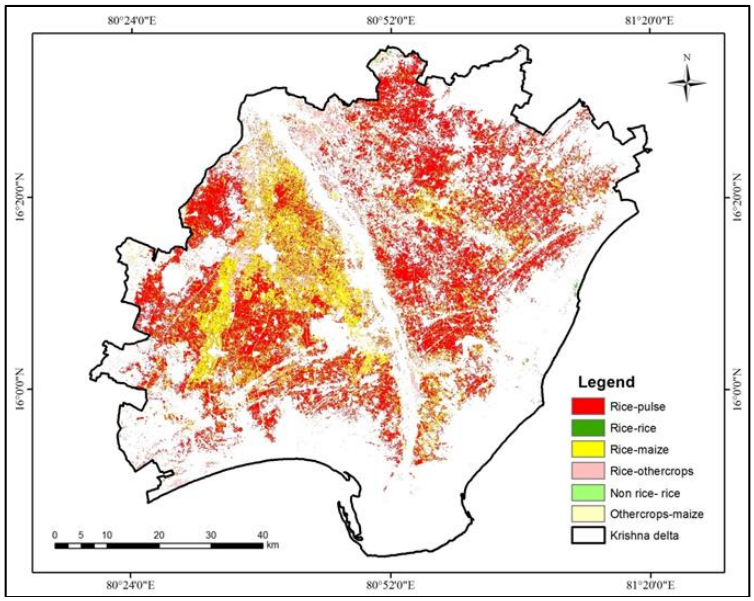

Fig 10: Cropping pattern of Krishna delta during 2015-16

***Kharif* Season**

During *kharif* season, rice was the dominant crop followed by sugarcane and cotton. Rice is extend upto 373.00, 372.72 and 290.78 (₹ 000 ha) contributing to 59.77, 59.73 and 46.60 per cent, sugarcane is extend to 4.48, 9.14 and 11.31 (₹ 000 ha) and contributing to 0.72, 1.46 and 1.81 per cent and cotton is the third major crop covering of 3.95, 3.14 and 6.70 (₹ 000 ha) and accounting for 0.63, 0.50 and 1.07 per cent of the total geographical area in 1996, 2005 and 2015, respectively. The data (Table 2) indicated that rice was occupying maximum area in 1996 and with time, there was a reduction in extent of area by 13.17 per cent in 2015 when compared to 1996. The fall in rice area during *kharif* 2015 could be attributed to lack of irrigation water and increase in production cost of rice (Ramana and Rekha, 2012) [2]. The extent under sugarcane was found to increase by 0.74 and 1.09 percent during 2005 and 2015, respectively while, the area under cotton crop was increased in 2015 by 0.44 per cent over 1996. Cotton crop was mostly concentrating in northern part of Krishna western delta, whereas sugarcane was mostly in eastern delta. The area under other crops (turmeric, leafy vegetables, plantations, *etc*.,) was 1.56, 6.18 and 2.25 per cent during 1996, 2005 and 2015, respectively. The extent under fallow was found to decrease in 2005 and this might have been shifted to other crops.

Among non-agricultural fields, aquaculture occupied the major share to a tune of 61.83, 58.27 and 39.55 (₹ 000 ha) with 9.91, 9.34 and 6.34 per cent in 1996, 2005 and 2016, respectively. In 2015, the extent of aquaculture was decreased, as cloud and cloud shadow covered part of the region blocking the land information. Mangrove area is more or less same from 1996 to 2016 with 8.86, 9.18 and 8.72 (₹ 000 ha) in 1996, 2005 and 2015, respectively.

Table 2: Extent of different land uses during *kharif* (October/November) season in Krishna delta region

S. No.	Crop	1996		2005		2015	
		Area ('000 ha)	Area (%)	Area ('000 ha)	Area (%)	Area ('000 ha)	Area (%)
1	Rice	373.00	59.77	372.72	59.73	290.78	46.60
2	Sugarcane	4.48	0.72	9.14	1.46	11.31	1.81
3	Cotton	3.95	0.63	3.14	0.50	6.70	1.07
4	Othercrops	9.76	1.56	38.56	6.18	14.04	2.25
5	Fallow	90.95	14.57	51.87	8.31	102.55	16.43
6	Aquaculture	61.83	9.91	58.27	9.34	39.55	6.34
7	Settlements	45.18	7.24	50.52	8.10	54.12	8.67
8	Mangroves	8.86	1.42	9.18	1.47	8.72	1.40
10	Canal water/ Ponds	19.27	3.09	19.12	3.06	30.32	4.86
11	Sand	6.77	1.09	11.53	1.85	13.16	2.11
12	Total	624.05	100	624.05	100	624.05	100

***Rabi* Season**

The major crops adopted during *rabi* season in Krishna delta region of Andhra Pradesh were pulses, rice and maize. Pulses were dominant crops occupying an area of 275.14, 152.22 and 203.25 (₹ 000 ha) contributing to 44.09, 24.39 and 32.57 per cent of total geographic area in 1997, 2006 and 2016, respectively. In 1997, pulses and rice were dominant crops but maize emerged as third dominant crop after pulses and rice in 2006 and second dominant crop in 2016. The extent of maize in the study area was found to be 53.43 and 76.86 (₹ 000 ha) covering 8.56 and 12.32 per cent in 2006 and 2016, respectively. The extent of area under rice was decreased by 4.32 and 8.82 per cent, respectively in 2006 and 2016 compared to 1997.

