

ESTIMATING YIELD POTENTIAL OF THE MAJOR CROPS AND ITS IMPLICATIONS FOR PAKISTAN'S CROPS SECTOR

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ABSTRACT

This paper examines the yield potentials of seven major crops, viz. wheat, cotton, rice, sugarcane, potato, maize and chickpea of Pakistan following the international agricultural expert's opinion regarding the alarming rates of population growth on the one hand and limits to the carrying capacity of the world agriculture, on the other. The aim is to investigate into the historical yield potential of these crops using the data from 1990 to 2006 and specifically report the crops that are more susceptible and need immediate attention because of their importance to satisfy ever increasing demand of food and fiber. Using nominal ratios of the major crop yields relative to the world averages this paper estimates and compares the historical trends of these crops. The results show that, leaving seed cotton as an exception, no other crop has been comparable to the world's average yield so much so that even the yield of cotton has been on a decline, recently. Seven crops; wheat, cotton, rice, potato, maize, and chickpea have improved yields while sugarcane has been stagnant over the last 18 years. Implications are: no matter low yielding crops of Pakistan raise concerns; they also provide a scope to improve yields. Hence existing lower yields could be positively addressed to answer the question of 'limits to the carrying capacity' in case of Pakistan.

Key Words: *Crop sector, yield potential, implications*

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INTRODUCTION

International institutions like World Bank, Food and Agriculture Organization and International Food Policy Research Institute have been emphasizing for a long time now towards the alarming rates of the anticipated population growth based on their long range population projections (Pinstrup and Andersen, 1999; Braun 2007 and 2008). On other hand, there is a difference of opinion on whether or not the world agriculture and food sector possesses substantial potential to feed future population. The traditionalists view growth in agricultural production through research and technology continuously reigning largely in the parts of the world' (Alexandratos, 1995). Then are ecological economists who view the agricultural production in the context of biophysical limits on carrying capacity (Martinez, 1995 and Gever *et al.* 1991). The Neoclassical Economists tend to reject this focus on limits, arguing that technological progress in raising yields can extend global carrying capacity well beyond present levels and local or regional limits can be overcome through trade (Mitchell, 1995). Crosson and Anderson (1992) are more optimistic on cropland expansion, projecting about 25% expansion by 2030. But they too indicate the crucial role of yield increases, saying that "the majority of all future increases in crop production will have to come from higher output per hectare".

The Pakistan Case

According to 2009 World Population datasheet, the population of Pakistan was 172.8 million in 2008 and is projected to be 228.9 million in 2025 and yet 250.2 million in 2050, making her the 5th populous country on the globe ((DEPweb, 2009). The historical evidence proves that the food production in the country has increased almost

50 percent over the past 20 years. The rate at which agriculture has progressed encourages the belief that progress would continue without worrying much.

However, the Agriculture sector in general and the crop sector in particular is deemed to be working far below its genuine potential, presently. In spite of 'so called' favorable conditions of soil, irrigation water and climate, agriculture in Pakistan suffers from under-utilizing of its potential resources, resulting in unnecessarily low yields per hectare and per unit of water consumed (Water Watch, 2003). Sandhu back in 1993 maintained that there was a considerable 'unachieved potential in wheat, 74%; paddy, 82%; maize 82%; sugarcane 86%; rapeseed, 77% and potato 73%, however, the country is still far from realizing the large potential yield that the well-irrigated and fertile soil from the Indus Irrigation System could produce'. Another study of Pakistan's agriculture reported that country's food supply 'remains highly dependent on good harvests rather than on any institutionalized process of technical change and it is therefore, vulnerable to sharp downturns (Gizewski, Peter and Dixon 1996). Malik, 1973 very critical expressed that discrete analysis over time reveals that 'agricultural production in Pakistan is highly erratic; one good year is either preceded or followed by bad year(s)'. Ahmad (1993), Faruqee (1999), Ali & Byerlee (2002) and Arifullah (2008), time and again, raised the concerns regarding Pakistan crop sector's potential to meet the challenge of providing food and fiber to its ever growing population.

This paper, in a straight line investigates into the yield potentials of seven major crops, specifically examining whether there exist some actual yield gaps and specifies the crops and the corresponding problem areas. If we succeeded in identifying and isolating such crops, the findings would help and guide future researchers, outreach activists and actual crops' practitioners in taking appropriate actions in their respective areas.

METHODS AND MATERIALS

This study using a simplified quantitative approach, compares major crops' yields corresponding to world averages and analyzes the trend in the yield gaps. Mathematically, the approach adopts to measure Pakistan yield-to-world yield nominal ratio, namely:

$$YRPK_i = YPK_i / YW_i \quad (1)$$

where $YRPK_i$ = Pakistan yield-to-world yield ratio for i^{th} crop

YPK_i = Yield of Pakistan's i^{th} crop per hectare (for years 1990-91 to 2006-07)

YW_i = World average yield of the i^{th} crop (for years 1990-91 to 2006-07)

An increasing ratio (i.e. $YRPK_i \geq 1$) would indicate that the numerator (Pakistan's yield) is outperforming relative to the denominator (world average yield), comparing to the ratio $YRPK_i < 1$, which would mean, otherwise.

