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Irrigation Inequalities in Pakistan 1960–1980: A District-level Analysis

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This study estimates the magnitudes of inequality in the distribution of irrigated areas at three points in time and extends the findings of Gill and Sampath (1990) using more disaggregated data. Specifically, it provides estimates of the level of inequality in the distribution of land and irrigation-related attributes among agricultural households across farm-size groups at provincial and district levels. It decomposes the levels of inequality in each province in terms of its two major components, namely, "between-districts" and "within-district" inequality, and tests a modified "Kuznet" hypothesis, according to which the relationship between the levels of inequality and the levels of development is an inverted "U". The major findings of the study are: There exists considerable inequality in the distribution of various land area variables across farm-size groups in all the districts of Pakistan, with considerable inter-district variations in their levels and movements over time; between the "within-district" inequality and "between-districts" inequality. The former represents 91 percent, 76 percent, 75 percent, and 65 percent of total inequalities for Sindh, the Punjab, Balochistan, and the NWFP, respectively. This means that more has to be done in terms of the irrigation distribution policy than in terms of removing the inter-district variations in irrigation development. And, finally, the modified "Kuznet" hypothesis is valid in explaining the inter-district variations in the levels of inequality in the distribution of at least some of the land area variables.

1. INTRODUCTION

The productivity of the agricultural sector continues to be poor in Pakistan, mainly due to the defective land-tenure system, inefficient cultivation practices, inadequate farm power, irrigation facilities, etc. Even after four decades of development, no significant improvement has been made to solve the problems of poverty and malnutrition, especially in the rural areas [Government of Pakistan (1988); Chaudhry (1973) and Mahmood (1984)]. Irrigation plays an important role in the development of agriculture, and the nature of distribution of irrigation water across farm-size groups determines to a significant extent the nature of distribution of agricultural income. The Pakistani irrigation system is federally controlled. The respec-

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tive departments of the four provinces, namely, Balochistan, the North West Frontier Province (NWFP), the Punjab, and Sindh receive water from dams and reservoirs and carry their water through a system of canals, branch canals, minors, and distributories to the water-courses and the outlets. Beyond the outlet, it is the responsibility of the farmer to carry water to his field through water channels and ditches. From these water channels, farmers get water by rotation, on a weekly basis [for more details, see Merry and Wolf (1986); Government of Pakistan (1988); Gill and Sampath (1992)].

2. OBJECTIVES

The main objective of this study is to estimate the nature and magnitude of inequality in the distribution of irrigation water at a point in time as well as over a period of time and extend the findings of Gill and Sampath (1992) using further disaggregated data. Gill and Sampath in their study analysed the census data pertaining to 1960, 1972, and 1980 in terms of the provincial level data. By doing that, they implicitly assumed that the patterns of inequality across districts within a province are identical. This is not realistic, and to the extent that there are significant interdistrict variations within a province, the levels of inequality at the provincial level estimated by Gill and Sampath are only the lower bounds of inequality, and so a district-level analysis will help in estimating inequalities more accurately. Since many of the programmes and policies formulated by the provincial and national governments are implemented using the district as the administrative unit for a variety of purposes, it is important to study the distribution problems at the district level. Further, in the provincial legislative assemblies, the legislators reflect their constituency interests in terms of the district to which their constituencies belong; to some extent, the interdistrict variations in development reflect the variations in the extent of influence exercised by different legislators. Thus, if the provincial government is serious about reducing inequality in the province as a whole, then, in order to introduce corrective programmes, it needs to know about the relative contribution made by "within-district" inequality and "between-districts" inequality to total inequality in the province. Specifically, the objectives of this paper are:

(a) To provide estimates of the level of inequality in the distribution of land- and irrigation-related variables among agricultural households across farm-size groups both at the provincial and the district levels at a point in time as well as over a period of time;
(b) to decompose the levels of inequality in each province in terms of its two major components, namely, "between-districts" and "within district"

inequality; and

(c) to test a modified Kuznet hypothesis according to which the relationship between the levels of inequality and the levels of development is an inverted U.

3. METHODOLOGY

In conducting this study, we followed the methodology used by Sampath (1990, 1990a) and Gill and Sampath (1992). In estimating the indices of inequality, we used Theil's entropy measure [Theil (1967)]. Sampath, in the papers mentioned earlier, discussed in detail the usefulness of Theil's index of inequality for irrigation distribution analysis. Theil's inequality is derived from the notions of "entropy" in information theory. Theil's measure incorporates certain value judgements or norms that have been accepted generally by the government or the irrigation management authorities as reflecting properly the ethical judgements with regard to equity in irrigation distribution policy [for a detailed discussion on this, see Sampath (1990a)]. For grouped data, Theil's information theoretic measure is defined as

$$T_1\,(Y{:}X) = \sum_{i=1}^{n} Y_i \ln \frac{Yi}{Xi} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

$$T_2\,(X{:}Y) = \sum_{i=1}^{n} X_i \ln \frac{Xi}{Yi} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

X_i = number of cultivating households in the farm-size class "i" as a proportion of the total number of cultivating households.

Y_i = irrigated area share of the ith farm-size class as a proportion of the total irrigated area.

Because we are estimating the extent of inequality in irrigation distribution across cultivating households, it is preferable to use T_2 rather than T_1. The aggregation procedure involved in our analysis is as follows:

We can write Sg, g=1...G for the gth district.

X_g = gth district's household share.

