# Land-Use Changes and Agricultural Growth in India, Pakistan, and Bangladesh, 1901-2004

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This version: January 2008 (earlier versions: November 2007, September 2007)

*Abstract*: This paper investigates land-use changes in India, Pakistan, and Bangladesh, associates the changes with long-term agricultural performance, and shows the importance of crop shifts in enhancing aggregate land productivity, which is a source of growth unnoticed in the existing literature. The use of unusually long-term data that correspond to the current borders of India, Pakistan, and Bangladesh for the period 1901-2004 also distinguishes this study from the existing ones. The empirical results show a sharp discontinuity between the pre- and the post- independence periods in all of the three countries: total output growth rates rose from zero or very low figures to significantly positive levels, which were sustained throughout the post-independence period. The improvement in aggregate land productivity explained the most of this output growth. To quantify the effect of crop shifts, a decomposition analysis is applied, which shows that the crop shifts contributed to the productivity growth in all three countries, especially during periods with limited technological breakthroughs. The contribution of the crop shifts was larger in India and Pakistan than in Bangladesh. The decomposition results and changes in crop composition are consistent with farmers' response to comparative advantage under liberalized market conditions.

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## 1 Introduction

To halve, between 1990 and 2015, the proportion of people whose income is less than one dollar a day and to halve, between 1990 and 2015, the proportion of people who suffer from hunger are the first two targets of the Millennium Development Goals. Whether these targets will be achieved critically depends on the performance of the South Asian region where the number of the absolute poor is the largest in the world (e.g., according to World Bank (2001), the number of people living on less than one dollar a day in 1998 was 522 millions in South Asia, out of the global total of 1,199 millions). At the same time, the three largest countries in the region, India, Pakistan, and Bangladesh, experienced a rapid agricultural production growth in the second half of the twentieth century. In these countries, the agricultural sector is the largest employer of the poor and the domestic food production is highly important in determining their welfare. Then, how was the agricultural growth achieved and why was there stagnation in the first half of the twentieth century? Why was the growth not sufficient to substantially reduce the number of the poor? How was the agricultural transformation related with market development? These are questions that motivated this article to investigate the source of agricultural growth and changes in land use in these countries during the last century. The importance of agriculture in poverty reduction is emphasized in the latest *World Development Report* as well (World Bank, 2008).

More specifically, this paper describes land-use changes in India, Pakistan, and Bangladesh, associates the changes with long-term agricultural performance, and shows the importance of crop shifts in enhancing aggregate land productivity, which is a source of growth unnoticed in the existing literature.[1] The use of unusually long-term data that correspond to the current borders of India, Pakistan, and Bangladesh for the period 1901-2004 also distinguishes this study from the existing ones on long-term agricultural development in South Asia.[2] Some of the previous studies on agricultural production in the colonial period deal with undivided India (e.g., Sivasubramonian, 1960; 1997; 2000), some deal with British India (Blyn, 1966; Guha, 1992), and others deal with areas of contemporary India (Roy, 1996), but very few investigate the case for areas of contemporary Pakistan and Bangladesh in a way comparable with that for India. If we restrict to Punjab and Bengal, there are several studies with comparative perspectives between Indian Punjab and Pakistan Punjab (e.g., Prabha, 1969; Dasgupta, 1981; Sims, 1988)

[1] Historical records show that agricultural productivity has increased thanks to the introduction of modern technologies, the commercialization of agriculture, capital deepening, factor shifts from agriculture to nonagricultural sectors, etc. This overall process can be called "agricultural transformation," and the contribution of each of the factors has been quantified in the existing literature (Timmer, 1988).

[2] Datasets are newly compiled by the author (Kurosaki, 2007), using government statistics and revising the author's previous estimates. Using the previous versions of these datasets, Kurosaki (1999) and Kurosaki (2002) investigated the performance of agriculture in India and Pakistan for the period c.1900-1995, Kurosaki (2003) quantified the growth impact of crops shifts in West Punjab, Pakistan for a similar period, and Kurosaki (2006) extended the analysis for India and Pakistan using data until 2004.

and between West Bengal and East Bengal (Bangladesh) (e.g., Islam, 1978; Boyce, 1987; Rogaly et al., 1999; Banerjee et al., 2002). However, the coverage of these studies is limited --- those investigating the pre-1947 period did not adjust for the boundary changes, while those comparing the areas corresponding to the current international borders investigated the post-1947 period only. Although it is true that the state of Pakistan did not exist before 1947 and the state of Bangladesh did not exist before 1971, investigating agricultural production trends for "fictitious" Pakistan before 1947 and "fictitious" Bangladesh before 1971 would give us valuable insights, since farming is carried out on land, which is immovable by definition.

The article is organized as follows. The next section defines the spatial coverage of the analyses and describes long-term changes in land utilization. Section 3 gives an analytical framework to investigate agricultural growth performance and to structurally associate changes in aggregate land productivity with inter-crop reallocation of land use. Section 4 presents empirical results, contrasting the difference in agricultural growth performance among India, Pakistan, and Bangladesh. Section 5 examines the impact of changes in crop mix, which shows that crop shifts did contribute to agricultural growth in these countries. Section 6 concludes the paper.

## 2 Changes in Land Utilization in India, Pakistan, and Bangladesh

In August 1947, the Indian Empire under British rule was partitioned into India and (United) Pakistan. Before 1947, the Empire was subdivided into provinces of British India and a large number of Princely States. The current international borders are different, not only from provincial/state borders, but also from boundaries of districts (the basic administrative unit within a province). The two important provinces of Bengal and Punjab were divided into India and (United) Pakistan with Muslim majority districts belonging to the latter. In the process, several districts in Bengal and Punjab were also divided.

Before 1947, agricultural statistics were collected regularly in all provinces of British India. In contrast, statistical information on the Princely States is limited in coverage and missing for many regions. Because of this reason, the classic and seminal study on agricultural growth in the colonial India by Blyn (1966) examined the area known as "British India," which covers all British provinces except for Burma (Burma Province became a separate colony in 1937). British India below corresponds to the area thus defined by Blyn (1966).

Table 1 shows decade-wise statistics on land utilization in British India. In 1901/02,[3] out of 182 million ha of land for which the information was available, 12.3% was under forest and

[3]"1901/02" refers to the agricultural year beginning on July 1, 1901, and ending on June 30, 1902. In figures with

50.7% was under cultivation. About one fifth of the total cultivated land lay fallow. In 1941/42, these shares were similar, while the absolute acreage of land under forest or land under cultivation increased, at the annual growth rate of 0.54% and 0.33%, respectively. Besides the land under forest or under cultivation, there was a huge area that was not available for cultivation or was classified as cultivable waste. Most of these lands were barren, with very limited vegetation.

Table 1 also shows decade-wise land utilization in India, Pakistan, and Bangladesh after the Partition in 1947. Each series shows statistics for a geographic area corresponding to the current international borders of the three countries. In 1951/52, just after the partition, 17.0% of the reported land was under forest and 51.5% was under cultivation in India, higher than corresponding figures for Pakistan (3.0% and 32.6%). This shows that Pakistan inherited more barren land than India did. The area under forest in Bangladesh was 9.1%, which is between the share in India and that in Pakistan. The area under cultivation in Bangladesh was 64.2%, much higher than in India and in Pakistan.

