Cropping Pattern Changes in Andhra Pradesh during the 1990s: Implications for Micro-level Studies

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Introduction

The study team on "Recent Changes in Indian Agricultural Villages: A Microeconomic Analysis" places its focus on the Indian state of Andhra Pradesh. As of January 2005, a study on child labor in a rural part of Andhra Pradesh is under way in collaboration with M. Venkatarangaiya Foundation (MVF). The team also collaborates with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), an international research organization that has continuously surveyed two villages in Andhra Pradesh.[*1]. In order to set the stage for these ongoing research efforts, this chapter presents an overview of the agricultural economy of Andhra Pradesh, focusing on the major

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[*1] For details on the village studies conducted by ICRISAT, refer to Walker and Ryan [1990] and Deb et al [2002].

shifts in cropping patterns that occurred during the 1990s.

Knowledge of crop pattern changes, as well as a grasp of the underlying forces, will aid in better interpreting micro-level observations. For instance, the education/child labor choices of rural households are affected by the type of crops produced in their neighborhood, since crop patterns are related to the marginal returns to education and work. Similarly, seasonal migration decisions are influenced by the demand for agricultural labor, which in turn are determined by which crops are produced locally vis-à-vis the potential migration destination. Risk and uncertainty, another important issue in development microeconomics, is also affected by cropping patterns, since crops vary in terms of their yield and price risk profiles. While a full exploration into these microeconomic issues is beyond the scope of this chapter, by describing and analyzing the changes in cropping patterns, we hope to provide a backdrop to future microeconomic research.

Using state-level data, we expand on the work of Bhalla and Singh [2001], and highlight the crop pattern changes that occurred in Andhra Pradesh and all-India during the 1990s. Subsequently, we examine

crop acreage shares at the district-level to analyze crop substitution patterns in more detail. It is shown that crop substitution patterns are distinctly different between highly irrigated and less irrigated districts.

The remainder of the chapter is organized as follows. Section I presents an overview of cropping pattern changes, seen from the state-level. In Section II, we present a more detailed analysis of the same issues using district-level data. The final section makes some concluding comments.

I Overview of Agricultural Change

The growth story of Andhra Pradesh agriculture inevitably centers on rice. The state was an early starter in the growth spurt of the 1960s, as can be seen from Table 1. Rice output grew at an average annual growth rate of nearly 5% in the 5 years up to 1966. Coincidentally, the first semi-dwarf rice cultivar of the International Rice Research Institute (IRRI), IR8, was introduced in 1966. From this, one can deduce that the growth of rice production in Andhra Pradesh during the early 1960s was due to domestic research efforts, which did indeed

Table 1. Average annual growth rates of rice production during consecutive 5-year periods in major rice-growing states (% per year)

5-year period ending:	*All-India*	State					
		Andhra Pradesh	*Bihar*	*Punjab & Haryana*	*Tamil Nadu*	*Uttar Pradesh*	*West Bengal*
1966	-1.49	4.99	-12.57	1.57	1.57	-8.06	1.27
1971	7.48	0.03	43.74	5.54	5.54	15.13	6.45
1976	0.47	2.62	-1.64	-0.82	-0.82	3.53	-1.26
1981	6.49	10.91	2.66	8.73	8.73	20.54	1.64
1986	3.48	-2.51	10.93	1.89	1.89	5.57	10.37
1991	4.75	8.78	-3.10	4.55	4.55	6.32	7.39
1996	1.99	3.31	13.51	-1.18	-1.18	4.70	1.21
2000*	1.02	4.10	-6.29	7.01	6.32	0.09	-0.25
Output in 2000 (1,000 tons)	127,305	17,175	8,130	17,745	10,830	17,310	18,645

Data source: Author's calculations from International Rice Research Institute, "World Rice Statistics" (accessed at http://www.irri.org/science/ricestat/ in February 2005)

* 4-year period ending 2000.

produce superior cultivars such as MTU-1, MTU-15, and HR-19 (Rai [2002]). In contrast to Andhra Pradesh, rice production in the other major rice-growing states did not experience such rapid growth until the latter half of the 1960s. Despite occasional slowdowns in the 1970s and 80s, rice in Andhra Pradesh continues to increase up to the present, placing the state in second place after West Bengal in terms of production.