Y_g = gth district's share in any given land variable.

$$X_g = \sum_{i \in Sg} X_i \,;\; Y_g = \sum_{i \in Sg} Y_i \,;\; g = 1 \ldots G$$

Now, we can write p_i for the ith farm-size class household population share of the gth district and n_i for its conditional share in the given land variable and

$$p_i = \frac{X_i}{X_g};\quad n_i = \frac{Y_i}{Y_g}\, i \varepsilon Sg, g = 1 \ldots G$$

Thus, Theil's inequality decomposition is defined in the following way:

$$I\,(X{:}Y) = I_o\,(X{:}Y) + \sum_{g=1}^{G} X_g\, I_g\,(X{:}Y) \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

where I_o $(X{:}Y)$ is the "between-districts" inequality and I_g $(X{:}Y)$ is the "within-district" inequality.

$$I_o\,(X{:}Y) = \sum_{g=1}^{G} X_g \ln \frac{X_g}{Y_g} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

$$I_g\,(X{:}Y) = \sum_{i \varepsilon Sg} p_i \ln \frac{p_i}{n_i}; g = 1 \ldots G \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

Using Theil's measure, we will show the inter-farm inequality in irrigation distribution in each of Pakistan's four provinces at two levels: (i) at the provincial level for each of Pakistan's four provinces, and (ii) at the district level in each of the four provinces. Further, we shall also decompose the provincial level of inequality in terms of its constituent parts, namely, "between-districts" and "within-district" inequality. The above decomposition will help us to see how much of the inequality that exists in a province as a whole is due to differential levels of irrigation development in different districts, and how much of it is due to inequality that exists within the districts across the nine farm-size groups. The nine farm-size groups are: under 1.0 acre, 1.0 to under 2.5 acres, 2.5 to under 7.5 acres, 7.5 to under 12.5 acres, 12.5 to under 25.0 acres, 25.0 to under 50.0 acres, 50.0 to under 100.0 acres, 100.0 to under 150.0 acres, and 150.0 acres and above, respectively. Using Theil's index and decomposition procedures, we estimated the between-districts and within-district inequality components for each of the four provinces for a number of variables that have a bearing on or consequences for irrigation distribution. This analysis is important because, as Sampath (1990) argues: "the government has a lot of direct say in the development and distribution of surface irrigation systems, in general, and canal irrigation systems, in particular; but as far as groundwater development is concerned, its influence is only indirect since most of the wells and tubewells are under the direct ownership of farmers. So, it may be expected that the government may achieve better equity in the development and distribution of surface irrigation but not be as successful with groundwater development. This could be verified by conducting disaggregate equity analysis in terms of different physical and ownership sources of irrigation development and distribution."

Specifically, following Sampath (1990) and Gill and Sampath (1992), we conducted the inequality analysis in terms of two groups of irrigation and irrigation-related variables, namely, (i) the first group representing four types of *net* land use area variables such as the farm area total (FAT), cultivated area total (CAT), net sown area (NSA), and irrigated cultivated area total (ICAT); and (ii) the second group representing a total of twelve *gross* land area use variables such as total cropped area (TCRA), total *kharif*[1] cropped area (TKCRA), total *rabi*[2] cropped area (TRCRA), total orchard area (TOA), irrigated cropped area (ICRA), irrigated *kharif* cropped area (IKCRA), irrigated *rabi* cropped area (IRCRA), irrigated orchard area (IOA), unirrigated cropped area (UICRA), unirrigated *kharif* cropped area (UIKCRA), unirrigated *rabi* cropped area (UIRCRA), and unirrigated orchard area (UIOA).[3]

Thus, the cropped areas are categorised in terms of two crop seasons, namely, *kharif* and *rabi*; and in terms of two sources of water, namely, irrigated and unirrigated (rainfall). Since there is some rainfall during the *kharif* season, and very little during the *rabi* season, the analysis of inequality in irrigation distribution in terms of crop seasons will give us some clues as to the effect of the relative scarcity of water on the extent of inequality in its distribution. Similarly, since irrigated cropped areas are more productive than unirrigated cropped areas, the levels of inequality in their distribution will give us some ideas about their likely influence on the distribution of income. Further, inequalities in the current distribution of unirrigated areas will give us some indication as to the likely impact of further development of irrigation on inequalities in the future. Since orchards represent the most commercial form of the agricultural activity, the levels of inequality in orchard cropped areas will tell us something about the relationship between the degree of commercialisation and the extent of inequality. Finally, the analysis of inequality in terms of the *net* and *gross* areas will tell us something about the nature of equity considerations in government's policies and programmes with respect to irrigation water development and its distribution. For example, a higher level of inequality in the *gross* irrigated area as compared to the *net* irrigated area would indicate that the

[1]*Kharif* crop season is from May to October.

[2]*Rabi* crop season is from November to April.

[3]Ideally, we would prefer to have a volume of irrigation water distributed across farms to analyse inequality in irrigation water distribution; but unfortunately such data are not available for any developing country of the world on a systematic basis. That is why irrigated area is used as a proxy variable to measure irrigation water. Whatever its limitations may be, it still throws some light on the nature of irrigation water distribution across farm-size groups.

government is concerned more with farm area's benefiting from irrigation development than with equitable distribution among the beneficiaries; in contrast, a lower inequality in the *gross* variables as compared to the *net* variables would indicate the concern of the government that, given the beneficiaries, the distribution of available irrigation water be more equitable among them.