In India and Pakistan, the area under forests and that under cultivation increased substantially throughout the post-independence period. The annual growth rates were higher in Pakistan (1.91% and 0.75%) than in India (0.70% and 0.23%), well above the figures for British India before independence as well. It is worth mentioning that the area not available for cultivation or cultivable waste decreased in India. In contrast, there was no growth of the area under cultivation in Bangladesh. The annual growth rate of "total area cultivated" was negative (-0.13%), but because of a rapid decline of the area under fallow, the growth rate of "net area sown" was close to zero (-0.09%).

The post-independence expansion of the cultivated area in India and Pakistan was more impressive and the post-independence stagnation of the cultivated area in Bangladesh was turned into an expansion if we take into account the area sown more than once during the agricultural year. Such changes in cropping patterns with accelerating intensity are the theme of the rest of this paper.

Regarding cropping patterns and crop output, there are several sources of information, covering Princely States. Utilizing these sources, Kurosaki (2007) compiled an updated version of the country-level dataset for India, Pakistan, and Bangladesh, covering a period from 1901/02 to 2003/04, and covering the production of principal crops that are contemporarily important in these countries.[4]

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limited space, it is shown as "1902."

[4] For India, eighteen crops are included: rice, wheat, barley, jowar (sorghum), bajra (pearl millet), maize, ragi (finger millet), gram (chickpea), linseed, sesamum, rapeseed & mustard, groundnut, sugarcane, tea, coffee, tobacco, cotton, and jute & mesta. For Pakistan, twelve major crops are covered: rice, wheat, barley, jowar, bajra, maize, gram, rapeseed & mustard, sesamum, sugarcane, tobacco, and cotton. For Bangladesh, fourteen crops are included: rice,

The data compilation procedure for the colonial period is explained in detail by Kurosaki (2007). Data on the areas that are currently in Pakistan and Bangladesh were subtracted from the database compiled by Sivasubramonian (2000). Information included in the district-level data in *Season and Crop Reports* from Punjab, Sind (or Bombay-Sind), the North-West Frontier Province, and Bengal, and the province-level data in *Agricultural Statistics of India* (before 1947) was utilized in the data compilation. The official data on the area and output of several produces for Bangladesh in the pre-1947 period were revised after consulting the "revision factor" estimated by Islam (1978).

Table 1 Decade-wise Land Utilization in India, Pakistan, and Bangladesh, 1901-2002.
(In million ha.)

| | Reported area (total of [1]-[5]) | Forest [1] | Not available for cultiva-tion [2] | Cultiva-ble waste [3] | Current fallow [4] | Net area sown [5] | Total area culti-vated ([4]+[5]) |
|---|---|---|---|---|---|---|---|
| British India | | | | | | | |
| 1901/02 | 182.01 | 22.33 | 33.66 | 33.73 | 16.08 | 76.20 | 92.28 |
| | (100.0%) | (12.3%) | (18.5%) | (18.5%) | (8.8%) | (41.9%) | (50.7%) |
| 1911/12 | 205.31 | 25.04 | 42.20 | 35.95 | 20.11 | 82.01 | 102.12 |
| 1921/22 | 205.52 | 26.78 | 39.58 | 36.45 | 18.88 | 83.84 | 102.72 |
| 1931/32 | 206.88 | 26.86 | 37.87 | 38.49 | 18.13 | 85.54 | 103.67 |
| 1941/42 | 207.25 | 27.67 | 36.86 | 37.32 | 19.08 | 86.32 | 105.40 |
| | (100.0%) | (13.3%) | (17.8%) | (18.0%) | (9.2%) | (41.6%) | (50.9%) |
| Growth rate | 0.32% | 0.54% | 0.23% | 0.25% | 0.43% | 0.31% | 0.33% |
| India | | | | | | | |
| 1951/52 | 287.83 | 48.89 | 50.17 | 40.40 | 28.96 | 119.40 | 148.36 |
| | (100.0%) | (17.0%) | (17.4%) | (14.0%) | (10.1%) | (41.5%) | (51.5%) |
| 1961/62 | 305.35 | 60.84 | 50.36 | 36.58 | 21.23 | 136.34 | 157.57 |
| 1971/72 | 304.02 | 65.41 | 41.82 | 34.66 | 24.53 | 137.59 | 162.12 |
| 1981/82 | 304.11 | 67.35 | 39.95 | 31.85 | 24.17 | 140.79 | 164.97 |
| 1991/92 | 304.84 | 67.98 | 40.91 | 29.40 | 23.83 | 142.72 | 166.55 |
| 2001/02 | 305.01 | 69.51 | 41.78 | 27.36 | 24.95 | 141.42 | 166.36 |
| | (100.0%) | (22.8%) | (13.7%) | (9.0%) | (8.2%) | (46.4%) | (54.5%) |
| Growth rate | 0.12% | 0.70% | -0.37% | -0.78% | -0.30% | 0.34% | 0.23% |
| Pakistan | | | | | | | |
| 1951/52 | 46.45 | 1.39 | 20.75 | 9.16 | 3.54 | 11.61 | 15.15 |
| | (100.0%) | (3.0%) | (44.7%) | (19.7%) | (7.6%) | (25.0%) | (32.6%) |
| 1961/62 | 50.99 | 1.68 | 18.73 | 12.46 | 4.85 | 13.27 | 18.12 |
| 1971/72 | 53.55 | 2.83 | 20.40 | 11.11 | 4.77 | 14.44 | 19.21 |
| 1981/82 | 53.92 | 2.85 | 19.90 | 10.86 | 4.89 | 15.41 | 20.30 |

wheat, barley, maize, gram, linseed, sesamum, rape & mustard, groundnut, sugarcane, tea, tobacco, cotton, and jute. These crops currently account for more than two thirds of the total output value from the crop sector in these countries and the contribution of these crops was higher in the colonial period.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1991/92 | 57.61 | 3.46 | 24.34 | 8.85 | 4.85 | 16.11 | 20.96 |
| 2001/02 | 59.28 | 3.61 | 24.50 | 9.13 | 5.67 | 16.32 | 21.99 |
| | (100.0%) | (6.1%) | (41.3%) | (15.4%) | (9.6%) | (27.5%) | (37.1%) |
| Growth rate | 0.49% | 1.91% | 0.33% | -0.01% | 0.94% | 0.68% | 0.75% |
| Bangladesh | | | | | | | |
| 1951/52 | 14.02 | 1.27 | 1.93 | 1.81 | 0.63 | 8.38 | 9.00 |
| | (100.0%) | (9.1%) | (13.8%) | (12.9%) | (4.5%) | (59.7%) | (64.2%) |
| 1961/62 | 14.28 | 2.22 | 2.43 | 0.75 | 0.41 | 8.47 | 8.88 |
| 1971/72 | 14.28 | 2.23 | 2.66 | 0.30 | 0.85 | 8.24 | 9.09 |
| 1981/82 | 14.29 | 2.14 | 2.77 | 0.25 | 0.55 | 8.58 | 9.13 |
| 1991/92 | 14.84 | 1.89 | 3.86 | 0.48 | 0.63 | 7.98 | 8.61 |
| 2001/02 | 14.84 | 2.58 | 3.51 | 0.32 | 0.41 | 8.02 | 8.43 |
| | (100.0%) | (17.4%) | (23.7%) | (2.2%) | (2.7%) | (54.1%) | (56.8%) |
| Growth rate | 0.11% | 1.41% | 1.06% | -3.45% | -0.87% | -0.09% | -0.13% |

Notes: The percentage in parenthesis shows the share in the total reported area. “Growth rate” shows an exponential annual growth rates throughout the per-1947 or the post-1947 period.