Let us now turn to the other crops. The acreage shares of various crops were calculated for each state by Bhalla and Singh [2001] (henceforth referred to as B-S). In Table 2, we present an updated version for Andhra Pradesh and all-India, newly containing data from the 3-year period of 1997-2000. It must be noted that the denominator for calculating shares is different between the original B-S work and the new figures for 1997-2000. Whereas B-S used the gross cropped acreage of 43 crops (listed in Appendix 1.2 of their book) as the denominator, the present calculations used gross cropped acreage of all crops – as reported by the Ministry of Agriculture – as the denominator. However as B-S themselves mention (p. 8), the 43 crops cover the total gross cropped area almost completely, so that the calculated

Table 2. Percent share of different crops in gross cropped area in Andhra Pradesh and All-India during various trienniums
(Extension of Bhalla and Singh [2001], appendix 2.1)

Andhra Pradesh	*Rice*	*Wheat*	*Coarse cereals***	*Pulses*	*Foodgrains*	*Non-foodgrains*	*Nine oilseeds* +	*Groundnut*	*Rapeseed & mustard*	*Sunflower*	*Soyabean* ++	*Total fibres*	*Jute* ++	*Cotton*	*Sugarcane*	*Remaining crops* #
1962-65	27.96	0.15	38.42	11.48	78.01	21.99	12.87	7.90	0.20	0.00	0.00	3.99	0.00	3.17	0.98	4.15
1970-73	35.69	0.16	36.00	11.20	73.05	26.95	17.36	11.96	0.01	0.19	0.00	3.37	0.00	2.57	1.01	5.21
1980-83	30.22	0.14	30.89	11.84	73.09	26.91	15.94	11.64	0.01	0.06	0.00	4.45	0.00	3.65	1.32	5.20
1992-95	30.62	0.08	14.90	13.24	58.85	41.15	26.86	19.90	0.04	2.71	0.02	6.84	0.00	6.19	1.52	5.94
1997-2000*	30.51	0.09	11.25	12.38	54.23	45.77	20.28	14.49	0.03	2.56	-	8.97	-	8.34	2.93	-

All-India	*Rice*	*Wheat*	*Coarse cereals***	*Pulses*	*Foodgrains*	*Non-foodgrains*	*Nine oilseeds* +	*Groundnut*	*Rapeseed & mustard*	*Sunflower*	*Soyabean*	*Total fibres*	*Jute*	*Cotton*	*Sugarcane*	*Remaining crops* #
1962-65	23.78	8.92	29.20	15.93	77.85	22.15	10.59	4.75	2.00	0.00	0.00	6.31	0.56	5.36	1.56	3.69
1970-73	23.84	12.10	28.04	13.96	77.94	22.06	10.58	4.65	2.18	0.07	0.02	5.68	0.48	4.91	1.59	4.21
1980-83	23.96	13.68	25.08	13.91	76.63	23.37	10.92	4.31	2.48	0.17	0.37	5.55	0.50	4.78	1.85	5.05
1992-95	24.91	14.32	19.81	13.17	72.21	27.79	15.31	4.94	3.73	1.35	2.23	5.04	0.46	4.42	2.13	5.32
1997-2000*	23.35	14.29	15.86	12.25	65.74	34.26	13.31	3.76	3.16	0.87	3.26	5.38	0.46	4.78	2.28	-

Data source: Bhalla and Singh [2001] and author's calculations from Ministry of Agriculture, "Indian Agricultural Statistics" downloaded from http://www.indiastat.com.

* For the 1997-2000 triennium, shares were calculated by using gross cropped area for all crops as the denominator, rather than the total cropped area of the 43 crops as specified by Bhalla and Singh [2001], Appendix 1.2.

** "Coarse cereals" include the major millets (sorghum, pearl millet and finger millet), barley, oats, and other minor cereals / millets.

+ The "nine oilseeds" refer to groundnut, sesamum, rapeseed & mustard, linseed, castor, safflower, sunflower, soyabean, and nigerseed.

++ Percentage shares for soyabean and jute could not be calculated for Andhra Pradesh in 1997-2000 due to the lack of detailed data.

Percentage shares for "remaining crops" could not be calculated for 1997-2000 because it was not clear from Bhalla and Singh [2001] which crops were to be included.

percentages are virtually consistent with the old series[*2].

