Determinants of Cropping Pattern Changes in Andhra Pradesh, India

Geetha Mohan[1*]

[1]*IR3S, The University of Tokyo, Japan.*

Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

Original Research Article

ABSTRACT

This paper has examined changes in cropping pattern in the state of Andhra Pradesh at the aggregate and regional levels for the period 1969-71 to 2004-05. A zero-order correlation coefficients for the change in the area under different crops were estimated. The results indicate that the Andhra Pradesh state has witnessed shifts in cropping pattern during the past three decades, and these shifts are towards cultivation of total pulses except (horse gram), fruits and vegetables, spices, drugs and narcotics and sugarcane. The fixed effect regression model was used to recognize the fundamental factors of shifts in the cropping pattern. The magnitude of these change, however, vary across the regions and also across districts within a region. These changes have been driven by sub-division of landholdings, mechanization, irrigation, technological change and farmers' improved access to institutional credit and infrastructure.

1. INTRODUCTION

Andhra Pradesh continues to be largely an agricultural state with a population of over 84.6 million, living on 2.75 lakh sq.km of land, the rural area accounting for about 70.0 per cent population of 56.3 million as per the latest Census 2011. The average farm-size is small, at

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1.08 ha as per 2010-11 data. Among the total holdings, 26.08 per cent are marginal (< 1 ha), 28.8 per cent are small (1-2 ha) 25.8 per cent are semi-medium (2-4 ha) 15.5 per cent are medium (4-10 ha) and 3.9 per cent are large (> 10 ha) in the state. The net sown area is 10.9 M ha, and 27.1 per cent of it is cultivated more than once. Irrigation covers only 6.7 M ha area i.e., 48.4 per cent of the gross cropped area.

Since geographical spread is quite large, the soils and climate across the state differ significantly. Due to these divergent soils, climate, and other resource endowments, several types of crops are grown in the state, and can be classified broadly as food crops and non-food crops, high-value crops and low-value crops. Over the years, there has been a significant change in the cropping pattern in the state due to changing consumer preferences and changes in the government policies, technological improvements, development of infrastructure, and improvements in agricultural support systems. A close examination of these factors and the related aspects form the basis for the present study.

The state agriculture is fraught with risks and uncertainties as about two-thirds of the cultivable land depend on monsoon for irrigation. The farmers are often not sure about the outcome of agriculture due to uncertain weather and market-induced risks. Under such circumstances, concentration of crop production may result in high degree of uncertainty in farm income and employment. Therefore, shifts in the cropping pattern, which involve transformation of a mono-cropped farm into a multifaceted enterprise, is a welcome step.

Earlier studies on cropping pattern in South Asia reveals that there is gradually shifting in favour of high value crops such as fruits and vegetables, livestock and fish products [1,2]. Similarly, in the Indian context, the previous studies discussed the patterns in the growth of crop sector in India has experienced substantial changes with a significant move from area under food grains to commercial crops [3]. In fact, there is a great beep forward with crop pattern changes taking place at micro level and the nature of cropping pattern changes is mainly from low level coarse cereals to high value crop and other food grains [4]. However, the implications of these shifts for crop diversification and balance in the inter-crop allocation of existing and additional areas brought under cultivation and the output and productivity impact of crop pattern changes [5].

The cropping pattern changes have emphasized two important characteristics of agricultural land, viz. its heterogeneity and the possibility of crop substitution. Heterogeneity arises from the agro-climatic differences arising due to soil, temperature, rainfall, which differ from region to region [6]. The studies on cropping pattern assume importance taking cognizance of soil-climate factors and the crops that could be grown within the environment [7]. The changes in cropping pattern represent response to the changing economic, technological, and institutional factors. The farmers tend to develop a stable cropping pattern in the given agro-climatic region and they do not shift much from this position, except to the extent dictated by the price factors in adjusting acreage allocations. However, they do change their cropping pattern, maybe with some time lags, in response to newer production opportunities provided by a new technology such as using high-yielding crop varieties along with fertilizers, pesticides, insecticides, and increase in irrigated area [1,2,3,8,9].

The state of Andhra Pradesh has a good potential for changes in the cropping pattern. In response to this potential and the changing market conditions, farmers have been changing their cropping pattern. A study on the nature of changes in the cropping pattern, whether they lead to crop diversification or crop concentration, in a detailed and analytical way will be useful for designing the policy for agricultural diversification. The present study is one such attempt. It has investigated the changes in cropping pattern in Andhra Pradesh, and has identified the causal factors behind cropping pattern shifts in the state.

2. DATA AND METHODOLOGY

This study is based on the secondary data drawn from the issues of Statistical Abstracts of Andhra Pradesh, published by Bureau of Economics and Statistics, Government of Andhra Pradesh. Some data were also drawn from the Statistical Abstracts of India, published by the Central Statistical Organization, Ministry of Statistics and Programme Implementation, Government of India. The study has covered the post-green revolution period from 1969-70 to 2004-05. To analyze the pattern of shifts in cropping pattern, the triennium averages of areas under various crops for the periods 1969-1971, 1979-81, 1989-91, 1999-01, and 2003-05 were considered. The analysis was carried out in terms of changes in

the proportion of area under the crops to the total gross cropped area, at the state and regional levels, considering 27 crops. For analyzing crop replacement or crop substitution, a zero-order correlation matrix was developed. To identifying the causal factors of shifts in the cropping patterns, the following fixed effect regression model was estimated. We carried out analysis with using Stata version 12, StataCorp LLC, Texas, USA.

$$Y_{it} = \beta_1 X_{1,it} + \beta_2 X_{2,it} + \beta_3 X_{3,it} + \beta_4 X_{4,it} + \beta_5 X_{5,it} + \beta_6 X_{6,it} + \beta_7 X_{7,it} + \beta_8 X_{8,it} + \beta_9 X_{9,it} + \beta_{10} X_{10,it} + \alpha_i + U_{it} \text{--- (1)}$$

In equation (2) we add dummies for the different regions.