4. DATA SOURCES

The cross-section data used in this study are from the three agricultural census reports, published by the agricultural census organisation of the Government of Pakistan relating to the years 1959-1960, 1971-72 , and 1979-1980. These census reports include data at the national, provincial, and district levels. [Government of Pakistan (Various Issues) and Government of Pakistan (Various Issues a)]. We also used supporting data from Government of Pakistan (Various Issues b) and the Government of Pakistan (Various Issues c) for the purposes of our analysis.

5. INEQUALITY IN LAND AND IRRIGATED AREA DISTRIBUTION

Table 1 provides estimates of Theil indices of inequality in the distribution of four *net* land area variables, namely, FAT, CAT, NSA, and ICAT. The inequality estimates given in Table 1 for each of the provinces for each of the three census years include the overall level of inequality (TI) and its decomposition into "within-district" inequality (WDI) and "between-districts" inequality (BDI), and WDI as a proportion of TI. From the information given in Table 1, we can derive the following inferences.

5.1 There exist considerable levels of inequality in the distribution of all four *net* land area variables in all four provinces. This is evident from the fact that the index values are all higher than zero. Generally, an index value of 0.25 or higher can be considered as indicating significant inequality in distribution. We observe that as compared to 1960, the level of inequality was lower in 1972 in all the four land area variables in Balochistan, the NWFP, and Sindh, the exception being the level of inequality for ICAT in the NWFP, which did not register any substantial change. But, in Punjab, there was a substantial increase in inequality for FAT, CAT, and NSA, though the Punjab also had a significant reduction in inequality in ICAT. Thus, it appears that the implementation of land reforms during the 1960s had been very successful in all the provinces except the Punjab. But, compared to 1972, the levels of inequality in the four land area variables in 1980 seems to have increased significantly for Balochistan, the Punjab, and Sindh except in the case of FAT in Balochistan, for which the level of inequality went down. In the case of the NWFP, the levels of inequality went down, though insignificantly. The plausible

Table 1

Inequalities Across Farm-Size Groups in the Distribution of FAT, CAT, NSA, and ICAT

	BALOCHISTAN					
	TI			BDI		
VARIABLE	1960	1972	1980	1960	1972	1980
FAT	1.109	0.920	0.842	0.109	0.127	0.111
CAT	0.875	0.581	0.695	0.113	0.117	0.122
NSA	0.595	0.535	0.619	0.122	0.150	0.162
ICAT	1.168	0.719	0.897	0.253	0.385	0.467
	WDI			WDI/TI		
FAT	1.000	0.793	0.730	0.902	0.862	0.868
CAT	0.761	0.464	0.573	0.871	0.798	0.825
NSA	0.474	0.385	0.457	0.796	0.720	0.738
ICAT	0.916	0.335	0.429	0.784	0.465	0.479
	NWFP					
	TI			BDI		
VARIABLE	1960	1972	1980	1960	1972	1980
FAT	1.280	0.938	0.921	0.236	0.359	0.233
CAT	0.742	0.666	0.620	0.165	0.258	0.169
NSA	0.698	0.558	0.539	0.143	0.193	0.120
ICAT	0.793	0.796	0.787	0.382	0.464	0.387
	WDI			WDI/TI		
FAT	1.044	0.579	0.687	0.816	0.618	0.746
CAT	0.577	0.408	0.450	0.778	0.613	0.727
NSA	0.555	0.365	0.419	0.796	0.655	0.777
ICAT	0.410	0.332	0.400	0.518	0.417	0.508
	PUNJAB					
	TI			BDI		
VARIABLE	1960	1972	1980	1960	1972	1980
FAT	0.381	0.489	0.921	0.052	0.036	0.233
CAT	0.325	0.408	0.620	0.070	0.034	0.169
NSA	0.320	0.399	0.539	0.072	0.037	0.120
ICAT	0.538	0.484	0.787	0.279	0.133	0.387
	WDI			WDI/TI		
FAT	0.330	0.453	0.687	0.864	0.926	0.746
CAT	0.255	0.374	0.450	0.784	0.916	0.727
NSA	0.248	0.362	0.419	0.774	0.907	0.777
ICAT	0.259	0.351	0.400	0.482	0.725	0.508
	SINDH					
	TI			BDI		
VARIABLE	1960	1972	1980	1960	1972	1980
FAT	0.548	0.446	0.488	0.043	0.031	0.034
CAT	0.351	0.298	0.351	0.035	0.018	0.029
NSA	0.316	0.250	0.331	0.031	0.011	0.028
ICAT	0.313	0.255	0.315	0.041	0.015	0.031
	WDI			WDI/TI		
FAT	0.505	0.415	0.454	0.922	0.931	0.930
CAT	0.316	0.280	0.322	0.902	0.940	0.918
NSA	0.285	0.239	0.304	0.902	0.956	0.917
ICAT	0.272	0.239	0.283	0.868	0.940	0.900

FAT = Farm Area Total;
CAT = Cultivated Area Total;
NSA = Net Sown Area;
ICAT = Irrigated Cultivated Area Total.

TI = Total Inequality;
BDI = Between-districts Inequality;
WDI = Within-district Inequality;

reasons for this trend given by Gill and Sampath (1992) are: (i) the ejection of tenants by large farmers due to the advent of the Green Revolution, which made self-cultivation more profitable; (ii) the beneficiaries of land distribution of the 1960s either sold out their lands or were forced to leave those tracts and did not pursue the matter due to the lengthy and costly process of litigation; and (iii) the fictitious transfers may have been readjusted by the landed class once the dust of the land reforms rhetoric had settled.