While the findings of B-S need not be repeated here, some characteristics of the crop pattern changes should be pointed out. In India as a whole, the share of wheat increased during the 1960s and 70s, mainly due to the widespread adoption of semi-dwarf cultivars in the northern states of Punjab, Haryana, and western Uttar Pradesh. Coarse cereals, which commanded almost 30% of total gross acreage in the 1962-65 triennium, decreased its share in the 1970s and 80s. The new figures show that the decrease of coarse cereals continued throughout the 1990s. Within this group, sorghum and pearl millet are the largest crops – together comprising over 10% of total gross cropped acreage in 1999-2000 – but both have decreased during the 1990s. In contrast, the share of maize has been relatively stable. Due to the decline in millet acreage, the share of foodgrains (cereals plus pulses) has continued to fall, down to around two-thirds of gross cropped area in the late 1990s. Within the non-foodgrain group, there was an

[*2] A fully compatible series requires the collection and use of acreage data for minor crops that are not featured in the Ministry of Agriculture's "Indian Agricultural Statistics".

expansion in the share of oilseeds during the 1980s, which reflects the massive replacement of coarse cereals by sunflower, rapeseed, mustard, groundnut, and other oilseeds (Bhalla and Singh [2001]: p. 43). However, the new figures show that the share of oilseeds *decreased* during the 1990s, with all the major oilseed crops, excluding soyabeans, contributing to the decline. The reason for this decline can be traced to the liberalization of imports that began in the mid-1990s under the Uruguay Round of the General Agreement on Tariffs and Trade (GATT), as described in detail in Chand [2002]. On the other hand, the growing share of soyabeans reflects the competitiveness of the state of Madhya Pradesh, who is the dominant soyabean producer in India (Chand [2002]: pp. 72-73).

Turning now to the crop acreage shares in Andhra Pradesh, the share of rice increased from the 1960s into the 70s, corroborating the finding from Table 1 that Andhra Pradesh rice production grew rapidly in the 1960s. The area share of rice has thereafter stabilized at around 30%. The relative decline of coarse cereals in Andhra Pradesh is faster than in the country as a whole. Whereas the group occupied nearly 40% of cropped area in the 1960s, it has dropped to 11% in the

late 1990s. Consequently, the share of foodgrains has fallen down to 54% even though pulses as a group have been stable at around 12% of acreage. The rise of oilseeds up to the mid-1990s has been steeper in Andhra Pradesh than in all-India, driven mainly by groundnut and later, by sunflower. The uptake of rapeseed, mustard, and soyabean has been minimal compared to the rest of the country. The decline of oilseeds since the mid-1990s has been observed in Andhra Pradesh, with groundnut showing the largest relative drop in share. Another notable feature is the rapid increase of cotton since the 1970s. Hybrid cotton was introduced into the state from Gujarat in the early 1970s, and has been rapidly adopted since. Today, Andhra Pradesh is also a center of the cotton seed industry, because the dry climate and abundance of agricultural labor make it an ideal production region. However, the emasculation and pollination of cotton flowers for F1 hybrid seed production is mainly carried out by children, so that the implications for human capital development in the production areas cannot be ignored.

II Cropping patterns at the district level

II.1 Choice of years

Having seen the trends at the state-wide level, let us now turn to the district-level data on crop acreage. District data were taken for the crop years 1991-92 and 1998-99. In this type of a study, it is preferable to take a cluster of years – rather than an individual year – as one period of observation, because the acreage variables fluctuate greatly across years. However, due to the availability of data, and reasons based on the rainfall pattern of the 1990s, we decided to compare two individual crop years taken from the beginning and the end of the 1990s, respectively.

Data were obtained from the Ministry of Agriculture's annual "Indian Agricultural Statistics" publication, via the Indiastat download service[*3]. The only years in the 1990s for which relatively complete

[*3] Indiastat (http://www.indiastat.com) is a paid subscription service that allows users to download spreadsheets of data published by the Indian government and other sources.

sets of data could be obtained were 1991-92, 1998-99, and 1999-2000. At first, we considered grouping 1998 and 1999 together to form an average of the late 1990s. However, a look at the rainfall patterns showed that the inclusion of 1999-2000 would be more problematic than helpful for our purposes.

Table 3 shows district-wise annual rainfall for each year in the 1990s. It can be seen that annual rainfall in the state varies between 500 and 1,800mm. Generally speaking, the Coastal districts (Srikakulam, Vizianagaram, Visakhapatnam, East Godavari, West Godavari, Krishna, Guntur, Prakasam, and Nellore) receive relatively more rainfall, whereas the inland districts of the Rayalaseema region (Kurnool, Anantapur, Cuddapah, and Chittoor) tend to get the lowest amounts of rain. The Telangana region is split between North and South, with the northern districts (Warangal, Khammam, Karimnagar, and Adilabad) receiving slightly higher precipitation than the districts of Southern Telangana (Rangareddy, Hyderabad, Nizamabad, Medak, Mahbubnagar, and Nalgonda).