$$Y_{it} = \beta_1 X_{1,it} + \beta_2 X_{2,it} + \beta_3 X_{3,it} + \beta_4 X_{4,it} + \beta_5 X_{5,it} + \beta_6 X_{6,it} + \beta_7 X_{7,it} + \beta_8 X_{8,it} + \beta_9 X_{9,it} + \beta_{10} X_{10,it} + \gamma_2 R_2 + \gamma_3 R_3 + \alpha_i + U_{it} \text{--- (2)}$$

where, Y_{it} is one of the six dependent variables viz., respective share in gross cropped area (GCA) of total cereal and millet crops (TC&M), share of total pulse crops (TP), share of total oilseed crops (TOS), share of total commercial crops (TCC), share of total fruits and vegetable crops (TF&V) and finally share of total other crops (TOC))[1], with *i* is the district and *t* is the time.
$X_{1,it}$ is the proportion of gross irrigated area in total cropped area, $X_{2,it}$ is the rainfall in (mm), $X_{3,it}$ is the institutional agricultural credit, $X_{4,it}$ is the number of tractors per '000 ha of cropped area, $X_{5,it}$ is the proportion of smallholders in the total landholders, $X_{6,it}$ is the average land-size in hectares, $X_{7,it}$ is the number of cultivators and agricultural workers per hectare, $X_{8,it}$ is the road density in sq km per 100 km of geographical area, $X_{9,it}$ is the fertilizer-use per hectare, and $X_{10,it}$ is the population density in number of persons per 100 sq km,

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[1] *Total cereals and millets: Rice, wheat, sorghum (jowar), pearl millet (bajra), maize, finger millet (ragi) and total minor millets; Total pulses: Horse gram, green gram, black gram, red gram, bengal gram, cow gram and other pulses; Total oilseeds: Groundnut, seasamum, safflower, sunflower, coconut, rapeseed and mustard, soyabean, castor, linseed and nigerseed; Total commercial crops: Chillies, turmeric, sugarcane, mangoes, banana (for harvest), cashewnut, potato, onions, cotton, mesta, and tobacco; Total fruits and vegetables: Total citrus fruits, grapes, guava, papaya, sapota, total fresh and dry fruits, bottle gourd, bhendi, brinjal, green leafy vegetables, cabbage, peas, beans and tomatoes; Total other crops: Flowers and aromatic plants, betel leaves, total drugs, narcotics & plantation and fodder crops [10].*

In Equation (2), R_2 and R_3 are regional dummy variables (Rayalaseema and Telangana); α_i (i=1,...,n) is the unknown intercept for each district by region; $\beta_1,... \beta_{10}$ are the coefficients for the endogenous variables i, γ_2 and γ_3 are the coefficients for binary regressors (regions), and U_{it} is the error-term.

3. RESULTS

3.1 Shifts in Cropping Pattern

In 1970-71, the major crop grown in the state was rice. It covered 25.30 per cent of the gross cropped area of 13.04 M ha. The next major crop was sorghum (19.44%) followed by groundnut (11.58 %), small millets (6.59 %), pearl millet (4.25 %), green gram 3.66 (%) and horse gram (3.22 %). The area covered by finger millet, cotton, spices and fruits and vegetables each ranged between 2 and 3 per cent, while the area covered by maize, red gram, black gram, sesamum, tobacco and chillies ranged between 1 and 2 per cent only. The rest of the crops, viz. bengal gram, other pulses, sugarcane and other oilseeds covered less than 1 per cent each of the gross cropped area.

While the changes in the cropping pattern in the state during the period 1970-71 to 2004-2005, position of the most dominant crop, rice, remained more or less the same (see Fig. 1). In fact, the proportion of rice area in gross cropped area kept increasing reaching a peak of 31.27 per cent in 2000-2001. However, there was a drastic fall thereafter and in 2004-05 it fell to 25.17 per cent. The area under total cereals and millets also declined drastically, the only exception being maize. The proportion of area under maize increased from 1.95 per cent in 1970-71 to 2.55 per cent in 1980-81, 2.36 per cent in 1990-91, 3.67 per cent in 2000-2001 and 5.39 per cent in 2004-05. Similarly, a significant area increases in the prominence of pulses, especially, the bengal gram (chickpea), red gram and green gram except horse gram. The area under oilseeds was subjected to wide fluctuations mainly on account of groundnut. Though, a substantial shift was perceived in favour of the commercial crops, particularly, sugarcane, whereas, the area under other commercial crops, viz. chillies, tobacco and cotton was noted instable. An impeccable change in favour of the cultivation of spice crops and drugs and narcotics was witnessed in the state. Remarkably, the proportion of area under high-value crops (fruits and vegetables)

increased from 2.7 per cent in 1970-71 to 3.8 per cent in 1990-91 but after 1990s, it uplifted rapidly reaching 6.06 per cent in 2000-01 and 6.90 per cent in 2004-05.

The shifts in cropping pattern differed significantly across the three regions, viz. coastal Andhra, Rayalaseema and Telangana (Figs. 2 to 4). In 1970-71, the predominant crop in the coastal Andhra region was rice. The proportion of area under rice declined from 43.86 per cent in 1970-71 to 39.59 per cent in 2004-05. The area under coarse cereals also declined drastically. On the other side, a significant shift was observed in favour of pulses: green gram, horse gram, black gram); commercial crops (sugarcane, cotton, chillies); and high-value crops (fruits and vegetables).

In the Rayalaseema region, the principal crop was groundnut and the area under groundnut grew impressive growth 29.39 per cent of the gross cropped area in 1970-71 to 45.61 per cent in 2004-05. However, a drastic decline was seen in the area under coarse cereals, but, a progressive shift in favour of maize cultivation, especially, in Anantapur district. The proportion of area under pulses has exhibited a optimistic growth, 5.98 per cent in 1970-71 to 12.80 per cent in 2004-2005: more towards bengal gram (chickpea) and red gram. Nevertheless, a notable shift in cropping pattern was observed in

favour of high-value crops (fruits and vegetables) in this region.

Until 1980s sorghum was the main crop in the Telangana region and area under this was somehow increased from 29.35 per cent in 1970-71 and 29.47 per cent 1980-81, but, after that sorghum area was declined drastically to 17.47 per cent in 1990-91 and further to 9.73 per cent in 2004-05. The area under commercial crop cotton has exhibited sharply increasing from 1.85 per cent in 1970-71 to 13.98 per cent in 2004-05. The cropping pattern changes in favour of chillies, spice crops and fruits and vegetables was witnessed in all the periods.