5.2 Though "within-district" inequality explains the predominant part of total inequality in each of the provinces for the FAT, CAT, and NSA variables, in the case of ICAT for Balochistan in 1972 and 1980, the NWFP in all the three years, and the Punjab in 1960 and 1980, about 50 percent of the level of inequality is due to "between-districts" inequality, indicating wide interdistrict variations in development as an equally important cause of the level of inequality in these provinces.

5.3 The levels of inequality in most land area variables for the two most irrigated provinces, namely, the Punjab and Sindh, are significantly lower as compared to the two least irrigated provinces, Balochistan and the NWFP.

5.4 It is generally known that the productivity of land goes up as we move from FAT to CAT to NSA. This is so because FAT includes CAT plus uncultivated land, and CAT includes NSA plus current fallow land. In the distribution of these classes of land across farm-size groups, government intervention is almost nil. What we notice from Table 1 is that the level of inequality in the distribution of these lands across farm-size groups goes on declining as we move from less productive FAT to more productive CAT to a still more productive NSA. This holds true for each and every province and for each and every year. But as soon as we move to the most productive land variable, namely, the ICAT, we find that the level of inequality registers a substantial increase. The only difference between ICAT and the other three types of land variable is that the distribution of ICAT across farm-size groups is determined to a great extent by the irrigation water distribution policy of the provincial governments, especially with respect to the canal and large tubewell irrigation water that they own, manage, and control.

5.5 There are four different trends in the movements of the level of inequality in the distribution of ICAT across farm-size groups over time across the four provinces. While the level of inequality for Balochistan went down in 1972, it went up in 1980, though it was still lower than the 1960 level. It remained virtually the same for the NWFP. But, in contrast, the level of inequality for Sindh went down in 1972, though it went up to the 1960 level in 1980; and the level of inequality for the Punjab went down in 1972, but went up to a significantly higher level in 1980 as compared to the 1960 level. It will be an interesting area of future research to identify the factors that led to the differential movements in inequality in different provinces.

6. INEQUALITY ACROSS FARM-SIZE GROUPS IN TERMS OF GROSS CROPPED AREAS AND CROP SEASONS

Table 2 provides estimates of the levels of inequality and their decomposition into "within-district" and "between-districts" inequalities in terms of total cropped, *kharif* cropped, *rabi* cropped, and orchard cropped areas for irrigated, unirrigated, and total areas for each of the four provinces over the period 1960–1980. From Table 2, we can infer the following.

6.1 We do not see any particular pattern with respect to the movement of the levels of inequality applicable to all the provinces for the TCRA, TKCRA, TRCRA, and TOA variables. Though in the case of the NWFP, the levels of inequality in all the variables except the TOA went consistently down from 1960 to 1980. It is important to note here that the levels of inequality in the most commercial use of land TOA is the highest for each of the four provinces in each of the census years among the four cropped areas.

6.2 There does not appear to be any particular pattern in the movement of the levels of inequality over time with respect to the four irrigated cropped area variables that is applicable to all the four provinces. The only striking observation is that, here too, we find that for all the provinces for each of the three years, the levels of inequality are the highest for the most commercial cropped areas, namely, the orchard areas. Similar is the observation with respect to the four unirrigated cropped area variables.

6.3 While the levels of inequality in IRCRA during the water-scarce *rabi* season are lower in Balochistan and the Punjab, they are higher for the NWFP and Sindh as compared to the levels of inequality in IKCRA in both 1972 and 1980. Once again, more research is needed to explain these observations.

7. DISTRICT LEVEL ANALYSIS OF INEQUALITY

Table 3 summarises the estimates of inequality at the district level for each of the four provinces in the distribution of the four *net* land area variables and the four *gross* cropped area variables.[4]

From Table 3 it can be seen that there is no discernible trend in the movement of inequalities in the distribution of any of the *net* or *gross* land area variables that is applicable to the majority of the districts for any of the provinces except in the cases of FAT and CAT for the NWFP. There was consistent reduction in the

[4]In order to save space, the complete estimates of inequality for each of the 62 districts are not reported; but they are available from the authors upon request.

Table 2

Inequality Across Farm-Size Groups in Terms of Crop Seasons

	Balochistan											
	TI			BDI			WDI			WDI/TI		
VARIABLE	1960	1972	1980	1960	1972	1980	1960	1972	1980	1960	1972	1980
Total Cropped Area												
TCRA	0.557	0.514	0.617	0.115	0.153	0.171	0.442	0.361	0.446	0.793	0.702	0.723
TKCRA	0.758	0.672	0.963	0.259	0.403	0.479	0.499	0.269	0.484	0.659	0.400	0.502
TRCRA	0.520	0.604	0.621	0.098	0.124	0.171	0.421	0.479	0.450	0.811	0.794	0.724
TOA	1.039	0.778	1.024	0.555	0.430	0.618	0.485	0.349	0.405	0.466	0.448	0.396
Irrigated Cropped Area												
ICRA		0.731	0.897		0.428	0.493		0.304	0.404		0.415	0.450
IKCRA		0.904	1.300		0.675	0.946		0.229	0.355		0.254	0.273
IRCRA		0.807	0.845		0.406	0.387		0.401	0.457		0.497	0.541
IOA		0.855	1.072		0.506	0.667		0.349	0.404		0.408	0.377
Unirrigated Cropped Area												
UICRA		0.768	0.918		0.232	0.386		0.536	0.531		0.698	0.579
UIKCRA		1.074	1.376		0.637	0.726		0.438	0.650		0.408	0.472
UIRCRA		0.894	0.973		0.229	0.479		0.664	0.494		0.743	0.508
UIOA		1.597	1.721		0.662	0.820		0.935	0.901		0.585	0.523