Data sources: For British India (excluding Burma), *Agricultural Statistics of India*, Government of India, various issues; For India, *Indian Agricultural Statistics*, Directorate of Economics and Statistics, Ministry of Agriculture, Government of India, various issues; For Pakistan (corresponding to contemporary Pakistan), *Economic Survey*, Ministry of Finance, Government of Pakistan, various issues. For Bangladesh (corresponding to contemporary Bangladesh), BBS web pages.

## 3 Analytical Framework

To analyze the growth performance of agriculture in the three countries, the gross output values of these crops are aggregated using 1960 prices,[5] and denoted by $Q$. As measures for partial productivity, $Q$ is divided by $L$ (the population estimates of India, Pakistan, and Bangladesh) or by $A$ (the sum of the acreage under the major crops covered in this article). As the first step to analyze the changes in agricultural productivity, a time series model for $Y_t$ is estimated as

$$\ln Y_t = a + bt + u_t \,, \qquad (1)$$

where $t$ is measured in years, $a$ and $b$ are parameters to be estimated, and $u_t$ is an error term. Equation (1) is estimated for the logarithm of $Q$, $Q/L$, and $Q/A$, by the ordinary least squares (OLS) method. The larger the coefficient estimate for $b$, the higher the growth rate of production or productivity. The standard error of regression for equation (1) shows variability, because it indicates how variable the output was around the fitted values in terms of the coefficient of variation.

Equation (1) can be extended to investigate the difference-in-difference (DID) of growth

[5] Ideally, the sum of the value-added evaluated at current prices and then deflated using a price index would be a better measure, but the sum of gross output values at constant prices is used as a proxy due to the absence of reliable data on input prices and quantities before independence. The results reported in this paper are insensitive to the choice of base year (1938/39 and 1980/81).

rates between the countries. Namely, we estimate

$$\ln Y_t^k = (a^k_0 + a^k_1 D_t) + (b^k_0 + b^k_1 D_t)\, t + u^k_t\,, \qquad (1')$$

for $k = I$ (India), $P$ (Pakistan), and $B$ (Bangladesh), where $D_t$ is a time dummy variable. For example, the DID estimator $b^I_1$ - $b^P_1$, when $D_t$ is set to one when $t$ is greater than 1947, captures the difference in growth rate changes observed between India and Pakistan after the Partition. Since both regions are inherently different, the potential level of output (captured by $a^k_0$ and $a^k_0 + a^k_1 D_t$) and the potential growth rate (captured by $b^k_0$) can differ. We are not interested in such a difference. Our interest is on the between-country difference in $b^k_1$. If the two regions were exposed to similar exogenous changes in environment, technology, and markets, then the DID estimator $b^I_1$ - $b^P_1$ can be interpreted as the impact of political regime change, i.e., the Partition. If it is not relevant to assume that the two regions experienced exactly the same changes in environment, technology, and markets, then the DID estimator $b^I_1$ - $b^P_1$ can be interpreted as the net impact of the regime change and changes in environment, technology, and markets. In this paper, the impact of the Partition using the whole sample period ($D_t$ is set to one when $t$ is greater than 1947) and the impact of Bangladesh's independence using the subsample after 1947 ($D_t$ is set to one when $t$ is greater than 1971) are investigated. The DID analysis contrasting the pre-1947 and the post-1947 periods for areas delineated by the contemporary international borders is the original contribution of this paper, which becomes feasible thanks to the use of the unusually long time series data.

In the next step, to capture long-term changes in the crop mix, the Herfindahl Index of crop acreage was calculated. Let $S_i$ be the acreage share of crop $i$ in the sum of the principal crops. The Herfindahl Index is defined as

$$H = \Sigma_i S_i^2\,, \qquad (2)$$

which can be intuitively understood as the probability of hitting the same crop when two points are randomly chosen from all the land under consideration. Therefore, a higher $H$ implies a greater concentration of acreage into a smaller number of crops.

In addition to $H$, two indices of crop compositions were calculated. The first measure, *SRW*, is defined as the sum of areas under rice and wheat divided by the sum of areas under cereal and pulses (so-called "foodgrains" in South Asia). This measure shows the tendency to grow the two Green Revolution crops instead of various kinds of coarse grains or pulses. The second measure, *SNF*, is defined as the sum of $S_i$ for non-foodgrain crops, which is a crude measure of the tendency toward growing non-food, pure cash crops.

The traditional approach in analyzing agricultural productivity is through growth accounting, estimating the total factor productivity (TFP) as a residual after controlling for factor inputs (Timmer, 1988). As a complement to the TFP approach, Kurosaki (2003) proposed a methodology to focus on the role of resource reallocation within agriculture --- across crops and across regions. Unlike in manufacturing industries, the spatial allocation of land is critically important in agriculture due to high transaction costs including transportation costs (Takayama and Judge, 1971; Baulch, 1997). Because of this, farmers may optimally choose a crop mix that does not maximize expected profits evaluated at market prices but does maximize expected profits evaluated at farm-gate prices after adjusting for transaction costs (Omamo, 1998a; 1998b). Subjective equilibrium models for farmers provide other reasons for the divergence of decision prices by farmers from market prices. In the absence of labor markets, households need to be self-sufficient in farm labor (de Janvry et al., 1991), and if insurance markets are incomplete, farmers may consider production and consumption risk or the domestic needs of their families (Kurosaki and Fafchamps, 2002). In these cases, their production choices can be expressed as a subjective equilibrium evaluated at household-level shadow prices.

During the initial phase of agricultural transformation, therefore, it is likely that the extent of diversification will be similar at the country level and the more micro levels because, given the lack of well-developed agricultural produce markets, farmers have to grow the crops they want to consume themselves (Timmer, 1997). As rural markets develop, however, the discrepancy between the market price of a commodity and the decision price at the farm level is reduced. In other words, the development of rural markets is a process which allows farmers to adopt production that reflects their comparative advantages more closely, and thus contributes to productivity improvement at the aggregate level evaluated at common, market prices. Therefore, the effect of crop shifts on productivity is a useful indicator of market development in developing countries.