Remarkably, significant area gains were identified in the crops like maize, bengal gram (chickpea) and red gram in all the three regions of the state. For instance, in 2000-01 onwards, the expansion of area under maize and bengal gram (chickpea) crop noticed increasing growth due to the adoption of single cross hybrids. Particularly, there are eight districts includes Karimnagar, Nizamabad, Mahbubnagar, Medak and Khammam in Telangana region and Guntur and West Godavari districts in Coastal Andhra jointly contributes above than 80 per cent in the total maize production in the state. Although, the growth of maize yield is higher in a resource poor district in Mahbubnagar, which accounts 33 percent followed by the Guntur district during TE

Fig. 1. Cropping pattern in Andhra Pradesh during 1970-71 to 2004-05
Source: GoAP, Statistical Abstract of Andhra Pradesh (various issues)

Fig. 2. Cropping pattern in Coastal Andhra region during 1970-71 to 2004-05
Source: GoAP, Statistical Abstract of Andhra Pradesh (various issues)

Fig. 3. Cropping pattern in Rayalaseema region during 1970-71 to 2004-05
Source: GoAP, Statistical Abstract of Andhra Pradesh (various issues)

2000-01 to 2004-05. Furthermore, in these two districts the area under maize crop were expanded 7000 ha in every year from the past 5 years [11].

On the other hand, black gram, green gram, red gram and bengal gram (chickpea) are the principal pulse crops, whereas, 70 per cent of

chickpea production were predominantly grown in Kurnool, Prakasam and Anantapur districts in the state. Moreover, it is emerging as a commercial crop in black cotton soil of Andhra Pradesh, particularly, because of higher returns and stability in productivity. Besides, a low risk crop and its suitable in a diverse dry land agro-climatic conditions [12,13].
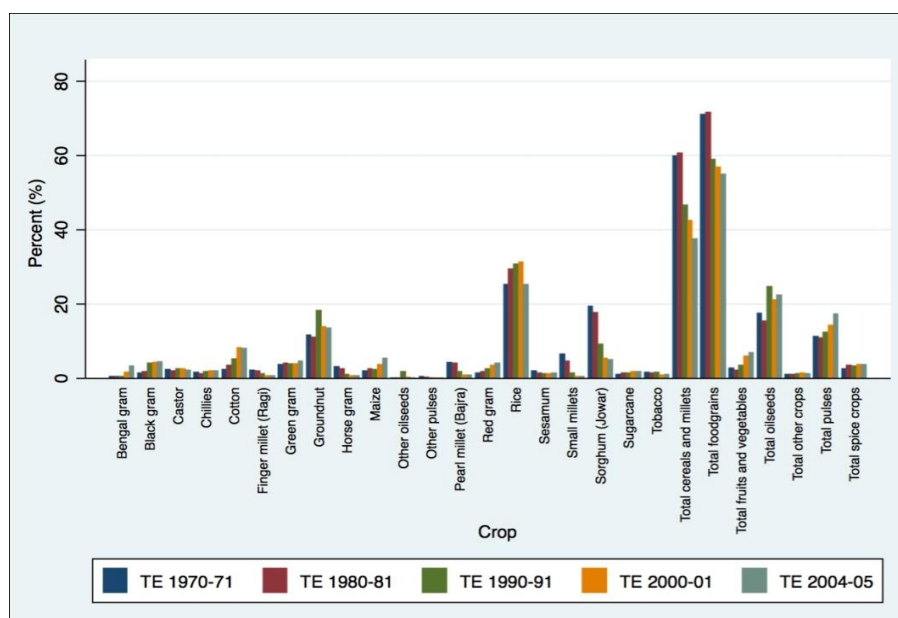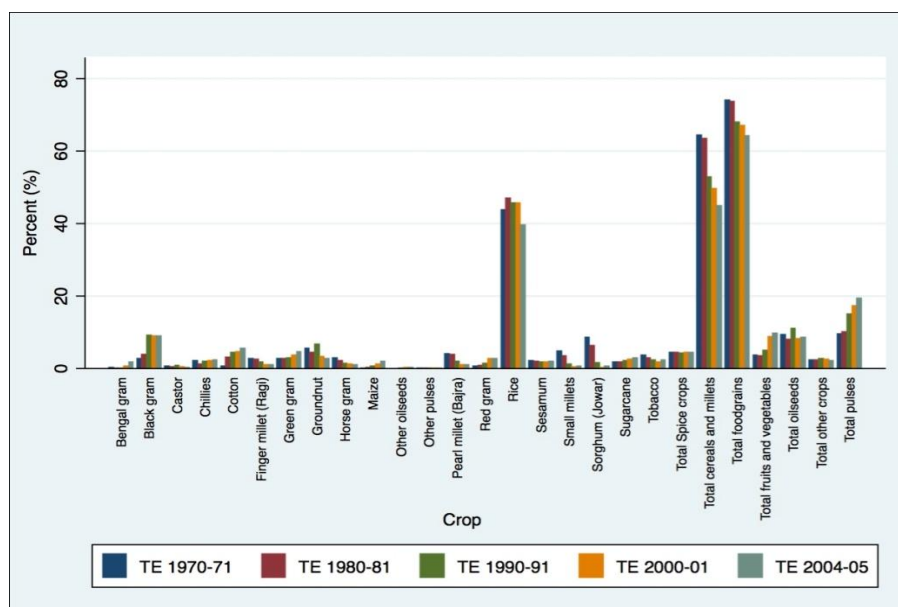
Fig. 4. Cropping pattern in Telangana region during 1970-71 to 2004-05
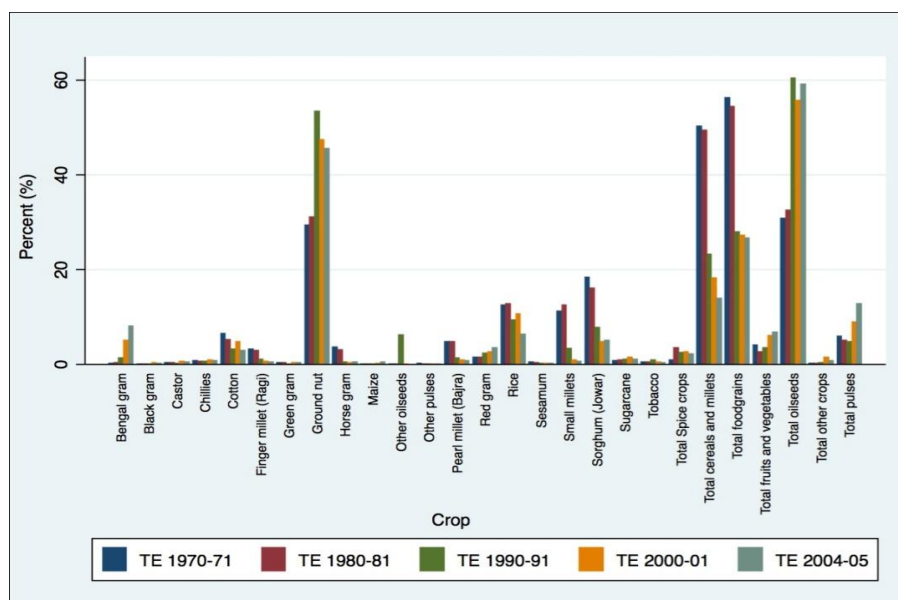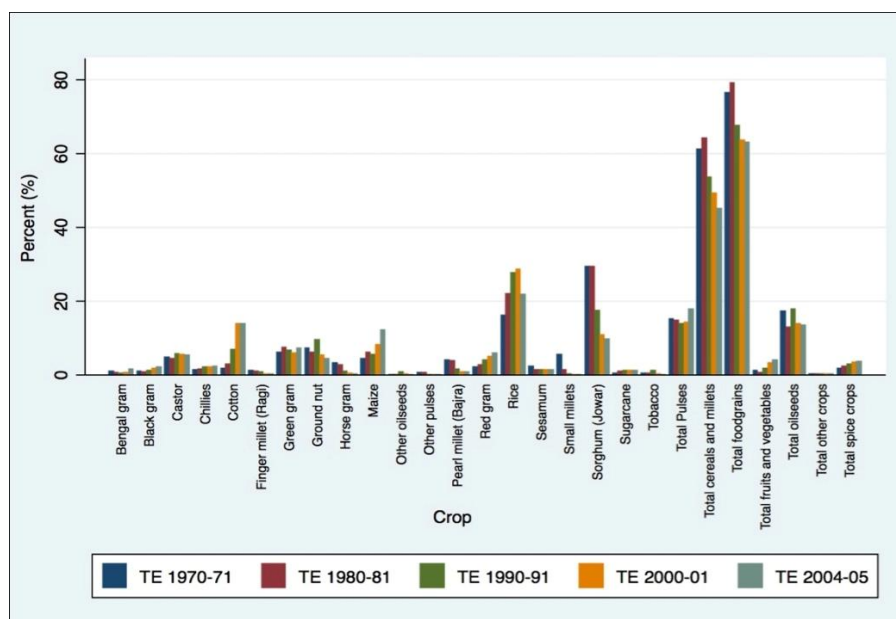*Source: GoAP, Statistical Abstract of Andhra Pradesh (various issues)*