The average rainfall for Andhra Pradesh state shows that the crop years of 1992-93, 1993-94, 1997-98, and 1999-2000 received the

Table 3. Annual rainfall in Andhra Pradesh during the 1990s

(millimeters per year)

District	Year									
	1990-91	1991-92	1992-93	1993-94	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000
Srikakulam	1,166	1,155	1,193	941	1,282	1,340	939	893	1,282	1,033
Vizianagaram	978	1,093	1,067	845	1,212	1,081	1,103	1,036	1,370	966
Visakhapatnam	955	1,094	1,362	856	1,346	1,186	1,419	974	1,555	896
East Godavari	988	1,283	1,084	937	1,546	1,246	1,616	1,062	1,692	1,012
West Godavari	968	1,549	1,052	803	1,397	1,268	1,465	900	1,531	881
Krishna	921	1,121	872	704	1,220	1,009	1,217	869	1,232	823
Guntur	859	1,112	864	728	1,107	856	1,076	846	1,103	785
Prakasam	942	959	654	890	1,026	678	1,060	1,042	995	698
Nellore	1,003	1,515	854	1,168	1,554	770	1,712	1,305	964	815
Kurnool	609	652	574	673	563	665	1,028	574	966	484
Anantapur	482	574	500	593	377	533	749	441	695	521
Cuddapah	851	816	534	707	608	631	1,153	674	757	529
Chittoor	904	1,343	702	1,108	912	817	1,468	957	1,136	719
Rangareddy	977	804	820	717	723	922	878	606	1,133	633
Hyderabad	731	740	714	772	850	1,056	972	610	985	576
Nizamabad	1,736	857	780	904	1,015	1,304	930	818	1,160	969
Medak	1,015	687	787	734	861	996	1,012	658	964	682
Mahbubnagar	674	814	577	617	515	762	746	499	845	454
Nalgonda	688	870	505	591	767	728	792	627	875	504
Warangal	1,010	792	799	869	1,131	1,056	1,173	834	1,182	838
Khammam	1,217	1,156	1,014	893	1,215	1,033	1,213	898	1,243	1,086
Karimnagar	1,286	732	724	789	920	932	909	705	1,066	789
Adilabad	1,622	841	1,056	941	1,266	1,389	883	915	1,208	1,048
Andhra Pradesh average	982	981	837	817	1,018	971	1,110	815	1,128	771
Net cropped area (1,000 ha)	11,021	11,041	10,466	10,362	10,365	10,637	10,834	9,846	10,978	10,610

Data source: Government of Andhra Pradesh, "Statistical Abstract", various issues.

lowest rainfall during the decade. If we match the annual rainfall with the net cropped area in each year, it is clear that lower rainfall leads to a smaller cropped area in the same year. Moreover, there is some evidence of drought effects spilling over to subsequent years: For instance, the years 1994-95 to 1996-97 experienced moderate rainfall levels, but crop acreage did not recover to the levels of 1991-92. This may be because farmers were making cropping decisions under adoptive expectations, or because irrigation sources such as tanks, canals, and underground water tables failed to replenish within a few years.

Returning to the topic of choosing our years, we first note that 1991-92 was a "normal" year in terms of rainfall, and that the net cropped area was similar to the previous year. We could say that 1991-92 is fairly representative of the early 1990s. Next, we observe that 1999-2000 saw an exceptionally low level of rainfall, with every district in the state experiencing a lower level of precipitation than the previous year. To the extent that farmers in the drylands are capable of adjusting their crop choice to actual monsoon outcomes – for instance by sowing after observing the actual arrival of the monsoon –

we feel that the cropping pattern of 1999-2000 would not be that of a "normal" year. On the other hand, 1998-99 was a good year in terms of total rainfall, though the previous year's drought may have suppressed cropping decisions. In deciding to choose between 1998-99 by itself or 1998-99 plus 1999-2000, we decided to take up 1998-99 solely as the better representative of the late 1990s.