To quantify this effect, changes in aggregate land productivity can be decomposed into crop yield effects, static inter-crop shift effects, and dynamic inter-crop shift effects (Kurosaki, 2003). Let $Y_t$ denote per-acre output in year $t$. Its growth rate from period 0 to period $t$ can be decomposed as

$$(Y_t - Y_0)/Y_0 = [\Sigma_i S_{i0}(Y_{it} - Y_{i0}) + \Sigma_i(S_{it} - S_{i0})Y_{i0} + \Sigma_i(S_{it} - S_{i0})(Y_{it} - Y_{i0})]/Y_0 \, , \qquad (3)$$

where the subscript $i$ denotes each crop so that $Y_{it}$ stands for per-acre output of crop $i$ in year $t$. The first term of equation (3) captures the contribution from the productivity growth of individual crops. The second term shows “static” crop shift effects, as it becomes more positive when the area under crops whose yields were initially high increases in relative terms. The third term shows “dynamic” crop shift effects, as it becomes more positive when the area under dynamic crops (i.e., crops whose yields are improving) increases relative to the area under non-dynamic crops.[6]

## 4 Gross Output and Land Productivity

### 4.1 *Total output and per-capita output*

The long-term trends of *Q* (total output value) are plotted in Figure 1. In all of the three countries, the total output value grew very little in the period before independence in 1947 and then grew steadily afterward.

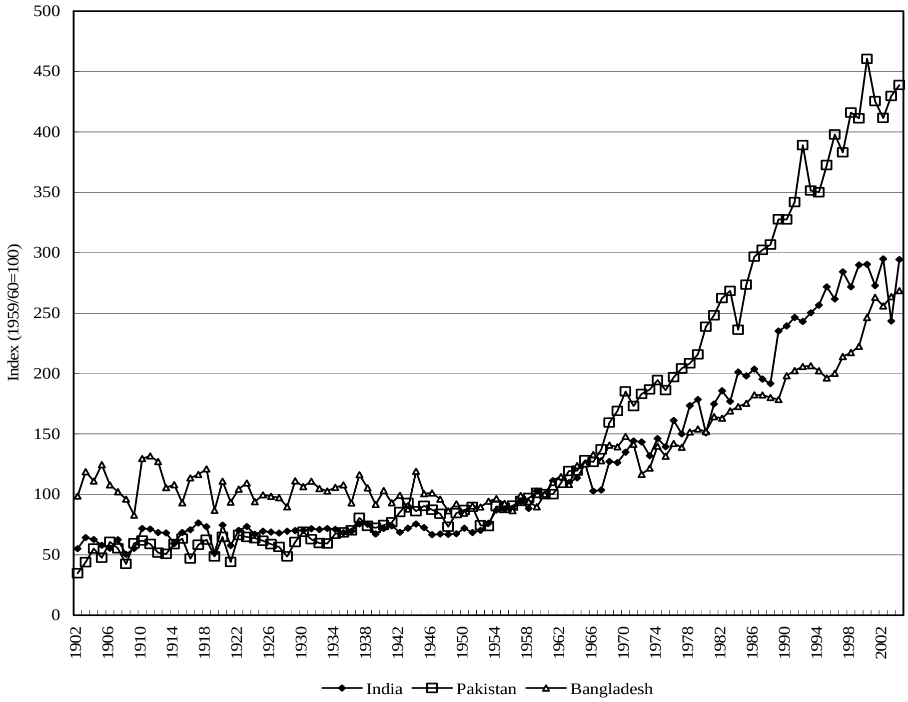


Figure 1 Agricultural Output (*Q*) in India, Pakistan, and Bangladesh, 1901/02-2003/04.

However, if we look at the figure in more detail, we observe differences across the three countries and across the decades. During the colonial period, the total output value in Bangladesh declined while that in Pakistan increased. India stood in between. In the post-1947 period, the total output value in Pakistan increased most rapidly, while that in Bangladesh increased slowly. Again, India stood in between. The timing when the growth accelerated further during the post-1947 period also differs across the three countries.

6 For each crop, another aspect of land-use changes can be investigated, focusing on the effect of inter-spatial crop shifts on land productivity. Kurosaki (2003) thus proposed a further decomposition of the crop yield effect for crop *i* in equation (3) into “District crop yield effects,” “Inter-district crop shift effects (static),” and “Inter-district crop shift effects (dynamic).” Kurosaki (2003) applied this decomposition to the district-level data of West Punjab from 1901/02 to 1991/92 and found that the inter-district shift effects were important contributor to productivity growth in cotton and rice.

To capture the between-country difference quantitatively, Table 2 reports the estimation results of equation (1), first for each decade and then for the pre- and post- 1947 periods. When we look at the results for each decade, we find that the total output value grew very little up to the Partition in all three countries. Only in Pakistan during the 1900s and 1930s, the growth rate was positive and statistically significant. When the whole pre-1947 period is taken, $Q$ grew at 1.3% per annum in Pakistan and at 0.4% in India, and it declined at 0.2% in Bangladesh, all of which were statistically significant. After the Partition, $Q$ increased in every decade in all three countries with statistical significance. The growth rates were generally higher in Pakistan than in India and Bangladesh. When the whole post-1947 period is taken, $Q$ grew at 3.5% per annum in Pakistan, at 2.7% in India, and at 2.0% in Bangladesh. The column "C.V." in Table 1 shows how variable was the output around the fitted values in terms of the coefficient of variation. The total output value was the most variable during the 1900s and 1910s but was stabilized since then, possibly due to the development of irrigation. The stabilization of agricultural output after the Partition is observed in all three countries. During the 1990s, the growth rate in India was 1.7%, a rate lower than the post-independence average of 2.7% but the 1990s were associated with less variability. The similar deceleration in agricultural growth, associated with stabilization, was observed in Pakistan during the 1990s as well.

Although these growth rates, except for the negative growth in the pre-1947 period in Bangladesh, seem impressive, they were not high enough to compensate for high population growth rates. This is shown in Figure 2, where the long-term trends of $Q/L$ (agricultural output per capita) is plotted, and in the middle columns of Table 1. In all three countries, including Pakistan, per-capita agricultural output declined in the colonial period. The decline was largest in Bangladesh (-1.2% per annum), followed by India (-0.4% per annum), which were statistically significant. The decline was larger in the 1920s and 1930s than in the 1900s and 1910s.