3.2 Crop Substitution Effect

The overall study period of 1970-71 to 2004-05, there was a gradual decrease in the gross cropped area in Andhra Pradesh accounts from 48.64 per cent to 45.62 per cent of the geographical area. There are clear significant shifts in the cropping pattern have been observed, which means, some of the crops are replaced or substituted by other crops. In order to study the crop replacement or crop substitution of major and minor crops includes rice, coarse cereals, total pulses, total oilseeds, cotton, sugarcane, tobacco, chillies, total fruits and vegetables, total spice crops and other crops, a zero-order correlation coefficients for the change in the area under different crops were estimated with district-wise cross section data for the each periods, viz. 1970-71 to 1980-81, 1980-81 to 1990-91, 1990-91 to 2000-01 and 2000-01 to 2004-05 and the results are presented in Tables 1 to 4. The negative sign of the coefficient indicates crop replacement or crop substitution.

The changes in area under rice is negatively correlated with the changes in area under tobacco and other crops, although, the correlation coefficient is not statistically significant. Nevertheless, it is stated that tobacco and other crops replaced the rice crop. Similarly,

cotton and other crops substituted the shifts in area under coarse cereals in 1970-71 to 1980-81. In addition, the commercial crop cotton could have replaced by tobacco, chillies, sugarcane, fruits and vegetables and spice crops. Alike, the other important commercial crop sugarcane was switched by tobacco and other crops. As a result, in the late 70's, the shutdown of sugar factories in Adilabad district leads to divert particularly, cotton crop [14].

On the other hand, the study identified that the area under rice and coarse cereals crops were replaced by oilseeds and tobacco in the period of 1980-81 to 1990-91. Apart from, the coarse cereals are statistically significant with changes in area under oilseeds. Likewise, the pulses were substituted by oilseeds, sugarcane, tobacco and spices. In Krishna and Guntur district, one of the pulse crops named black gram was a major producer, but, after 1990's, it declines with larger area and production, and switches to crop like sunflower, maize, and cotton. While, the changes of area under oilseeds were replaced by the spice crops, which is statistically significant. Whereas, the commercial crops like sugarcane and tobacco substituted by chillies and other crops. Furthermore, the situation with respect to other commercial crop chillies was statistically insignificant among the shifts in area under spices, fruits and vegetables.

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Table 1. Zero-order correlation coefficient of changes in area under specific crops in Andhra Pradesh[a] : TE 1970-71 to TE 1980-81

Crops	Δ Rice	Δ Coarse cereals	Δ Total pulses	Δ Total oilseeds	Δ Cotton	Δ Sugarcane	Δ Tobacco	Δ Chillies	Δ Total fruits and vegetables	Δ Total spice crops	Δ Total other crops
Δ Rice	1.00										
Δ Coarse cereals	0.259 (0.232)	1.00									
Δ Total pulses	0.383 (0.072)	0.346 (0.105)	1.00								
Δ Total oilseeds	0.230 (0.291)	0.325 (0.130)	0.078 (0.724)	1.00							
Δ Cotton	0.084 (0.703)	-0.204 (0.351)	-0.054 (0.806)	-0.017 (0.939)	1.00						
Δ Sugarcane	0.218 (0.317)	0.153 (0.485)	0.028 (0.900)	0.001 (0.997)	-0.001 (0.995)	1.00					
Δ Tobacco	-0.053 (0.811)	0.250 (0.249)	-0.020 (0.928)	0.112 (0.610)	-0.734** (0.000)	-0.012 (0.958)	1.00				
Δ Chillies	0.035 (0.873)	0.321 (0.136)	0.015 (0.945)	0.088 (0.689)	-0.722** (0.000)	0.046 (0.835)	0.740** (0.000)	1.00			
Δ Total fruits and vegetables	0.759** (0.000)	0.463* (0.026)	0.508* (0.013)	0.404 (0.056)	-0.147 (0.502)	0.164 (0.453)	0.152 (0.489)	0.074 (0.736)	1.00		
Δ Total spice crops	0.815** (0.000)	0.513* (0.012)	0.388 (0.067)	0.338 (0.115)	-0.154 (0.484)	0.258 (0.234)	0.135 (0.540)	0.147 (0.504)	0.849** (0.000)	1.00	
Δ Total other crops	-0.170 (0.439)	-0.158 (0.470)	-0.021 (0.924)	-.028 (0.898)	0.304 (0.159)	-0.124 (0.573)	0.024 (0.915)	-0.499* (0.015)	0.020 (0.928)	-0.026 (0.907)	1.00