Continued–

Table 2–(*Continued*)

	NWFP											
	TI			BDI			WDI			WDI/TI		
VARIABLE	1960	1972	1980	1960	1972	1980	1960	1972	1980	1960	1972	1980
Total Cropped Area												
TCRA	0.602	0.450	0.417	0.101	0.121	0.061	0.501	0.329	0.355	0.832	0.731	0.852
TKCRA	0.447	0.307	0.307	0.038	0.033	0.017	0.410	0.274	0.291	0.916	0.891	0.946
TRCRA	0.799	0.606	0.575	0.229	0.236	0.171	0.570	0.370	0.404	0.713	0.611	0.703
TOA	1.063	1.417	1.235	0.560	0.429	0.372	0.503	0.988	0.863	0.473	0.697	0.699
Irrigated Cropped Area												
ICRA		0.671	0.667		0.379	0.309		0.292	0.358		0.436	0.536
IKCRA		0.630	0.594		0.338	0.250		0.291	0.344		0.463	0.579
IRCRA		0.749	0.810		0.461	0.443		0.288	0.366		0.385	0.452
IOA		1.543	1.298		0.513	0.419		1.030	0.879		0.667	0.677
Unirrigated Cropped Area												
UICRA		0.591	0.582		0.191	0.183		0.400	0.398		0.677	0.685
UIKCRA		0.655	0.685		0.396	0.420		0.259	0.265		0.396	0.387
UIRCRA		0.718	0.689		0.242	0.212		0.476	0.477		0.662	0.693
UIOA		0.885	1.143		0.319	0.449		0.566	0.694		0.639	0.608

Continued–

Table 2–(*Continued*)

	Punjab											
	TI			BDI			WDI			WDI/TI		
VARIABLE	1960	1972	1980	1960	1972	1980	1960	1972	1980	1960	1972	1980
					Total Cropped Area							
TCRA	0.308	0.369	0.425	0.070	0.031	0.035	0.238	0.338	0.389	0.773	0.917	0.917
TKCRA	0.322	0.361	0.433	0.081	0.028	0.048	0.241	0.333	0.386	0.749	0.922	0.890
TRCRA	0.313	0.398	0.442	0.078	0.058	0.056	0.235	0.340	0.386	0.751	0.855	0.874
TOA	1.210	1.131	1.363	0.580	0.355	0.432	0.630	0.776	0.931	0.521	0.686	0.683
					Irrigated Cropped Area							
ICRA		0.460	0.525		0.133	0.145		0.326	0.380		0.710	0.724
IKCRA		0.496	0.567		0.160	0.175		0.336	0.393		0.677	0.692
IRCRA		0.438	0.492		0.124	0.133		0.314	0.359		0.716	0.730
IOA		1.180	1.391		0.390	0.450		0.790	0.941		0.669	0.677
					Unirrigated Cropped Area							
UICRA		1.190	1.384		0.737	0.891		0.453	0.493		0.381	0.356
UIKCRA		1.193	1.348		0.805	0.964		0.387	0.384		0.325	0.285
UIRCRA		1.248	1.472		0.761	0.937		0.487	0.536		0.390	0.364
UIOA		1.416	1.505		0.611	0.831		0.804	0.673		0.568	0.447

Continued–

Table 2–(*Continued*)

	Sindh											
	TI			BDI			WDI			WDI/TI		
VARIABLE	1960	1972	1980	1960	1972	1980	1960	1972	1980	1960	1972	1980
Total Cropped Area												
TCRA	0.273	0.222	0.275	0.012	0.010	0.009	0.261	0.212	0.267	0.956	0.956	0.969
TKCRA	0.366	0.235	0.331	0.078	0.024	0.045	0.288	0.211	0.286	0.788	0.899	0.864
TRCRA	0.317	0.227	0.292	0.067	0.020	0.051	0.250	0.207	0.242	0.790	0.912	0.827
TOA	0.648	1.662	1.751	0.367	0.617	0.461	0.280	1.044	1.290	0.433	0.628	0.737
Irrigated Cropped Area												
ICRA		0.234	0.293		0.012	0.034		0.222	0.258		0.947	0.882
IKCRA		0.236	0.304		0.025	0.054		0.211	0.249		0.893	0.821
IRCRA		0.354	0.336		0.120	0.081		0.234	0.256		0.661	0.761
IOA		1.673	1.753		0.625	0.462		1.048	1.291		0.627	0.736
Unirrigated Cropped Area												
UICRA		0.720	1.069		0.527	0.678		0.193	0.391		0.268	0.366
UIKCRA		1.206	2.150		0.677	1.618		0.528	0.532		0.438	0.247
UIRCRA		0.803	1.047		0.622	0.818		0.182	0.228		0.226	0.218
UIOA		1.675	2.345		0.246	0.737		1.429	1.608		0.853	0.686