Table 2 Growth Performance of Agriculture in India, Pakistan, and Bangladesh, 1901-2004.

| | *Q* (Total output value) | | | *Q/L* (Output per capita) | | | *Q/A* (Output per acre) | | |
|---|---|---|---|---|---|---|---|---|---|
| | Growth rate | | C.V. | Growth rate | | C.V. | Growth rate | | C.V. |
| India | | | | | | | | | |
| 1901/02 - 10/11 | 1.31% | | 11.6% | 0.66% | | 11.6% | -0.25% | | 9.8% |
| 1911/12 - 20/21 | -0.81% | | 13.3% | -0.90% | | 13.3% | -0.47% | | 8.1% |
| 1921/22 - 30/31 | 0.05% | | 2.7% | -0.96% | ** | 2.7% | -0.28% | | 2.5% |
| 1931/32 - 40/41 | 0.29% | | 4.0% | -1.11% | ** | 4.0% | 0.15% | | 3.0% |
| 1941/42 - 50/51 | -0.52% | | 4.2% | -1.76% | *** | 4.2% | -1.42% | ** | 4.0% |
| 1951/52 - 60/61 | 4.24% | *** | 5.1% | 2.28% | *** | 5.1% | 2.34% | *** | 4.2% |
| 1961/62 - 70/71 | 2.53% | ** | 8.8% | 0.32% | | 8.8% | 1.89% | ** | 7.2% |
| 1971/72 - 80/81 | 2.62% | ** | 7.1% | 0.41% | | 7.1% | 2.12% | *** | 5.6% |
| 1981/82 - 90/91 | 3.21% | *** | 6.2% | 1.07% | | 6.2% | 3.23% | *** | 3.7% |
| 1991/92-2000/01 | 1.68% | *** | 3.5% | -0.27% | | 3.5% | 1.62% | *** | 2.4% |
| 1901/02 - 46/47 | 0.43% | *** | 8.7% | -0.39% | *** | 10.0% | -0.04% | | 6.2% |
| 1947/48-2003/04 | 2.72% | *** | 7.5% | 0.60% | *** | 7.6% | 2.19% | *** | 6.3% |
| Pakistan | | | | | | | | | |
| 1901/02 - 10/11 | 4.32% | ** | 15.1% | 2.75% | | 15.1% | 0.99% | | 10.9% |
| 1911/12 - 20/21 | -0.33% | | 14.6% | -1.18% | | 14.6% | -0.19% | | 6.6% |
| 1921/22 - 30/31 | -0.64% | | 10.3% | -1.73% | | 10.3% | -1.15% | | 7.4% |
| 1931/32 - 40/41 | 2.81% | *** | 5.8% | 0.97% | | 5.8% | 1.86% | ** | 5.1% |
| 1941/42 - 50/51 | 0.05% | | 6.7% | -2.92% | *** | 6.7% | -0.19% | | 3.4% |
| 1951/52 - 60/61 | 3.44% | *** | 5.2% | 1.00% | | 5.2% | 1.66% | *** | 3.3% |
| 1961/62 - 70/71 | 5.85% | *** | 5.2% | 2.99% | *** | 5.2% | 3.93% | *** | 4.5% |
| 1971/72 - 80/81 | 3.24% | *** | 3.7% | 0.09% | | 3.7% | 1.75% | *** | 3.3% |
| 1981/82 - 90/91 | 3.50% | *** | 5.2% | 0.85% | | 5.2% | 2.65% | *** | 5.3% |
| 1991/92-2000/01 | 2.30% | *** | 5.3% | -0.35% | | 5.3% | 1.61% | ** | 5.5% |
| 1901/02 - 46/47 | 1.30% | *** | 12.8% | -0.03% | | 11.9% | 0.38% | *** | 8.6% |
| 1947/48-2003/04 | 3.48% | *** | 8.2% | 0.68% | *** | 7.7% | 2.30% | *** | 6.4% |
| Bangladesh | | | | | | | | | |
| 1901/02 - 10/11 | 0.55% | | 15.6% | -0.55% | | 15.6% | -0.66% | | 13.4% |
| 1911/12 - 20/21 | -1.63% | | 12.1% | -2.53% | * | 12.1% | -1.15% | | 11.3% |
| 1921/22 - 30/31 | 0.52% | | 7.7% | -0.44% | | 7.7% | 0.57% | | 5.9% |
| 1931/32 - 40/41 | -0.98% | | 7.4% | -2.13% | ** | 7.4% | -1.19% | | 8.2% |
| 1941/42 - 50/51 | -1.76% | | 9.2% | -1.88% | * | 9.2% | -0.72% | | 6.8% |
| 1951/52 - 60/61 | 1.25% | * | 6.0% | -1.24% | * | 6.0% | 1.28% | ** | 3.9% |
| 1961/62 - 70/71 | 3.02% | *** | 4.1% | 0.34% | | 4.1% | 0.96% | ** | 3.1% |
| 1971/72 - 80/81 | 3.35% | *** | 3.9% | 1.03% | ** | 3.9% | 2.29% | *** | 2.9% |
| 1981/82 - 90/91 | 2.00% | *** | 2.9% | -0.15% | | 2.9% | 1.97% | *** | 2.2% |
| 1991/92-2000/01 | 2.60% | *** | 5.6% | 1.03% | | 5.6% | 1.99% | *** | 4.1% |
| 1901/02 - 46/47 | -0.24% | ** | 10.5% | -1.20% | *** | 10.6% | -0.21% | * | 9.4% |
| 1947/48-2003/04 | 2.00% | *** | 6.4% | -0.26% | *** | 7.1% | 1.39% | *** | 5.8% |

Source: Estimated by the author using the dataset described in the text.

Note: "Growth rate" provides a parameter estimate for the slope of the log of *Q* (or *Q*/*L* or *Q*/*A*) on a time trend, estimated by OLS (see equation (1)). The parameter estimate is statistically significant at 1% ***, 5% **, or 10% * (two sided t-test). "C.V." shows the coefficient of variation approximated by the standard error of the OLS regression.

Since 1947, per-capita output grew at statistically-significant growth rates in India and Pakistan. In both countries, the largest improvement in per-capita output occurred in the 1950s and 1960s. In sharp contrast, in Bangladesh during the post-1947 period, per-capita agricultural output continued to decline, although at a slower rate (-0.26% per annum) but still with statistical significance. In Bangladesh during the 1990s, however, the trend was turned around into a positive one (see also Figure 2).

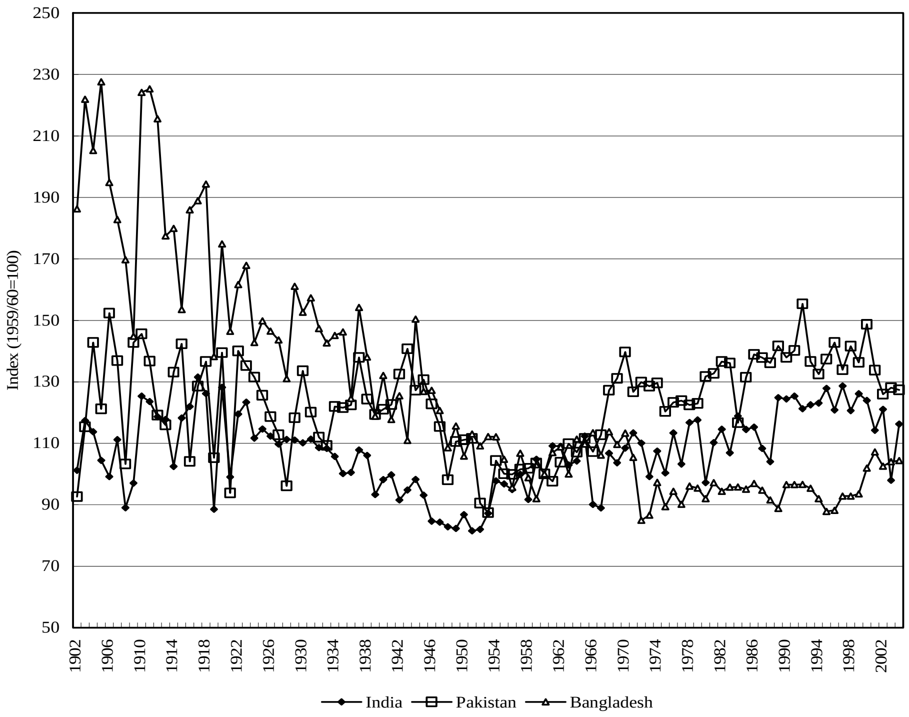


Figure 2 Agricultural Output Per Capita (*Q/L*) in India, Pakistan, and Bangladesh, 1901/02-2003/04.