II.2 District-level changes in irrigation and cropping

In Table 4, we present the initial conditions (net cropped area, plus area under canal or tubewell irrigation) in 1991-92 for each district. We also calculate the percentage change in net cropped area between 1991-92 and 1998-99, changes in irrigated areas as a percentage of cropped area, and changes in the areas of selected crops as a percentage of cropped area. The crops were chosen on the basis of our discussion in section I; these are the crops whose long-term acreage shifts are of special interest. Looking at the changes in cropped acreage under irrigation, we find that the area under canal irrigation has fallen during the 1990s, by as much as 2% of net cropped area. On the other hand,

Table 4. District-wise land-use: net cropped area, irrigated area, and area under selected crops

District	Net cropped area in 1991-92	Percentage of net cropped area under canal or tubewell irrigation in 1991		Percentage change in net cropped area between 1991-92 and 1998-99	Change in canal/tubewell irrigated area as percentage of net cropped area, 1991-92 to 1998-99	Change in tubewell irrigated area as percentage of net cropped area, 1991-92 to 1998-99	Change in area under selected crops as a percentage of net cropped area, 1991-92 to 1998-99				
		Canal	Tubewell				Rice	Millets*	Groundnut	Other oilseeds**	Cotton
	(ha)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Srikakulam	325,038	31.14	1.38	-1.79	-3.75	0.47	-4.97	-4.09	-0.73	-2.78	0.63
Vizianagaram	329,601	9.91	1.07	1.48	0.71	0.45	1.54	-2.27	-3.95	2.47	3.97
Visakhapatnam	330,078	14.67	1.05	6.53	-0.13	0.77	3.58	-5.63	-3.56	-2.54	0.40
East Godavari	430,624	45.40	5.74	5.49	-1.97	6.10	9.22	-2.10	-1.40	-10.50	1.01
West Godavari	441,404	46.60	16.49	7.51	-4.00	9.34	13.91	-0.34	-1.17	-2.65	0.43
Krishna	503,081	54.06	2.81	2.45	-6.95	1.76	7.71	-0.06	-4.35	-1.28	6.27
Guntur	609,416	51.03	2.91	5.62	-1.15	2.02	3.17	0.22	-1.66	-3.43	4.35
Prakasam	605,178	15.23	3.30	-7.98	-2.50	2.15	-0.45	-10.80	-9.64	-2.29	2.63
Nellore	331,948	25.60	10.31	-1.26	-1.20	3.85	-0.14	-4.06	-7.16	-0.66	0.56
Kurnool	896,826	10.16	1.00	0.35	-1.46	3.91	2.06	-6.22	-9.87	-3.49	8.00
Anantapur	965,999	4.09	1.24	4.80	-0.78	4.56	0.56	-3.12	6.24	0.48	-0.05
Cuddapah	406,703	6.00	7.70	-1.33	-0.59	13.93	0.95	-2.72	-25.43	13.45	4.90
Chittoor	495,309	0.43	1.63	-3.66	-0.03	4.43	-2.21	-2.69	-4.90	-0.14	0.00
Rangareddy	309,135	1.01	2.02	0.07	-0.04	8.33	-0.01	-4.69	-0.11	-4.58	3.58
Nizamabad	275,370	20.98	13.70	-8.38	-12.27	22.25	8.38	1.35	2.89	0.94	2.87
Medak	396,766	1.12	2.87	13.88	-0.37	18.80	3.66	-3.42	0.21	1.06	4.03
Mahbubnagar	934,517	2.29	0.66	-14.79	-0.80	8.22	-1.68	-12.14	-8.39	-1.93	7.00
Nalgonda	575,125	15.19	0.40	-1.31	-2.67	5.17	8.73	-6.89	-2.43	-11.65	15.85
Warangal	426,136	0.73	0.64	22.95	-0.26	2.18	11.71	-1.20	-9.35	-0.07	20.96
Khammam	474,046	14.83	2.16	-2.77	-1.33	1.85	5.39	-3.73	-5.11	0.20	11.70
Karimnagar	415,236	14.41	0.05	-4.70	-1.64	0.91	10.29	-0.88	-7.93	-0.41	13.97
Adilabad	562,701	3.07	0.73	-2.78	0.31	2.11	2.96	-6.09	0.59	-1.01	-1.70
Andhra Pradesh total	11,040,237	16.53	3.05	0.30	-2.00	5.25	3.45	-4.31	-4.40	-1.64	5.20

Data source: Ministry of Agriculture, "Indian Agricultural Statistics", various issues.

* Millets = Total cereals - Rice - Wheat - Maize.