Table 3

The Analysis of District-level Inequalities in the Distribution of Net and Gross Land Area Variables

PROVINCE	VARIABLE	NDSCRIIE	NDSCIIIE	NDSICMIIE	NDL3YD	TOTAL
		NET LAND AREA VARIABLES				
BALOCHISTAN	FAT	1	1	6	9	17
	CAT	1	1	6	9	17
	NSA	1	1	6	9	17
	ICAT	2	1	5	9	17
NWFP	FAT	4	0	1	4	9
	CAT	3	0	2	4	9
	NSA	2	0	3	4	9
	ICAT	1	1	3	4	9
PUNJAB	FAT	3	0	16	4	23
	CAT	3	0	16	4	23
	NSA	2	0	17	4	23
	ICAT	2	1	16	4	23
SINDH	FAT	2	2	7	2	13
	CAT	0	1	10	2	13
	NSA	0	1	10	2	13
	ICAT	0	2	9	2	13
		GROSS LAND AREA VARIABLES				
BALOCHISTAN	TCRA	2	1	5	9	17
	TKCRA	0	5	3	9	17
	TRCRA	1	2	5	9	17
	TOA	2	2	4	9	17
NWFP	TCRA	2	0	3	4	9
	TKCRA	1	0	4	4	9
	TRCRA	2	0	3	4	9
	TOA	2	0	3	4	9
PUNJAB	TCRA	3	0	16	4	23
	TKCRA	5	1	13	4	23
	TRCRA	3	0	16	4	23
	TOA	1	4	14	4	23
SINDH	TCRA	1	1	9	2	13
	TKCRA	2	1	8	2	13
	TRCRA	0	1	10	2	13
	TOA	0	5	6	2	13

Notes: NDSCRIIE: Number of districts showing consistent reduction in inequality.
NDSCIIIE: Number of districts showing consistent increase in inequality.
NDSICMIIE: Number of districts showing inconsistent movements in inequality.
NDL3YD: Number of districts lacking 3-year data.

Since data are not available for all three years for irrigated and unirrigated gross cropped areas, they are omitted in the preparation of this table, though the estimates of inequality for the two years (1972 and 1980) were estimated for the districts for which data are available.

levels of inequality for FAT and CAT in a majority of the districts in the NWFP over the period. For a majority of the districts in each of the four provinces, inequalities in the distribution of each *net* and *gross* land variable went down from its 1960 level in 1972, but went back up again in 1980. For a few, the level of inequality in the 1980 inequalities was even higher than their 1960 levels.

Thus, the overall impression one gets about agricultural development during 1960-1980 is that while during the 1960s there was some positive movement towards reducing inequalities in the distribution of land variables, during the 1970s the momentum reversed its direction.

8. THE KUZNET HYPOTHESIS

The Kuznet hypothesis is popularly known as the inverted U-hypothesis, according to which income inequality first increases as economics growth occurs, and then starts declining as it reaches a maximum. We want to statistically test whether the Kuznet hypothesis can be extended to the distribution of wealth. We define land as a proxy variable for wealth since the wealth of a household in the agricultural sector depends on the land size of the farm. We use the proportion of cultivated area irrigated (ICAT/CAT) as a proxy variable for the level of development, since the data on district level per capita incomes or per hectare productivities are not available. Thus, our dependent variables in the regression equations are the Theil index values of inequality in different land variables, and the independent variables are (ICAT/CAT) and the square of (ICAT/CAT). The Kuznet hypothesis can be tested with the estimation of the following regression equation.

$$I_{it} = a_0 + a_1 \ (ICAT/CAT)_{it} + a_2 \ (ICAT/CAT)^2_{it} + U_{it} \quad \ldots \quad \ldots \quad (6)$$

Where

I_{it} = the Theil index value for the land area variable in district '*i*' in time '*t*';

$(ICAT/CAT)_{it}$ = the proportion of cultivated area irrigated in district '*i*' in time '*t*';

i = 1.....45 for 1960, 1.....46 for 1972 and 1.....60 for 1980;

t = 1960, 1972 and 1980; and

u = the random error term.

If the Kuznet hypothesis is valid, then we would expect the parameter a_1 to be positive, and a_2 to be negative. This will show that the function I_{it} is in fact an inverted "*U*" with respect to *(ICAT/CAT)*.

We estimated the above regression equation using the pooled cross-section data of all the districts in the four provinces for 1960, 1972, and 1980. The total number of districts in the combined four provinces for the three years was 45, 46, and 60, respectively, totalling to 151 potential observations. Since data are not available separately for irrigated and unirrigated gross cropped areas for 1960, there are only 106 observations for the eight regression equations pertaining to ICRA, UICRA, IKCRA, UIKCRA, IRCRA, UIRCRA, IOA, and UIOA, and 151 observations for the other eight regression equations pertaining to FAT, CAT, NSA, ICAT, TCRA, TKCRA, TRCRA, and TOA. In order to test whether there was any structural change in the relationship over time, we used time dummies (1972 and 1980) to estimate the shifts in the intercept and slope coefficients. We used both the 1972 and 1980 time dummy variables for those eight land area regressions for which we had observations pertaining to all the three years; but we used only the 1980 time dummy variable for the other eight land area variables for which we had observations pertaining to 1972 and 1980 only. In estimating these equations, we used both with and without step-wise regression procedures. Among the alternative regression equations estimated for each of the sixteen relations, we selected those which fulfilled, at least, some of the following criteria: having the highest adjusted R^2; significant 't' statistics, at least at 90 percent confidence level (two-tailed test); correctness of the algebraic signs of the estimated parameters, and the proper numerical magnitudes. Table 4 provides the summary statistics for the sixteen regression equations.