Source: GoAP, Statistical Abstract of Andhra Pradesh (various issues)
Notes: a. List wise N=23 (Number of districts),
Upper rows figures are simple correlation coefficient,
Figures within the parentheses are p-values.
*** Correlation is significant at the 0.01 level (2-tailed)*
** Correlation is significant at the 0.05 level (2-tailed)*
Δ indicates the change in the area under a crop category

Table 2. Zero-order correlation coefficient of changes in area under specific crops in Andhra Pradesh[a]: TE 1980-81 to TE 1990-91

Crops	Δ Rice	Δ Coarse cereals	Δ Total pulses	Δ Total oilseeds	Δ Cotton	Δ Sugarcane	Δ Tobacco	Δ Chillies	Δ Total fruits and vegetables	Δ Total spice crops	Δ Total other crops
Δ Rice	1.00										
Δ Coarse cereals	-0.100 (0.649)	1.00									
Δ Total pulses	0.004 (0.985)	0.178 (0.416)	1.00								
Δ Total oilseeds	-0.265 (0.222)	-0.758** (0.000)	-0.265 (0.221)	1.00							
Δ Cotton	0.346 (0.106)	0.051 (0.817)	0.231 (0.289)	-0.387 (0.068)	1.00						
Δ Sugarcane	-0.039 (0.861)	0.330 (0.124)	-0.211 (0.335)	-0.234 (0.282)	-0.112 (0.611)	1.00					
Δ Tobacco	-0.210 (0.335)	-0.101 (0.648)	-0.248 (0.254)	0.175 (0.425)	-0.048 (0.827)	-0.067 (0.761)	1.00				
Δ Chillies	0.421* (0.046)	-0.404 (0.056)	0.259 (0.233)	-0.070 (0.752)	0.472* (0.023)	-0.106 (0.632)	-0.367 (0.085)	1.00			
Δ Total fruits and vegetables	0.279 (0.197)	0.093 (0.673)	0.227 (0.297)	-0.066 (0.765)	-0.185 (0.398)	0.331 (0.122)	0.055 (0.802)	-0.003 (0.988)	1.00		
Δ Total spice crops	0.309 (0.151)	0.269 (0.214)	-0.107 (0.626)	-0.564** (0.005)	0.175 (0.426)	-0.055 (0.804)	0.095 (0.666)	-0.004 (0.984)	0.009 (0.966)	1.00	
Δ Total other crops	0.164 (0.453)	-0.257 (0.237)	0.104 (0.638)	0.035 (0.874)	-0.229 (0.294)	-0.043 (0.844)	-0.257 (0.236)	0.546** (0.007)	0.194 (0.376)	-0.071 (0.749)	1.00

Source: GoAP, Statistical Abstract of Andhra Pradesh (various issues)
Notes: a. List wise N=23 (Number of districts),
Upper rows figures are simple correlation coefficient,
Figures within the parentheses are p-values.
** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)
Δ indicates the change in the area under a crop category

Table 3. Zero-order correlation coefficient of changes in area under specific crops in Andhra Pradesh[a]: TE 1990-91 to TE 2000-01

Crops	Δ Rice	Δ Coarse cereals	Δ Total pulses	Δ Total oilseeds	Δ Cotton	Δ Sugarcane	Δ Tobacco	Δ Chillies	Δ Total fruits and vegetables	Δ Total spice crops	Δ Total other crops
Δ Rice	1.00										
Δ Coarse cereals	-0.004 (0.986)	1.00									
Δ Total pulses	0.098 (0.656)	-0.621** (0.002)	1.00								
Δ Total oilseeds	0.017 (0.937)	0.326 (0.129)	-0.120 (0.585)	1.00							
Δ Cotton	0.004 (0.986)	-0.116 (0.599)	-0.308 (0.153)	-0.506* (0.014)	1.00						
Δ Sugarcane	0.058 (0.794)	0.156 (0.478)	-0.057 (0.798)	-0.119 (0.587)	-0.156 (0.477)	1.00					
Δ Tobacco	0.004 (0.984)	0.554** (0.006)	-0.199 (0.361)	-0.039 (0.859)	-0.079 (0.722)	0.061 (0.784)	1.00				
Δ Chillies	0.052 (0.812)	-0.121 (0.583)	0.108 (0.625)	0.047 (0.830)	-0.261 (0.228)	-0.202 (0.356)	-0.128 (0.560)	1.00			
Δ Total fruits and vegetables	-0.229 (0.294)	-0.113 (0.607)	0.129 (0.558)	-0.386 (0.069)	-0.078 (0.722)	0.524* (0.010)	-0.019 (0.933)	-0.060 (0.786)	1.00		
Δ Total spice crops	0.182 (0.405)	0.323 (0.132)	-0.262 (0.227)	-0.052 (0.813)	0.336 (0.117)	-0.021 (0.923)	0.149 (0.496)	-0.146 (0.508)	-0.229 (0.294)	1.00	
Δ Total other crops	0.316 (0.142)	-0.141 (0.521)	0.114 (0.604)	-0.029 (0.897)	-0.093 (0.672)	-0.139 (0.529)	-0.042 (0.849)	0.648** (0.001)	0.154 (0.482)	-0.310 (0.150)	1.00

Source: GoAP, Statistical Abstract of Andhra Pradesh (various issues)
Notes: a. List wise N=23 (Number of districts),
Upper rows figures are simple correlation coefficient,
Figures within the parentheses are p-values.
*** Correlation is significant at the 0.01 level (2-tailed)*
** Correlation is significant at the 0.05 level (2-tailed)*
Δ indicates the change in the area under a crop category