** Other oilseeds = Total oilseeds - groundnut

acreage under tubewell irrigation increased in every district, adding up to a state-wide increase of 5.3% of net cropped land.

On the cropping pattern front, two shifts are near-unanimous among the districts; the decrease in millets and the increase in cotton. The movements in rice and oilseeds acreage are rather mixed, and one cannot easily discern any further patterns from Table 4.

II.3 Correlations of changes in area

As a final step towards analyzing the change in cropping pattern, we calculated the pairwise correlations between various changes in acreage that took place during the 1990s. Tables 5a-c present the correlation coefficients between crop-acreage changes, net-cropped-area changes, and tubewell-coverage changes. All these changes were measured in hectares. We used tubewell acreage instead of canal acreage, because the data on canal coverage may not accurately reflect the actual irrigated area.

Table 5a shows the results using the 22 districts of Andhra Pradesh (all the districts excluding Hyderabad, the state capital city). Starting

Table 5a. Correlations among area changes between 1991-92 and 1998-99 in districts of Andhra Pradesh (All 22 districts)

	Δ net cropped area	Δ millets	Δ rice	Δ ground-nut	Δ other oilseeds	Δ pulses	Δ cotton	Δ chili	Δ vege-tables	Δ fruits & nuts	Δ tube-well area
Δ net cropped area	**1.0000**										
Δ millets	**0.4525** ** 0.0345	**1.0000**									
Δ rice	**0.4297** ** 0.0459	**0.5086** ** 0.0157	**1.0000**								
Δ ground-nut	**0.1257** 0.5774	**0.1984** 0.3760	**0.0998** 0.6585	**1.0000**							
Δ other oilseeds	**-0.0300** 0.8946	**0.2050** 0.3600	**-0.2309** 0.3012	**-0.5301** ** 0.0112	**1.0000**						
Δ pulses	**0.1050** 0.6420	**-0.3420** 0.1192	**-0.3572** 0.1027	**0.0177** 0.9375	**0.0536** 0.8127	**1.0000**					
Δ cotton	**0.2300** 0.3032	**0.0294** 0.8968	**0.4704** ** 0.0272	**-0.3240** 0.1413	**-0.0871** 0.6999	**-0.2601** 0.2424	**1.0000**				
Δ chili	**0.2256** 0.3128	**0.0969** 0.6678	**0.0340** 0.8805	**0.1151** 0.6100	**-0.0481** 0.8318	**0.0955** 0.6724	**0.0771** 0.7331	**1.0000**			
Δ vege-tables	**0.0302** 0.8939	**0.0944** 0.6760	**0.0733** 0.7457	**-0.0042** 0.9851	**-0.1176** 0.6022	**0.4246** ** 0.0489	**0.0121** 0.9573	**0.2797** 0.2074	**1.0000**		
Δ fruits & nuts	**0.0613** 0.7863	**0.1265** 0.5747	**-0.1001** 0.6576	**-0.1236** 0.5838	**0.0468** 0.8362	**-0.0195** 0.9312	**-0.2533** 0.2554	**-0.3615** * 0.0984	**-0.3324** 0.1307	**1.0000**	
Δ tube-well area	**-0.0433** 0.8483	**0.1830** 0.4149	**0.1358** 0.5469	**0.0332** 0.8834	**0.2810** 0.2052	**0.4084** * 0.0591	**-0.1384** 0.5392	**0.1873** 0.4038	**0.4328** ** 0.0442	**-0.2913** 0.1884	**1.0000**

Data source: Ministry of Agriculture, "Indian Agricultural Statistics" various issues.
Upper-row figures in larger font represent simple correlation coefficients.
Lower-row figures in smaller font represent p-values.

* significant at the 10% level
** significant at the 5% level
*** significant at the 1% level

Table 5b. Correlations among area changes between 1991-92 and 1998-99 in districts of Andhra Pradesh (11 districts where tubewell coverage was more than 2% of net cropped area in 1991)