### 4.2 *Aggregate land productivity*

The growth of total output (*Q*) can be decomposed into the contribution from the aggregate land productivity (*Q*/*A*) and the growth of cropped areas (*A*). To investigate how much of the growth (or stagnation) of output was due to the growth of the land productivity, Figure 3 plots the long-term trends of *Q*/*A* and the right columns of Table 2 report regression coefficients of the growth equation (1) for *Q*/*A*. First, the shape of Figure 3 is very close to that of Figure 1. Figure 3 again indicates the reversal of trends at around 1947 in all three countries --- aggregate land productivity stagnated during the pre-1947 period; since the Partition, it continued to grow. A surprising finding is that the reversal of the land productivity occurred *before* the breakthrough in the cereal production technology known as the “Green Revolution” in the late 1960s.

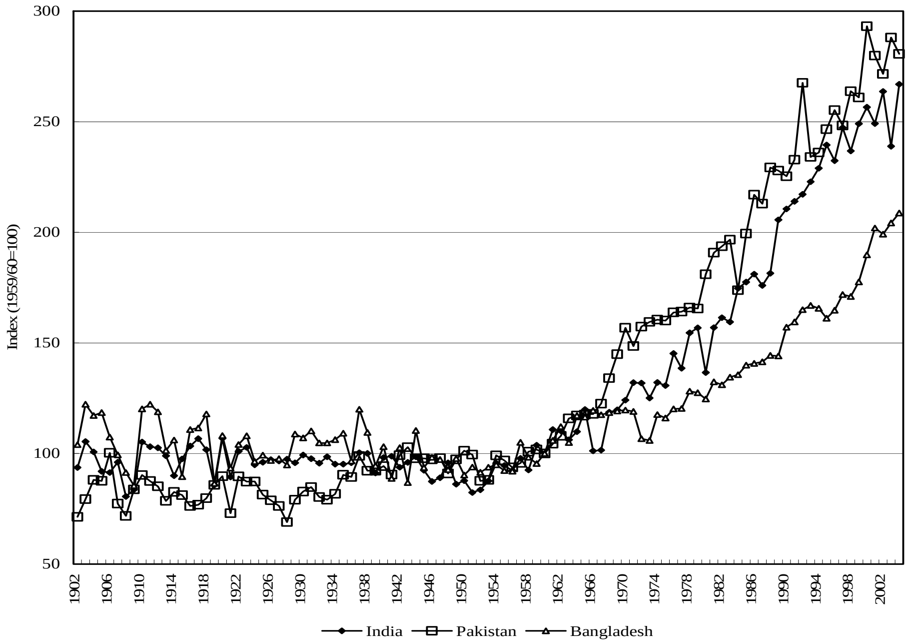


Figure 3 Agricultural Output Per Acre (Q/A) in India, Pakistan, and Bangladesh, 1901/02-2003/04.

To show this formally, a series of tests are conducted for a structural change of unknown timing for the entire 20th century, following the procedure by Hansen (2001). First, a time series model of (1') is estimated by OLS. For all candidate breakdates, Chow statistics for the null hypothesis of no structural change are estimated and their sequence is plotted as a function of candidate breakdates. The year with the highest Chow test statistics is the Quandt statistic, whose statistical significance can be tested by critical values provided by Bai and Perron (1998). If we can find a statistically-significant breakdate, the sample is then split in two and the test is re-applied to each subsample, following Bai and Perron's sequential procedure.

The breakdate estimates for *Q*/*A* in India, Pakistan, and Bangladesh are 1950/51, 1951/52, and 1949/50, respectively. All of the three are statistically significant at the 1% level. The hypothesis of two or more structural breaks is not supported by the data for India and Bangladesh, while the second break at 1934/35 was found with the 5% level significance for Pakistan. The dominant break at around 1950 is thus clearly shown for all three countries, confirming the previous results based on similar methods applied to South Asia (e.g., see Hatekar and Dongre, 2005; Kurosaki, 2003). In the context of India, the Nehruvian era was thus the turning point for agricultural productivity changes.

Coefficient estimates for *b* reported in Table 2 show that, during the pre-1947 period, agricultural output per acre stagnated (growth rate was -0.04% per annum and statistically insignificant) in India. Therefore, the growth of total output at 0.43% during the colonial period was totally attributed to the increase in cropped areas in India. During the post-1947 period, $Q$ in India grew at 2.7% per annum while $Q/A$ increased at 2.2%. Therefore, the major contribution to agricultural growth after independence came from the improvement in aggregate land productivity. During the 1980s and 1990s, the growth rates of $Q$ and $Q/A$ were very similar in India, indicating the limited contribution of area expansion to agricultural growth in recent years.

The experience in Pakistan was slightly different from that in India. Even during the pre-1947 period, $Q/A$ increased at 0.38% per annum, which was statistically significant. Nevertheless, considering the growth rate of total output at 1.3% in the colonial period, the dominant contribution to agricultural growth in Pakistan came from the increase in cropped areas before independence, as in India. During the post-1947 period, $Q$ in Pakistan grew at 3.5% per annum while $Q/A$ increased at 2.3%. Therefore, the major contribution to agricultural growth after independence came from the improvement of the overall land productivity in Pakistan, but the contribution from area expansion was larger in Pakistan than in India. Unlike in India, the contribution from area expansion to agricultural growth continued to be positive in Pakistan during the 1980s and 1990s.

In Bangladesh, the growth rate of $Q/A$ was negative before 1947 and its absolute value is close to that of the growth rate of $Q$. Therefore, the agricultural stagnation in Bangladesh during the British period can be attributed to the stagnation in land productivity, rather than a decrease in cropped areas. During the post-1947 period, $Q$ in Bangladesh grew at 2.0% per annum while $Q/A$ increased at 1.4%. Therefore, the major contribution to agricultural growth came from the improvement in land productivity in Bangladesh, but the contribution from area expansion (land-use intensification) was also substantial, and its contribution continued to be positive during the 1990s. Furthermore, unlike in India or Pakistan, the growth of $Q/A$ did not decelerate during the 1990s in Bangladesh. Comparing the growth rates during the 1990s, the performance of the Bangladeshi agriculture thus surpassed those of India and Pakistan.

### 4.3 *Difference-in-difference*

From Table 2, it was found that the level of growth performance was highest in Pakistan, followed by India, with Bangladesh at the bottom. However, it is possible that such difference in growth levels reflects the inherent differences among these countries, such as agro-ecological conditions, leading to the difference in potential growth rates. To capture the impact of regime shifts, it is better to focus on the difference-in-difference (DID). Therefore, equation (1') was estimated, whose results are reported in Table 3.