As a second step, ratios of historical crop yields, obtained through equation 1, analyzes the trend using trend analysis econometric technique (Gujarati, 2004, p. 180), namely:

$$YRPK_i = \beta_0 + \beta_1 t + u \quad (2)$$

Where 't' is the trend variable (1, 2, 3, ..., N), representing the number of years in ascending order from 1990 to 2007. The model in equation 2 would be interpreted over the period 1990-2007; β_1 would measure the *absolute* rate of change in ratios per year, over the 1990-2007 period. The positive (negative) sign would imply growth (decay) and significance level would determine whether the rates of growth or decay had been statistically significant.

RESULTS AND DISCUSSION

Table I provides data on per hectare yields of seven major crops of Pakistan for 1990 – 2007 period, along with the world average yields of respective crops for the same period. Even a visual examination of these data and the averages worked out, reflects that almost all of the crops have lower-than-world average yields, yet it does not clearly reveal the direction and the magnitude of the gaps, as if these have been expanding or shrinking over time, from 1990 to 2007. Quantitative analysis, carried out in terms of Pakistan crops' yield-to world yield ratios using equation 1 (Table I) and their trends analyzed through equation 2 (Table II), further clarifies the results discussed, as follows.

Empirical Results

Table II provides Pakistan's crop yields to world nominal yields ratios for seven crops namely; wheat, maize, rice, seed cotton, sugar cane, potato and chick-pea, for the 1990-2007 periods. The crops presentation in Table II is in the order of their nominal yield ratio performances; i.e. seed cotton having average $YRPK_{\text{cotton}} = 1.05$ to the lowest performing maize, having $YRPK_{\text{maize}} = 0.44$. The hypothesis that 'Pakistan's crop's yields per hectare

are comparable to the world average yields' is accepted in case of only one crop, cotton, in terms of its YRPK ≥ 1 ; for all other crops this hypothesis stands rejected (Table II).

Table I *Pakistan crops yields versus world averages (1990-2007) (Kilograms per hectare)*

Year	Seed Cotton		Potato		Wheat		Chic-pea		Rice		Sugar Cane		Maize	
	Pak	World	Pak	World	Pak	World	Pak	World	Pak	World	Pak	World	Pak	World
1990	18453	16310	104002	151288	18249	25611	5426	6838	23151	35285	415469	616687	14014	36805
1991	23074	17205	104452	146007	18410	24486	4864	7093	23199	35352	407204	612557	14195	36882
1992	16290	15452	113708	151408	19909	25408	5143	7175	23685	35864	433711	614990	13643	38933
1993	14630	15661	122808	165269	19466	25318	3446	6693	27397	36301	430238	595727	13807	36213
1994	16729	16410	133170	150403	18935	24501	3930	7149	24332	36589	461435	619399	14818	41208
1995	18037	15912	139417	156003	20811	25083	5246	8015	27522	36594	467476	631031	16017	37988
1996	15192	15992	134794	166883	20184	25803	6073	7049	28684	37853	469626	629767	16066	42120
1997	15833	15991	112294	161985	20533	27107	5402	7695	28047	38182	435442	648742	16259	41264
1998	15346	15549	136186	160095	22375	26967	6959	7756	28929	38181	502785	650983	17304	43912
1999	19226	16211	165413	152615	21698	27545	6480	7750	30744	38942	477803	659756	17177	43458
2000	18705	16621	169078	163390	24906	27198	5808	7868	30311	38847	458829	641791	17406	42419
2001	17381	17323	164180	158594	23254	27484	4386	7307	27542	39357	453854	638924	17676	44188
2002	18651	17480	163628	165830	22620	26881	3877	7981	30192	38514	480560	649067	18568	43583
2003	17151	17781	168027	165200	23877	26965	7011	7379	29551	39363	473406	661070	20033	44799
2004	22800	20157	176672	175301	23733	29166	6221	7985	29914	40333	500884	655450	28488	49386
2005	20423	19924	180794	169120	25858	28451	7937	8235	31741	40844	462184	657812	29842	48444
2006	20331	20840	133447	167223	25186	27906	4660	7872	31638	41209	492290	679026	29059	47657
2007	19938	21441	198810	166467	27690	27918	7847	7979	31923	41524	532089	708775	32400	49709
Average	18233	17348	145604	160727	22094	26655	5595	7546	28250	38285	464183	642864	19265	42720

Table II *Pakistan's major crop yields to world average yields Nominal ratios (1990-2007)*