In terms of adjusted R^2, we find that Kuznet's hypothesis does not seem to explain very well the interdistrict variations in inequality in the distribution of any of the land area variables in terms of variations in the levels of their development; but, in empirical studies using cross-section data, the reported adjusted R^2 values are not very high. But, even by that standard, our R^2 values are low except for the regression equations pertaining to FAT, CAT, IKCRA, and IRCRA. This suggests two things: (i) there are other important variables that determine the variations in the levels of inequality in the distribution of different land area variables across districts in Pakistan; and (ii) even though for 12 of the 16 land area variables the Kuznet hypothesis is not robust in explaining the interdistrict variations, it does explain a statistically significant proportion of the variations in the case of four important land area variables, namely, FAT, CAT, IKCRA, and IRCRA. It will be worth explaining the implications of these equations.

According to the FAT equation 1b, which is the better of the two regressions la and 1b, in 1960 the interdistrict variations are partly due to interdistrict variations in $(ICAT/CAT)^2$; and the higher the value of $(ICAT/CAT)^2$, the lower the level of inequality in the distribution of farm area across farm-size groups. In other words, up until that time whatever development took place, it led to a reduction in inequality in FAT. That this negative relationship between the levels of inequality in FAT

Table 4

Levels of Inequality of Distribution and the Levels of Agricultural Development

Eq. No.	Dep. Var	Con-stant	ICT/CT	ICT/CT^2	D70	D80	SLOPE 1D7	SLOPE 1D8	SLOPE 2D7	SLOPE 2D8	DF	R^2/F Ratio
1a	FAT	0.669	0.559*	–0.824*							148	0.232
			(0.254)	(0.231)								(23.60)
1b		0.907		–0.387*	–0.178*	–0.391*		1.020*		–0.747*	145	0.320
				(0.062)	(0.044)	(0.092)		(0.3873)		(.3558)		(15.08)
2	CAT	0.400	0.669*	–0.718*			–0.095				147	0.204
			(0.168)	(0.153)			(0.037)					(13.82)
3	NSA	0.381	0.417*	–0.456*			–0.078*				147	0.119
			(0.157)	(0.142)			(0.035)					(7.736)
4a	ICAT	0.547		–0.217*							149	0.062
				(0.068)								(9.868)
4b		0.526	0.117	–0.320							148	0.050
			(0.350)	(0.319)								(4.960)
5	TCRA	0.359	0.404*	–0.449*			–0.076*				147	0.134
			(0.148)	(0.135)			(0.033)					(8.764)
6a	ICRA	0.581	–0.296*								104	0.135
			(0.073)									(16.15)

Continued–

Table 4–(*Continued*)

Eq. No.	Dep. Var	Con-stant	ICT/CT	ICT/CT^2	D70	D80	SLOPE 1D7	SLOPE 1D8	SLOPE 2D7	SLOPE 2D8	DF	R^2/F Ratio
6b		0.634	–0.630***	0.310							103	0.125
			(0.362)	(0.330)								(8.511)
7	UICRA	0.326	0.747*	–0.613							103	0.009
			(0.461)	(0.420)								(1.500)
8a	TKCRA	0.388					–0.117*				149	0.054
							(0.040)					(8.516)
8b		0.361	0.260	–0.318**							148	0.034
			(0.190)	(0.173)								(3.609)
9a	IKCRA	0.641	–0.358*								104	0.156
			(0.081)									(19.180)
9b		0.703	–0.755**	0.369							103	0.148
			(0.403)	(0.366)								(10.096)
10a	UIKCRA	0.473								0.343*	104	0.111
										(0.095)		(12.96)
10b		0.409	0.344	–0.108							103	0.022
			(0.542)	(0.493)								(2.172)
11	TRCRA	0.395	0.381**	–0.495*							148	0.113
			(0.191)	(0.174)								(10.561)

Continued–

Table 4–(*Continued*)

12a	IRCRA	0.674	–0.400*				104	0.167
			(0.087)					(20.84)
12b		0.762	–0.963*	0.524			103	0.165
			(0.429)	(0.390)				(11.401)
13	UIRCRA	0.339	1.310***	–1.163***			103	0.005
			(0.824)	(0.749)				(1.264)
14a	TOA	0.629			0.448*	0.575*	148	0.103
					(0.151)	(0.143)		(9.563)
14b		0.793	–0.952	1.231**			148	0.055
			(0.659)	(0.600)				(5.390)
15a	IOA	0.763		0.374**			104	0.045
				(0.168)				(4.933)
15b		1.027	–1.505	1.715			103	0.052
			(0.904)	(0.823)				(3.891)
16a	UIOA	0.631	0.883	–0.332			102	0.059
			(1.350)	(1.229)				(4.255)
16b		0.622	0.914*			–0.631**	102	0.016
			(0.323)			(0.291)		(1.864)

* Statistically Significant at 99 percent Confidence Level.
** Statistically Significant at 95 percent Confidence Level.
***Statistically Significant at 90 percent Confidence Level.