Table 4. Zero-order correlation coefficient of changes in area under specific crops in Andhra Pradesh[a]: TE 2000-01 to TE 2004-05

Crops	Δ Rice	Δ Coarse cereals	Δ Total pulses	Δ Total oilseeds	Δ Cotton	Δ Sugarcane	Δ Tobacco	Δ Chillies	Δ Total fruits and vegetables	Δ Total spice crops	Δ Total other crops
Δ Rice	1.00										
Δ Coarse cereals	-0.585**	1.00									
	(0.003)										
Δ Total pulses	-0.113	-0.310	1.00								
	(0.609)	(0.150)									
Δ Total oilseeds	-0.032	0.161	0.495*	1.00							
	(0.884)	(0.464)	(0.016)								
Δ Cotton	0.040	-0.004	-0.498*	-0.333	1.00						
	(0.854)	(0.987)	(0.016)	(0.121)							
Δ Sugarcane	-0.018	0.086	0.008	0.146	0.025	1.00					
	(0.935)	(0.698)	(0.971)	(0.507)	(0.911)						
Δ Tobacco	-0.103	-0.119	0.371	0.177	0.034	-0.015	1.00				
	(0.640)	(0.590)	(0.081)	(0.419)	(0.877)	(0.945)					
Δ Chillies	-0.285	0.399	-0.487*	0.018	0.317	0.039	-0.381	1.00			
	(0.187)	(0.059)	(0.018)	(0.934)	(0.141)	(0.861)	(0.073)				
Δ Total fruits and vegetables	-0.024	-0.063	0.157	-0.265	-0.066	-0.140	0.255	-0.121	1.00		
	(0.913)	(0.777)	(0.475)	(0.221)	(0.765)	(0.052)	(0.240)	(0.581)			
Δ Total spice crops	-0.342	0.118	-0.250	-0.457*	0.345	-0.229	0.417*	0.102	0.121	1.00	
	(0.111)	(0.592)	(0.251)	(0.028)	(0.107)	(0.293)	(0.048)	(0.645)	(0.582)		
Δ Total other crops	0.284	-0.325	-0.162	-0.495*	0.371	-0.126	-0.196	-0.300	0.193	0.178	1.00
	(0.189)	(0.131)	(0.460)	(0.016)	(0.081)	(0.568)	(0.370)	(0.165)	(0.378)	(0.417)	

Source: GoAP, Statistical Abstract of Andhra Pradesh (various issues)
Notes: a. List wise N=23 (Number of districts),
Upper rows figures are simple correlation coefficient,
Figures within the parentheses are p-values.
** Correlation is significant at the 0.01 level (2-tailed)
* Correlation is significant at the 0.05 level (2-tailed)
Δ indicates the change in the area under a crop category

There is robust evidence that the area under coarse cereals and oilseeds are statistically significant and depict a negative correlation with the changes in area under total pulses and cotton. Also, the cotton and tobacco was replaced among the changes in the area under chillies, fruits and vegetables and other crops. Remarkably, the prominent crop rice was substituted by the high-value crop fruits and vegetables in 1990-91 to 2000-01. Not only that, even in the period of 2000-01 to 2004-05, a tremendous continuous change in the area under rice has been observed and switched to crops like pulses, oilseeds, sugarcane, tobacco, chillies, fruits and vegetables, spice crops and cereal crops. At the district level, coarse cereals (maize crop), which is statistically significant and performed well in Karimnagar, pulses (chickpea) in Prakasam and Kurnool, and oilseeds (sunflower) in Kurnool, Kadapa and Mahabubnagar, Fruits and Vegetables in Nalgona and Krishna, sugarcane in Visakhapatnam, West Godavari, Chittor, Medak and Krishna and Chillies crop in Gunter, Warangal and Khammam [15]. The pulse crops are negatively correlated, which means in some of the districts, the area under pulses that are statistically significant and replaced by the cotton and chillies. Equally, the oilseeds are statistically significant and substituted with the changes in area under spice crops and other crops. On the other hand, the commercial crops of sugarcane and chillies were observed to replaced by the fruits and vegetables and other crops, which is clearly indicates that the growing of horticulture incomes and demand of produce leads to increase growth in fruits and vegetables that supports in boosting export earning and nutritional wellbeing. Fruits and vegetable cultivation has become an impressive growth in Andhra Pradesh with crop area increase 2.73 per cent in 1970-71 and 6.90 per cent in 2004-05.

3.3 Determinants of Cropping Pattern Changes

Cropping pattern shifts are influenced by percentage of gross irrigated area in the gross cropped area, number of tractors, rainfall, fertilizer application, number of smallholders, agricultural labour, road length, access to institutional credit, average land-size, and population density. In the present study, these causal factors were considered for explaining the shifts in cropping pattern.

The estimated values for the parameters of fixed effect regression model are presented in Table 5.

Among the set of explanatory variables considered in the model under different cropping pattern, the coefficients of irrigation, institutional agricultural credit, mechanization (tractors), smallholdings, agricultural labour, road length, fertilizer-use and population density are statistically significant for the coastal Andhra region. In the Rayalaseema region, the coefficients of irrigation, institutional credit, mechanization (tractors), agricultural labour and road length are statistically significant. In the Telangana region, the coefficients of irrigation, rainfall, agricultural credit, tractors, smallholders, average land-size, agricultural labour, road length, fertilizer-use and population density are statistically significant. However, the regression coefficients do not have the expected signs in case of cereals and millets, pulses, fruits and vegetables, oilseeds, and commercial crops in the three regions. Generally, we expect that growing of more number of crops results in use of same piece of land more number of times, but, it was not observed in Andhra Pradesh agriculture. In fact, with increased opportunity for using the same piece of land more number of times, the farmers switch over to high-value crops. The same argument is applicable to fertilizer-use, agricultural credit, tractors and irrigation. In other words, the increase in irrigation facilities, fertilizers-use, road length and mechanization (tractors), induce the farmers to switch over to more remunerative crops like paddy, fruits and vegetables, spice crops, sugarcane, cotton and chillies from less-remunerative crops. This process was leading to crop concentration. Some other coefficients like road length and agricultural credit also have a similar effect. Perhaps the farmers in all the three regions of Andhra Pradesh are not much aware about the benefits of shifts in cropping pattern and consider switching over to newer and riskier crops. The smallholders can easily switch over to the new crops and naturally diversity of cropping among them is high. Although their risk bearing capacity is low, they play a larger role in cultivation of high-value (fruits and vegetables) crops [16].