When the pre-1947 and post-1947 performances are compared for $Q$ (total agricultural output), there are no significant difference across the three countries. In all of them, the growth rate of *Q* increased by 2 percentage points after the Partition. When the DID in *Q*/*L* (per-capita output) is compared, the additional growth after the Partition is less in Pakistan than in India or Bangladesh. The difference between India's and Pakistan's performances is marginally significant. This reflects the higher population growth rates in Pakistan after the Partition than in India or Bangladesh. When the pre-1947 and post-1947 performances are compared for *Q*/*A* (per-acre output), the top achiever is India, followed by Pakistan, with Bangladesh at the bottom. The pair-wise difference is statistically significant for all three pairs. The null hypothesis that the three countries' performances are the same is also rejected at the 1% level for *Q*/*A*.

Table 3 Difference-in-Difference of Agricultural Growth Rates in India, Pakistan, and Bangladesh, 1901-2004.

| | *Q* (Total output value) | | *Q/L* (Output per capita) | | *Q/A* (Output per acre) | |
|---|---|---|---|---|---|---|
| 1. Impact of the Partition, 1947 | | | | | | |
| (a) Difference in growth rates after 1947 ($b_1$ in equation (1')) | | | | | | |
| India | 2.29% | *** | 1.00% | *** | 2.23% | *** |
| Pakistan | 2.18% | *** | 0.70% | *** | 1.91% | *** |
| Bangladesh | 2.24% | *** | 0.94% | *** | 1.60% | *** |
| (b) Statistical significance of the difference-in-difference (chi2 statistics) | | | | | | |
| India=Pakistan ($b_1^I = b_1^P$) | 0.51 | | 3.53 | * | 6.29 | ** |
| Pakistan=Bangladesh ($b_1^P = b_1^B$) | 0.15 | | 1.97 | | 5.27 | ** |
| Bangladesh=India ($b_1^B = b_1^I$) | 0.14 | | 0.14 | | 40.52 | *** |
| India=Pakistan=Bangladesh | 0.53 | | 3.67 | | 41.16 | *** |
| 2. Impact of Bangladesh's independence, 1971 | | | | | | |
| (a) Difference in growth rates after 1971 (b1 in equation (1')) | | | | | | |
| Pakistan | -0.63% | ** | -0.77% | *** | 0.00% | |
| Bangladesh | -0.19% | | 0.27% | | 0.54% | *** |
| (b) Statistical significance of the difference-in-difference (chi2 statistics) | | | | | | |
| Pakistan=Bangladesh ($b_1^P = b_1^B$) | 2.71 | * | 13.58 | *** | 5.78 | ** |

Source: Estimated by the author using the dataset described in the text.

Note: "Difference in growth rates" is estimated by a seemingly unrelated regression (SUR) model treating three countries as a system. The parameter estimate for the difference in growth rates is statistically significant at 1% ***, 5% **, or 10% * (two sided t-test). "Statistical significance of the difference-in-difference" reports chi2 statistics for testing across-equation restrictions on the SUR model. The degrees of freedom for the chi2 statistics are 1 when two countries are compared and 2 when three countries are compared. The null hypothesis that the difference-in-difference is zero is rejected at 1% ***, 5% **, or 10% *.

From these DID results, one is tempted to conclude that the agricultural performance in Pakistan and Bangladesh was adversely affected by the political regime change in 1947, and the adverse impact of the politics was larger in Pakistan. This interpretation assumes that India and United Pakistan experienced exactly the same changes in environment, technology, and markets, which is difficult to accept. It thus makes more sense to interpret these results as that the net effect of various kinds of exogenous macro changes that occurred after 1947 was more negative in Pakistan than in India, with Bangladesh in between.

To investigate growth changes that occurred in East Pakistan after it became the independent nation of Bangladesh, the pre-1971 and post-1971 performances are compared between Pakistan and Bangladesh. The subsample after the Partition is used for this exercise. The DID results are reported in the lower half of Table 3. Pakistan's growth rates declined ($Q$ and $Q/L$) or remained unchanged ($Q/A$) after 1971, while Bangladesh's growth rates remained unchanged ($Q$) or were increased ($Q/L$ and $Q/A$). The DID is statistically significant for all three indicators. Therefore, the net effect of exogenous macro changes that occurred after 1971 was more negative in Pakistan than in Bangladesh. The late surge of "Green Revolution" in Bangladesh during the late 1980s and 1990s (Rogaly et al., 1999) could be responsible for these DID results.

### 4.4 *Summary and comparison with previous studies*

The above findings suggest that, first, the Partition in 1947 reversed the trends of agricultural production in India, Pakistan, and Bangladesh, leading to a sustained growth of total output and land productivity. Factors responsible for this reversal may include the food production campaigns just after the Partition, national programs for agricultural extension and rural development, and institutional reforms including land reforms. Another important factor in increasing crop areas as well as land productivity could be the expansion of irrigation since 1947 in India and Pakistan.

Second, among the three countries, Pakistan achieved the highest growth throughout the period, and its superior performance was especially significant before 1947. Nevertheless, the performance in India improved after 1947 and that in Bangladesh improved during the latest years.

Third, all of the three countries experienced the reversal of the land productivity at around 1950. In all of them, the growth rate of $Q/A$ during the 1950s was positive and statistically significant. It is important to note that the reversal of the land productivity occurred *before* the breakthrough of the "Green Revolution." As Kurosaki (1999) showed, the per-acre yields of rice and wheat were stagnant during the 1950s.

The first two points confirm research results found in the existing literature. Considering the fact that we calculate the gross value of output, patterns depicted in Figures 1-3 during the colonial period are reasonably close to those in Sivasubramonian's (2000) estimates for the value-added for Undivided India. The overall growth rates during the pre-1947 period reported in Sivasubramonian (2000) lie within the range of our estimates for the total output value for India, Pakistan, and Bangladesh. A new insight from this study is that the positive growth rate in Undivided India was mostly attributable to the growth that occurred in the areas currently in Pakistan.

This paper also confirms Blyn's (1966) finding for British India that agricultural production increased until the late 1910s, followed by fluctuations with their average lower than the previous peak. This study decomposes this pattern into contributions from the areas currently in India, Pakistan, Bangladesh separately, to find a contrast that Pakistan areas were most favored before 1947 but Pakistan's superiority in growth performance was reduced after 1947.

The regional contrast after the Partition was demonstrated in earlier studies that compared agricultural performance in West and East Punjab --- Prabha (1969) quantified this contrast through investigation on official data and Sims (1988) explained it through a political-economy approach. This study has added new evidence that the contrast can be extended to the country level between India and Pakistan. Similarly, the stagnation of agricultural production and the decline of per-capita output during the colonial period in areas currently in Bangladesh, which we found in this study, confirms Islam's (1978) finding for various regions of (united) Bengal and the recent acceleration of agricultural production in Bangladesh found in this study confirms the dynamic changes reported by Rogaly et al. (1999). This study has added new evidence that these findings can be extended to the country level between Bangladesh and India (or Pakistan).