and the level of $(ICAT/CAT)^2$ continued throughout the 1960s is evident from the fact that the slope coefficient remained the same for 1970. That in 1970 there was a significant reduction in inequality in FAT across all the districts is indicated by the statistically significant (at 99 percent confidence level) 1970 intercept dummy. This was due to the land reform measures undertaken by the then Pakistan government. That this overall reduction in FAT inequality continued into 1980 is indicated by the negative 1980 intercept dummy. But there was a structural change in the relationship that took place in the 1970s due to the advent of the Green Revolution, which made farming extremely profitable. In 1980, not only the coefficient of (ICAT/CAT) became statistically significant but also assumed a positive value as predicted by the Kuznet hypothesis. Further, the coefficient of $(ICAT/CAT)^2$ also changed to a higher absolute value. Thus, the Kuznet hypothesis became fully operational after the Green Revolution. According to the regression equation, in 1980, the higher the level of development of a district [as measured by a higher level of (ICAT/CAT)], the higher tends to be the level of inequality in FAT, until the level of development reached 0.45 in terms of the (ICAT/CAT) ratio, after which the level of inequality tends to decline. In other words, until a district develops its irrigation potential to irrigate upto about 50 percent of its cultivated area, it tends to promote an increase in inequality, after which further development tends to reduce the level of inequality in the distribution of FAT. In the case of CAT, the Kuznet hypothesis is validated from the very beginning, i.e., 1960. The turning point in the inverted "*U*" relationship between inequality in the distribution of CAT and the level of development across districts occurs at 0.47, very close to what we observed in the case of FAT regression equation. Unlike the FAT equation, here, none of the time dummies are statistically significant. One explanation for the Kuznet's phenomenon could be that in the initial stages of development, due to a variety of reasons such as superior financial, social, and economic status that they enjoy, the bigger farms (especially the medium and the large size farms) expand their operations initially by increasing their farm sizes by buying new lands or by evicting tenants or by leasing in land or by reducing the amount of land leased out; but as development further takes place, intensive cultivation techniques such as multiple cropping, the application of high-yielding-variety seeds, fertilizer, and pesticides become the engine of growth and extensive cultivation becomes less profitable and even uneconomical with diseconomies of scale setting in, resulting in the bigger farms leasing out or outright selling off their excess lands to smaller farms. The invalidity of the Kuznet hypothesis for FAT in 1960 could be due to the fact that FAT includes in its definition the lands that are uncultivated and uncultivable, which are basically held by large farms for non-economic reasons such as prestige, social status, feudalism, etc; and the opportunity cost of these lands was low during the 1950s. And so the districts with higher irrigation development had less of these unused lands, resulting in lower FAT, which led to this inverse relationship between inequality in FAT and the (ICAT/CAT) ratio; but the advent of the Green Revolution and rapid irrigation development in the 1960s reduced the unused lands considerably, resulting in a sizeable increase in the influence of the changes in the CAT variable on the behaviour of the FAT variable inequality, resulting in the validity of the Kuznet hypothesis.

So far as the testing of the relevance of the Kuznet hypothesis with respect to all other land variables was concerned, our attempt was purely statistical. Unlike in the case of FAT and CAT, we did not have any *a priori* explanation for expecting the Kuznet hypothesis to be relevant. If the rest of the land variables are subsets of CAT and FAT, there is no reason to expect that each and every component of CAT and FAT would follow the Kuznet hypothesis. In fact, one could even expect the opposite to happen. For example, given the amount of cultivated land and its distribution across farm-size groups, if irrigated cultivated land of, say, small farm group goes up, given all other things are constant, then that will simultaneously decrease the level of inequality in the distribution of irrigated cultivated land and increase the level of inequality in the distribution of unirrigated cultivated land across farm-size groups. In the income inequality literature also, the Kuznet hypothesis is validated only between the level of development and the level of inequality in income distribution, and not between the level of development and each component of income distribution. In the case of IKCRA and IRCRA equations, the Kuznet hypothesis is not validated since the coefficients are of opposite signs to the ones expected.

So, on the whole, it appears that while the Kuznet hypothesis has some validity in explaining the behaviour of inequality in the distribution of farm and cultivated areas across farm-size groups in Pakistan, it does not seem to be relevant in explaining the interdistrict variations in the levels of inequality in all other land area variables. Of course, Kuznet's hypothesis was originally designed to explain only the movement of inequality in income as development takes place. But now, its extension to explain the variations in inequality in the distribution of at least some of the aggregate wealth variables such as FAT and CAT shows its greater generality. The implication of this finding is that if the government is keen on reducing inequality throughout the development period, then it has to adopt a much faster rate of development so that the turning-point in the inverted "U" curve can be reached sooner, or else adopt a development and distribution policy for irrigation that would specifically favour the small farms in the initial stages of development, as outlined in Sampath (1990) and Gill and Sampath (1992).

9. CONCLUSIONS

The following are the major findings of our study:

(a) There exists considerable inequality in the distribution of various land area variables across farm-size groups in all the districts of Pakistan, with considerable interdistrict variations in their movements over time.

(b) Between the "within-district" inequality and "between-districts" inequality, the former represents 91 percent, 76 percent, 75 percent, and 65 percent of the total inequalities for Sindh, the Punjab, Balochistan, and the NWFP, respectively. This means that more has to be done in terms of irrigation distribution policy than in terms of removing interdistrict variations in irrigation development.

(c) Finally, we find that the Kuznet hypothesis is relevant in explaining the interdistrict variations in the levels of inequality in at least some of the land variables.

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