	Δ net cropped area	Δ millets	Δ rice	Δ ground-nut	Δ other oilseeds	Δ pulses	Δ cotton	Δ chili	Δ vege-tables	Δ fruits & nuts	Δ tube-well area
Δ net cropped area	**1.0000**										
Δ millets	**0.3143** 0.3465	**1.0000**									
Δ rice	**0.3122** 0.3499	**0.6475** ** 0.0312	**1.0000**								
Δ ground-nut	**0.2722** 0.4181	**0.3197** 0.3378	**0.4438** 0.1715	**1.0000**							
Δ other oilseeds	**-0.2105** 0.5344	**0.0244** 0.9432	**-0.3041** 0.3632	**-0.7439** *** 0.0087	**1.0000**						
Δ pulses	**0.0639** 0.8520	**-0.4321** 0.1844	**-0.3652** 0.2694	**-0.0420** 0.9025	**0.0532** 0.8766	**1.0000**					
Δ cotton	**-0.1455** 0.6694	**0.0065** 0.9848	**-0.1122** 0.7427	**-0.1534** 0.6525	**0.3008** 0.3688	**-0.4596** 0.1550	**1.0000**				
Δ chili	**0.4484** 0.1666	**0.4552** 0.1595	**0.2207** 0.5142	**0.1107** 0.7460	**0.0720** 0.8334	**-0.0388** 0.9099	**0.1450** 0.6707	**1.0000**			
Δ vege-tables	**-0.0286** 0.9334	**0.2529** 0.4531	**0.0712** 0.8352	**0.3149** 0.3456	**-0.1570** 0.6448	**0.5242** * 0.0979	**-0.2056** 0.5443	**0.3857** 0.2413	**1.0000**		
Δ fruits & nuts	**0.0004** 0.9991	**-0.0153** 0.9645	**0.1241** 0.7163	**-0.3274** 0.3257	**-0.0550** 0.8725	**-0.1757** 0.6054	**-0.2085** 0.5384	**-0.6385** ** 0.0345	**-0.3295** 0.3224	**1.0000**	
Δ tube-well area	**0.0816** 0.8114	**0.3187** 0.3395	**0.1702** 0.6168	**0.1067** 0.7549	**0.3959** 0.2281	**0.5719** * 0.0660	**-0.2189** 0.5178	**0.2896** 0.3876	**0.6105** ** 0.0461	**-0.3771** 0.2529	**1.0000**

Data source: Ministry of Agriculture, "Indian Agricultural Statistics" various issues.
Upper-row figures in larger font represent simple correlation coefficients.
Lower-row figures in smaller font represent p-values.

* significant at the 10% level
** significant at the 5% level
*** significant at the 1% level

Table 5c. Correlations among area changes between 1991-92 and 1998-99 in districts of Andhra Pradesh (11 districts where tubewell coverage was less than 2% of net cropped area in 1991)

	Δ net cropped area	Δ millets	Δ rice	Δ ground-nut	Δ other oilseeds	Δ pulses	Δ cotton	Δ chili	Δ vege-tables	Δ fruits & nuts	Δ tube-well area
Δ net cropped area	**1.0000**										
Δ millets	**0.5838** * 0.0593	**1.0000**									
Δ rice	**0.5083** 0.1104	**0.3411** 0.3046	**1.0000**								
Δ ground-nut	**-0.0144** 0.9664	**0.0896** 0.7933	**-0.3333** 0.3165	**1.0000**							
Δ other oilseeds	**0.1607** 0.6369	**0.4472** 0.1678	**-0.2172** 0.5213	**0.0138** 0.9679	**1.0000**						
Δ pulses	**0.2078** 0.5399	**-0.1816** 0.5930	**-0.3999** 0.2229	**0.1868** 0.5823	**0.0970** 0.7766	**1.0000**					
Δ cotton	**0.3691** 0.2639	**0.1482** 0.6637	**0.8035** *** 0.0029	**-0.6008** * 0.0506	**-0.3307** 0.3206	**-0.3077** 0.3573	**1.0000**				
Δ chili	**-0.0314** 0.9269	**-0.5950** * 0.0535	**-0.2497** 0.4589	**0.0915** 0.7890	**-0.4590** 0.1556	**0.7511** *** 0.0077	**-0.0529** 0.8773	**1.0000**			
Δ vege-tables	**0.0609** 0.8588	**-0.1178** 0.7302	**0.0354** 0.9177	**-0.4359** 0.1802	**-0.1144** 0.7377	**0.3841** 0.2434	**0.1366** 0.6888	**0.2880** 0.3904	**1.0000**		
Δ fruits & nuts	**0.0897** 0.7932	**0.2268** 0.5024	**-0.2424** 0.4727	**0.0712** 0.8352	**0.1583** 0.6419	**0.1889** 0.5780	**-0.2734** 0.4160	**-0.1074** 0.7533	**-0.3489** 0.2929	**1.0000**	
Δ tube-well area	**-0.4287** 0.1883	**-0.6868** ** 0.0196	**-0.1809** 0.5946	**-0.0918** 0.7884	**-0.3268** 0.3266	**0.1083** 0.7513	**0.1036** 0.7617	**0.5463** * 0.0821	**0.1546** 0.6498	**-0.5193** 0.1016	**1.000**

Data source: Ministry of Agriculture, "Indian Agricultural Statistics" various issues.
Upper-row figures in larger font represent simple correlation coefficients.
Lower-row figures in smaller font represent p-values.