Year	Seed Cotton	Potato	Wheat	Chic-pea	Rice	Sugar Cane	Maize
1990	1.13	0.69	0.71	0.79	0.66	0.67	0.38
1991	1.34	0.72	0.75	0.69	0.66	0.67	0.39
1992	1.05	0.75	0.78	0.72	0.66	0.71	0.35
1993	0.93	0.74	0.77	0.52	0.76	0.72	0.38
1994	1.02	0.89	0.77	0.55	0.67	0.75	0.36
1995	1.13	0.89	0.83	0.66	0.75	0.74	0.42
1996	0.95	0.81	0.78	0.86	0.76	0.75	0.38
1997	0.99	0.69	0.76	0.70	0.74	0.67	0.39
1998	0.99	0.85	0.83	0.90	0.76	0.77	0.39
1999	1.19	1.08	0.79	0.84	0.79	0.72	0.40
2000	1.13	1.04	0.92	0.74	0.78	0.72	0.41
2001	1.00	1.04	0.85	0.60	0.70	0.71	0.40
2002	1.07	0.99	0.84	0.49	0.78	0.74	0.43
2003	0.97	1.02	0.89	0.95	0.75	0.72	0.45
2004	1.13	1.01	0.81	0.78	0.74	0.76	0.58
2005	1.03	1.07	0.91	0.96	0.78	0.70	0.62
2006	0.98	0.80	0.90	0.59	0.77	0.73	0.61
2007	0.93	1.19	0.99	0.98	0.77	0.75	0.65
AVE	1.05	0.90	0.83	0.74	0.74	0.72	0.44

Source: The Authors' calculations based on Equation 1.

Table III provides empirical results of trends analysis, using equation 2. This table further divides crops on the basis of crops' yield performances; those with positive trends are reported in the first part, and the one with negative trend is placed in the second part. Additionally, table provides significance levels of respective β_1 , indicating whether trends have been statistically significant or otherwise.

Table III Empirical results of the Linear Trend Model ($YRPK_i = \beta_0 + \beta_1 t + u$)

Crops	Trend Results	Significance level
Crops reporting positive trends		
Wheat	$YRPK_i = 0.719 + 0.011t$ (37.17) (6.34)	0.00
Potato	$YRPK_i = 0.696 + 0.022t$ (13.41) (4.55)	0.00
Maize	$YRPK_i = 0.301 + 0.015t$ (10.81) (5.84)	0.00
Rice	$YRPK_i = 0.679 + 0.006t$ (39.13) (3.76)	0.02
Sugar cane	$YRPK_i = 0.699 + 0.002t$ (49.30) (1.80)	0.09
Chick-pea	$YRPK_i = 0.650 + 0.009t$ (8.71) (1.36)	0.19
Crops reporting negative trends		
Seed Cotton	$YRPK_i = 1.123 - 0.007t$ (22.53) (1.61)	0.13

Source: The Authors' calculations based on Equation 2.

CONCLUSION AND RECOMMENDATION

The analysis presented in Tables I and II reveals that amongst seven crops examined, only one crop - seed cotton - has been found comparable with the world average yield, nonetheless, that also is trended negatively over the period, although insignificantly ($\alpha = 13$). This could be a warning that currently Pakistan's cotton is not maintaining its positive pace that proved the 'supremacy of silver queen' in the last decade. Of the remaining six crops possessing lower yields than the world average, four crops including wheat, potato, maize and rice have exhibited statistically significant positive trends in their respective yields, compared to the world averages. These four crops, on average, have yield gaps of 27%, 10%, 56% and 26%, respectively. So, all four crops, especially the three major food grains, namely wheat, maize and rice have great potential for improvements in their yield. Sugarcane and chick-pea although are showing positive trends but the trends are statistically insignificant, indicating that no commendable changes have happened in Pakistan's yields of sugarcane and chickpea relative to the world average levels. Although these crops have a great scope for improvement; sugar cane at present has an average yield gap of 28% and chick-pea 26%, reflecting a unique opportunity of improving if planned efforts are carried out in right direction.

On the basis of these results and discussion, it is concluded that since seed cotton is the only exception comparable in yield with world average, there exists a great scope for another 'green revolution' with respect to all other crops in the country. The crop-wise diagnostics of the problems facing these crops and/or recommendation for a plan of action is beyond the scope of this paper, which estimates whether the gaps exist and the magnitude of these gaps. However, we consider it our duty to indicate the positivism glimpsed in the results in the form of the implications. The implications are; whereas the low yields of Pakistan crops sector relative to the world averages raise concerns, these also provide chances for improvements, as there are yield-gaps ranging from the lowest level of 10 percent in potato to maximum level of 56 percent in maize. It should be the priority concern of agricultural policy makers in Pakistan to concentrate on efforts increasing crops' yields and bring them at least at par with world average levels.

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