In equation 2, the coefficients of irrigation, rainfall, institutional credit, mechanization (tractors), smallholders, average land-size, labour, road length, fertilizer-use, population density and regional dummies have been statistically significant. But, regression coefficient for cereals and millets, pulses, fruits and vegetables, oilseeds, and commercial crops did not have the expected signs in Andhra Pradesh.

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Table 5. The value of district-level fixed regressions by region and state of Andhra Pradesh

Explanatory variable	Coastal Andhra Pradesh						Rayalaseema					
	TC&M	TP	TOS	TCC	TF&V	TOC	TC&M	TP	TOS	TCC	TF&V	TOC
Irrigation (% of total cropped irrigated area)	0.86*	-0.51*	-0.16	-0.25**	0.01	0.06	0.08	-0.95**	0.1	0.64	0.08	0.06
	(7.0)	(-3.3)	(-1.5)	(-2.0)	(0.3)	(0.7)	(0.3)	(-2.0)	(0.3)	(1.6)	(0.6)	(0.4)
Rainfall (mm)	0.001	-0.002	-0.002	0.001	-0.001	0.001	0.003	-0.004	-0.003	0.003	0.002	0.001
	(0.7)	(-1.3)	(-1.4)	(1.6)	(-1.2)	(1.3)	(1.1)	(-1.2)	(-1.4)	(0.9)	(1.4)	(0.3)
Institutional agricultural Credit (Rs/ ha.)	-0.001	-0.001	0.001*	0.001	0.000	0.000	-0.001	-0.001**	0.001*	0.001	0.001*	0.000
	(-1.5)	(-1.6)	(2.8)	(0.5)	(1.3)	(0.3)	(-1.3)	(-2.4)	(2.7)	(0.9)	(2.6)	(-0.3)
Tractors (No./1000ha)	0.24	0.15	-0.34***	-0.01	0.25*	-0.29**	0.74	-0.64	-1.66**	1.03	0.42	0.14
	(1.1)	(0.6)	(-1.8)	(-0.1)	(3.6)	(-2.1)	(1.1)	(-0.7)	(-2.5)	(1.3)	(1.5)	(0.4)
Smallholders (% in total landholdings)	0.26	3.56***	-1.04	-2.5	0.45	-0.71	-0.62	2.8	1.46	-3.12	-0.26	-0.26
	(0.2)	(1.7)	(-0.7)	(-1.5)	(0.9)	(-0.7)	(-0.4)	(1.2)	(1.0)	(-1.6)	(-0.4)	(-0.4)
Average land-size (ha)	-0.06	48.2	-22.8	-42.2	5.67	11.5	-1.68	22.4	13.7	-29.7	-2.71	-1.76
	(-0.0)	(1.1)	(-0.8)	(-1.2)	(0.5)	(0.5)	(-0.1)	(0.9)	(0.8)	(-1.4)	(-0.4)	(-0.2)
Labour- Agriculture and cultivar (No./ha)	-2.35	-6.79**	-2.59	8.72*	2.31*	0.87	-5.45	11.2	-11.3*	-2.12	7.71*	-0.14
	(-0.9)	(-2.0)	(-1.1)	(3.2)	(2.7)	(0.5)	(-1.3)	(1.8)	(-2.7)	(-0.4)	(4.2)	(-0.1)
Road length (km/100 sq km)	6.49	17.8***	-14.7**	-15.8***	7.04*	-0.87	-9.49	20.4	16.2	-22.6	-9.05***	4.72
	(0.8)	(1.7)	(-2.1)	(-1.9)	(2.7)	(-0.2)	(-0.8)	(1.2)	(1.4)	(-1.5)	(-1.8)	(0.8)
Fertilizer-use (kg/ha.)	0.01	-0.08*	0.02	0.06**	-0.01	0.001	0.09	-0.002	-0.09	0.02	-0.01	-0.01
	(0.5)	(-2.6)	(0.8)	(2.4)	(-1.7)	(0.3)	(1.7)	(-0.0)	(-1.6)	(0.2)	(-0.5)	(-0.2)
Population density (No. of persons/100 sq km)	0.02	0.01	-0.03	-0.04	-0.02***	0.06*	0.06	-0.18	-0.01	0.14	-0.02	0.02
	(0.8)	(0.2)	(-1.3)	(-1.2)	(-1.9)	(3.0)	(0.5)	(-1)	(-0.1)	(0.9)	(-0.4)	(0.4)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.98	0.93	0.92	0.92	0.98	0.85	0.96	0.88	0.99	0.93	0.99	0.48
Contd.												

*,** and *** denotes significance at 1 per cent, significance at 5 per cent; significance at 10 per cent levels, respectively.

Note: Total cereal and millet crops (TC&M), total pulse crops (TP), total oilseed crops (TOS), total commercial crops (TCC), total fruits and vegetable crops (TF&V) and total other crops (TOC).

Table 5. The value of district-level fixed regressions by region and state of Andhra Pradesh -----Contd