The area under pulses has decreased from 275.14 during 1997 to 152.22 (₹ 000 ha) in 2006. This variation might be due to late release of water to Krishna western delta resulting in late transplantation of *kharif* paddy and, thereby, led to missing of the season for pulse (black gram) in rice fallows. Besides this reason, low productivity of the crop due to unexpected heavy rains and severe pest attack on the crop also made the farmers to curtail the area under the crop. Farmers switched over to maize crop, which proved to be remunerative. But later the extent under pulses increased to 203.25 (₹ 000 ha) in 2016.

In 2006 area under aquaculture was reduced from 61.83 to 36.45 (₹ 000 ha) from 1997 to 2006 due to severe drought and in 2016 extent of area under aquaculture is 57.91 (₹ 000 ha). Area under mangroves was more or less similar. The area under settlements was more or less similar with 7.24, 8.10 and 8.67 per cent in 1997, 2006 and 2016 respectively. The fallow land increased with time series accounting from 74.23 to 157.63 (₹ 000 ha) and 157.63 to 165.43 (₹ 000 ha) with 11.89 to 25.3 and 25.26 to 26.51 per cent from 1997 to 2006 and 2006 to 2016, respectively.

Table 3: Extent of different land uses during *rabi* (February/March) season in Krishna delta region

S. No.	Crops	1997		2006		2016	
		Area ('000 ha)	Area (%)	Area ('000 ha)	Area (%)	Area ('000 ha)	Area (%)
1	Pulses	275.14	44.09	152.22	24.39	203.25	32.57
2	Rice	119.27	19.11	92.30	14.79	1.82	0.29
3	Maize	--	--	53.43	8.56	76.86	12.32
4	Othercrops	7.72	1.24	51.72	8.29	21.82	3.50
5	Fallow	74.23	11.89	157.63	25.26	165.43	26.51
6	Aquaculture	61.83	9.91	36.45	5.84	57.91	9.28
7	Settlements	45.18	7.24	50.53	8.10	54.12	8.67
8	mangroves	8.89	1.43	9.18	1.47	8.72	1.40
10	Sand	13.90	2.23	12.90	2.07	17.43	2.79
11	Canal water/ Ponds	17.89	2.87	7.71	1.24	16.67	2.67
12	Total	624.05	100	624.05	100	624.05	100

Cropping Pattern

The temporal data revealed that rice-pulse system has been the dominant cropping pattern of Krishna delta region at all years studied (1996-2016) with an extent of 232.80, 125.94 and 147.46 (₹ 000 ha) in 1996-97, 2005-06 and 2015-16, respectively (Table 3). However, there was a drastic reduction in extent under this system during 2005-06 (16.10%) and 15-16 (13.67%) compared to 1996-97. This decline in acreage can be explained by the corresponding increase in rice-maize system during this period. This clearly

emphasizes that maize has replaced pulse crops because of their failure due to yellow mosaic virus.

Perusal of the data in the table 4.4 on the cropping pattern and its changes indicated that there was a continuous reduction in extent of area under rice-rice system from 1996-97 to 2015-16. The per cent decline in area under this system was found to be 14.16 with only 1.82 (₹ 000 ha) against an area of 90.24 in 1996-97. This is attributed to the same reasons explained earlier for reduction in rice area. The rice-maize system was introduced in the area during 2003-2004 and reached to an extent of 75.73 in 2015-16. This is almost coinciding with the extent of reduction in area under rice-rice and rice-pulse pattern. Other cropping patterns observed in the study area were rice-other crops, other crops-rice, other crops-maize.

The results indicated that during the last 20 years from 1996 to 2005 and 2005 to 2015, the *kharif* cropping pattern has almost remained same, with rice as a dominant crop. Sugar cane was the next dominant crop in *kharif* whereas, in *rabi* season a shift in pulse to maize crop was observed.

Table 4.4. Temporal variation in cropping pattern of Krishna delta region

S. No	Cropping pattern	1996-97		2005-06		2015-16	
		Area ('000 ha)	Area (%)	Area ('000 ha)	Area (%)	Area ('000 ha)	Area (%)
1	Rice-Pulse	232.80	37.30	125.94	21.19	147.46	23.63
2	Rice-Rice	90.25	14.46	62.55	10.52	1.82	0.34
3	Rice-Maize	-	-	50.05	8.42	75.73	12.2
4	Rice-Other crops	6.61	1.06	39.87	6.71	15.20	2.44
5	Non-rice-Rice	29.03	4.65	24.93	4.19	0.35	0.07
6	Others-Maize	-	-	3.38	0.57	1.13	0.18

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