* significant at the 10% level
** significant at the 5% level
*** significant at the 1% level

from the left-most column, we see that the change in net cropped area is correlated most strongly (and significantly positively) with the changes in areas under millets and rice. This reflects in part the large acreage of the two crop items. We can infer that any changes in net cropped area were due mainly to changes in rice and millet acreage. This could be because the two crops are grown on extreme ends of the land type spectrum; rice on specially prepared wetlands, and millets on drylands not suitable for most other crops. Next, wee find a strong and significantly negative correlation between groundnut and "other oilseeds". This is because groundnut was being substituted by other, newer oilseeds such as sunflower in some districts. Looking across at the row titled "Δ tube-well area", where "Δ" stands for "change", we find that an increase in tubewell irrigation is significantly correlated with an increase in acreage of pulses and vegetables. While it is easy to understand how vegetable acreage may have increased with assured irrigation, it is not clear exactly how pulses were affected.

In Table 5b, we picked out the 11 districts where more than 2% of the net cropped area was irrigated by tubewell in 1991. Here, the negative correlation between groundnut and "other oilseeds" is shown

to be stronger than in the full sample. Also, a change in tubewell coverage is positively and significantly correlated with changes in pulses and vegetables acreage. Acreage change of fruits and nuts are shown to be negatively correlated with changes in chili acreage, suggesting substitution from one to the other.

The 11 districts where less than 2% of net acreage was tubewell-irrigated are contained in Table 3c. It is interesting to note here that the correlation coefficient between "Δ net cropped area" and "Δ millets" is significantly positive, but none of the other crops are significantly correlated with change in net cropped area. This suggests the large presence of millets in the non-irrigated areas, while implying that the other crops were not sufficiently filling the vacant acreage left by the millets. The bottommost "Δ tubewell" row shows that an increase in tubewell coverage is correlated with a significantly negative shift in millets, and a significantly positive shift in chili. This implies that the expansion of tubewell irrigation often resulted in substitution from millets to chili in the less-irrigated areas.

Conclusions

This paper has worked with state-level and district-level data to describe and analyze the changes in cropping patterns in Andhra Pradesh during the 1990s. From the state-level analysis, it was found that coarse cereals, most of which are millets, continued their declining trend. Another significant movement was the slowdown and retreat of oilseed acreage after the GATT trade liberalization measures were implemented. Cotton was the one major crop that continued to increase its share during the 1990s.

The analysis from the district-level data showed a relationship between cropping pattern and land use, namely that changes in rice and millets acreage translated directly into changes in net cropped area. In particular, the decline in millets in less-irrigated districts was not being met by increases in other crops. Some interesting patterns on crop substitution were also found. Substitution between groundnut and other oilseeds occurred, though more strongly in the highly irrigated areas. In the less irrigated areas, a notable substitution was that between millets and chili, catalyzed by increased tubewell irrigation.

Thus, the decline in millets was being covered by other crops such as chili, *only when accompanied by an increase in irrigation.*

The last point may have some interesting implications from a trade and pricing policy perspective. The expansion in oilseeds during the 1980s was enabled by substituting land away from coarse cereals (Bhalla and Singh [2001], Gulati and Sharma [1997]). It is natural to think that the land released from millets during the 1990s could have been absorbed by dryland oilseed crops if the market conditions for oilseeds were favorable. However, as already noted, trade liberalization in the 1990s resulted in a deterioration of the profitability of oilseeds, so that farmers chose not to shift in that direction.

If the release of non-irrigated land under millets is simply leading to higher incidence of fallows, then the cropping pattern changes may have implications for seasonal migration by dryland farmers. It has been pointed out by Deb et al. [2002] and others that in Andhra Pradesh, small landowners are increasingly going for seasonal migration. When these families cannot find people in their village to take care of their school-age children, the children are taken along to the migration destination, so that education outcomes are adversely affected. In this

way, cropping pattern changes are indirectly related to child education issues as well.

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