Explanatory variable	Telangana[§]						Andhra Pradesh[§]					
	TC&M	TP	TOS	TCC	TF&V	TOC	TC&M	TP	TOS	TCC	TF&V	TOC
Irrigation (% of total cropped irrigated area)	0.98*	-0.44*	-0.54*	0.03	-0.01	-0.01	0.58*	-0.55*	0.19*	-0.17*	0.03	-0.08*
	(7.5)	(-4.6)	(-4.5)	(0.2)	(-0.2)	(-0.4)	(11.4)	(-14.9)	(3.2)	(-3.1)	(1.4)	(-6.0)
Rainfall (mm)	0.01**	-0.000	-0.002	-0.003	-0.000	-0.001	0.01**	-0.001	-0.01*	0.002	0.01*	0.000
	(2.1)	(-0.0)	(-0.8)	(-0.9)	(-0.3)	(-1.3)	(2.0)	(-1.5)	(-2.9)	(0.8)	(3.8)	(0.5)
Institutional agricultural Credit (Rs/ ha.)	-0.001**	-0.000	0.001***	0.0002	0.0001	-0.000	0.001	-0.00**	0.001	-0.001***	0.000	-0.000
	(-2.2)	(-1.2)	(1.9)	(1.0)	(1.0)	(-1.1)	(1.6)	(-2.0)	(1.6)	(-1.8)	(0.4)	(-1.2)
Tractors (No./1000ha)	0.52*	-0.02	-0.45*	-0.04	0.01	-0.02	0.03	0.43*	-0.43***	-0.27	0.27*	-0.03
	(3.0)	(-0.1)	(-2.7)	(-0.2)	(0.3)	(-0.9)	(0.1)	(2.9)	(-1.8)	(-1.2)	(3.0)	(-0.5)
Smallholders (% in total landholdings)	-1.42**	0.33	0.9	0.53	-0.27	-0.06	0.74	1.6*	-1.32**	-0.5	-0.66*	0.14
	(-2.0)	(0.6)	(1.4)	(0.6)	(-1.4)	(-0.6)	(1.6)	(4.8)	(-2.4)	(-1.0)	(-3.3)	(1.1)
Average land-size (ha)	-14.55	6.15	12.77	1.62	-5.86**	0.09	20.0**	16.7*	-11.9	-18.8**	-8.12**	2.1
	(-1.3)	(0.7)	(1.2)	(0.1)	(-2.0)	(0.1)	(2.4)	(2.8)	(-1.2)	(-2.1)	(-2.2)	(0.9)
Labour- Agriculture and cultivar (No./ha)	-0.64	-2.44	-1.46	3.32	1.4*	-0.22	-3.76	-8.64*	2.16	1.23	8.38*	0.68
	(-0.3)	(-1.5)	(-0.7)	(1.2)	(2.3)	(-0.7)	(-1.8)**	(-5.8)	(0.9)	(0.6)	(9.4)	(1.2)
Road length (km/100 sq km)	14.13	17.43**	-19.5**	-14.51	1.86	-0.28	-12.12	18.16*	10.9	-8.16	-9.71*	0.83
	(1.4)	(2.3)	(-2.0)	(-1.2)	(0.7)	(-0.2)	(-1.5)	(3.2)	(1.2)	(-1.0)	(-2.8)	(0.4)
Fertilizer-use (kg/ha.)	-0.004	-0.01	0.02***	-0.001	-0.001	-0.01**	-0.05*	0.08*	-0.09*	0.06*	-0.02*	0.03*
	(-0.3)	(-0.5)	(1.7)	(-0.3)	(-1.2)	(-2.1)	(-3.4)	(7.3)	(-5.0)	(3.6)	(-3.4)	(6.5)
Population density (No. of persons/100 sq km)	0.01	0.03	-0.01	-0.04	-0.0001	0.01*	0.05*	-0.04*	0.01	-0.05*	0.03*	-0.01*
	(0.5)	(2.4)	(-0.7)	(-1.6)	(-0.0)	(3.2)	(4.3)	(-4.6)	(1.0)	(-3.4)	(5.6)	(-3.6)
Regional dummy 2	-	-	-	-	-	-	-16.77*	-10.13*	35.07*	-6.23*	0.77	-2.72*
							(-8.8)	(-7.4)	(15.3)	(-3.1)	(0.9)	(-5.2)
Regional dummy 3	-	-	-	-	-	-	10.48*	-5.01*	0.96	0.36	-2.78*	-4.0*
							(6.4)	(-4.3)	(0.5)	(0.2)	(-3.9)	(-8.9)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R-squared	0.96	0.93	0.97	0.93	0.97	0.92	0.86	0.67	0.85	0.40	0.66	0.45

*,** and *** denotes significance at 1 per cent, significance at 5 per cent; significance at 10 per cent levels, respectively
[§] Excluded Hyderabad district
Note: Total cereal and millet crops (TC&M), total pulse crops (TP), total oilseed crops (TOS), total commercial crops (TCC), total fruits and vegetable crops (TF&V) and total other crops (TOC).

The effect of irrigation variables, viz. proportion of irrigated area and rainfall on cereals and millets, oilseeds, and fruits and vegetables was positive. Similarly, the effect of technological and institutional variables, mechanization and agricultural credit was expected to have a positive impact on the cropping pattern shifts. The coefficient of variables representing mechanization (tractors), rainfall, agricultural labour and population density was positive and statistically significant on fruits and vegetables. The coefficients of smallholders, average land-size, road length, number of tractors and fertilizer-use are positively and statistically significant to the cropping pattern shifts in the total pulse regression and total commercial crops regression in equation 2. The coefficients of the irrigation, rainfall, average land-size, population density and regional dummy for Telangana were positive and statistically significant in total cereals and millets regression. One possible explanation is that Andhra Pradesh state (including Telangana region) prefers to grow maize instead of other cereal crops.

4. CONCLUSIONS

As an evidence from the results presented that the state has witnessed shifts in cropping pattern during the past three decades, though they vary across regions and across districts within a region. There has been a significance area gains in the prominence of dominant crops like sugarcane, maize and pulse crops: bengal gram (chickpea), red gram (pigeon pea) and black gram performed well in all three regions as well as state. Interestingly, from the year 2000 onwards, the state leading crop area under rice is gradually replaced by the maize, bengal gram, oilseeds (sunflower), sugarcane, tobacco, fruits and vegetables, perhaps, lack of water resources. In addition, the farmers' opinion towards cultivating only cereals is not a favorable choice [15]. Among the high-value fruits and vegetables, spice crops and drugs and narcotics has been observed substantial area expansion in the state. It is clearly specifying that farmers in Andhra Pradesh now prefer to cultivate high demanding crops to low-value cereal crops.

The estimated fixed effect regression analysis, has revealed that the common causal factors of cropping pattern in the three regions of Andhra Pradesh are irrigation, access to institutional agricultural credit, number of tractors, agricultural labour, and road length, except rainfall, smallholders, average land-size, fertilizer-use

and population density in coastal Andhra and Telangana region. The changes in these various determinants such as irrigation facilities, access of markets by road length are influenced to shifting to the commercial crop like sugarcane and the high-values crops: fruits and vegetables, for instance, the promotion of Andhra Pradesh Micro Irrigation Project (APMIP) has certainly fostered the horticulture sector. Besides, the farmers were attracted towards the cultivation of pulse crops especially, bengal gram (chickpea) and red gram (pigeon pea) due to low risk, high income and less agricultural labour requirements [12].

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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