The third point was first indicated by Kurosaki (1999; 2002). The point is that even with no changes in land productivity of individual crops and in available land for cultivation, agricultural output can grow by shifting the crop mix toward high value crops. This shift is accelerated when rain-fed land is turned into irrigated land. Although the aggregate output per acre did increase during the 1950s at a statistically significant rate, per-acre productivity of major crops (rice and wheat) did not increase much during the same period. Therefore, one of the most important factors for the reversal at the Partition should have been a change in crop composition toward high value crops, as shown in the next section.

## 5 Changes in Crop Mix and Their Contribution to Land Productivity

### 5.1 *Trends in crop mix*

Figure 4 shows the Herfindahl Index (*H*) of crop acreage over the study period. There are several interesting contrasts among India, Pakistan, and Bangladesh. First, there is a difference in overall levels. In every year, *H* is the highest in Bangladesh and the lowest in India, with Pakistan in the middle. This seems to reflect the size of the economy and the diversity of agro-ecological conditions. Indian agriculture is the largest and the most diverse among the three, resulting in the lowest crop concentration ratio in India.

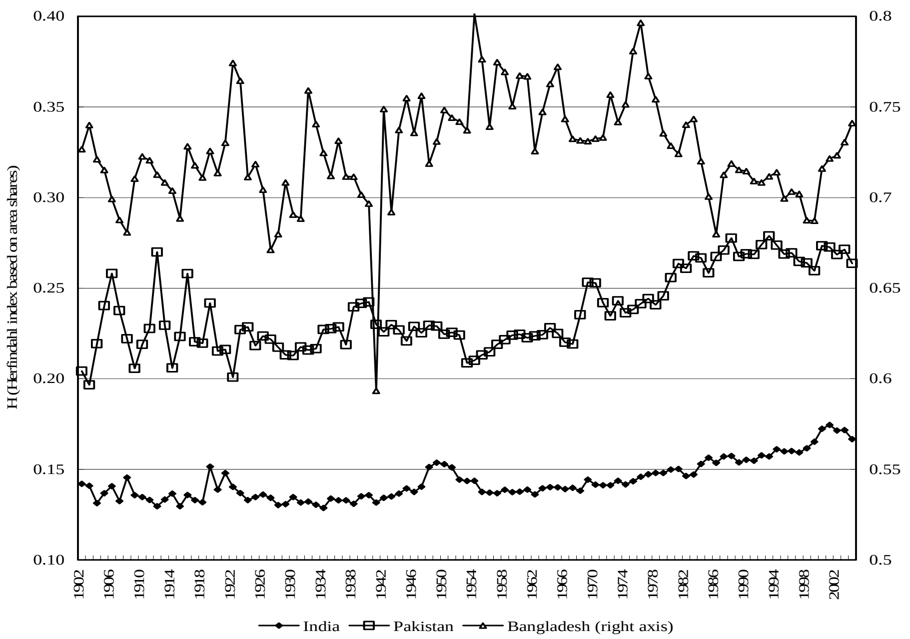


Figure 4 Crop Concentration in India, Pakistan, and Bangladesh, 1901/02-2003/04.

Second, there is a difference in annual fluctuations: *H* of India is the most stable and *H* of Bangladesh is the most variable, with Pakistan in the middle. This again seems to reflect the size of the economy.

Third, a distinct pattern emerges after the independence in India and Pakistan --- *H* fluctuated with no trend before 1947 while it increased continuously since the mid 1950s. In contrast, it is difficult to find such a shift at the Partition for Bangladesh. According to Timmer’s (1997) stylization, the one-way concentration of crops since the mid 1950s in India and Pakistan can be interpreted as a stage before a mature market economy with diversified production and consumption at the national level.

Fourth, there is a difference in recent trends. In India, the level of concentration accelerated in the 1990s and seems to have reached a plateau in the early 2000s. In contrast, the crop concentration index in Pakistan did not accelerate in the 1990s but it remained at the high level that had already been reached during the late 1980s or early 1990s. This seems to indicate that shifts in acreage toward crops with comparative advantages occurred earlier in Pakistan than in India, possibly reflecting Pakistan's attempt to liberalize agricultural marketing during the early 1980s. The recent trend in *H* for Bangladesh seems to be a negative one. According to Timmer's (1997) stylization, when the agriculture of a country enters the next stage with a mature market economy, both production and consumption become diversified at the national level. Figure 4 may suggest that such transformation occurred first in Bangladesh during the early 1980s, followed by Pakistan in the late 1980s, and finally occurring in India in the early 2000s.

The changes in crop composition are shown more concretely in Figures 5 and 6. In all three countries, *SRW* (the sum of areas under rice and wheat divided by the sum of areas under foodgrains) increased throughout the 20th century and the trend was accelerated during the post-colonial period (Figure 5). Therefore, there is a strong tendency to shift to the two Green Revolution crops instead of various kinds of coarse grains or pulses. However, the trend of *SRW* in Bangladesh is weak because the rice is highly dominant as the staple crop.

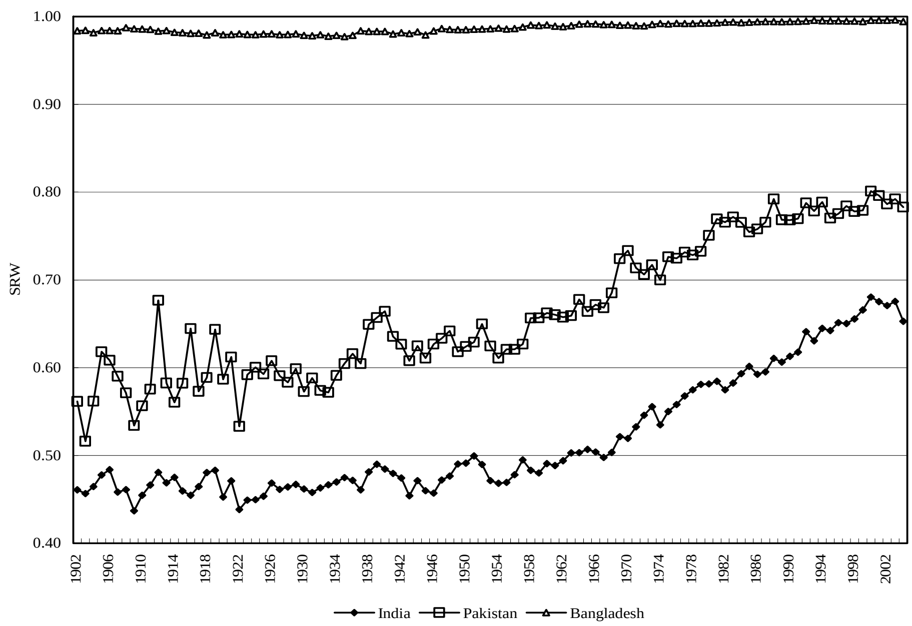


Figure 5 Area Share of Rice and Wheat in Total Foodgrains Acreage in India, Pakistan, and Bangladesh, 1901/02-2003/04.

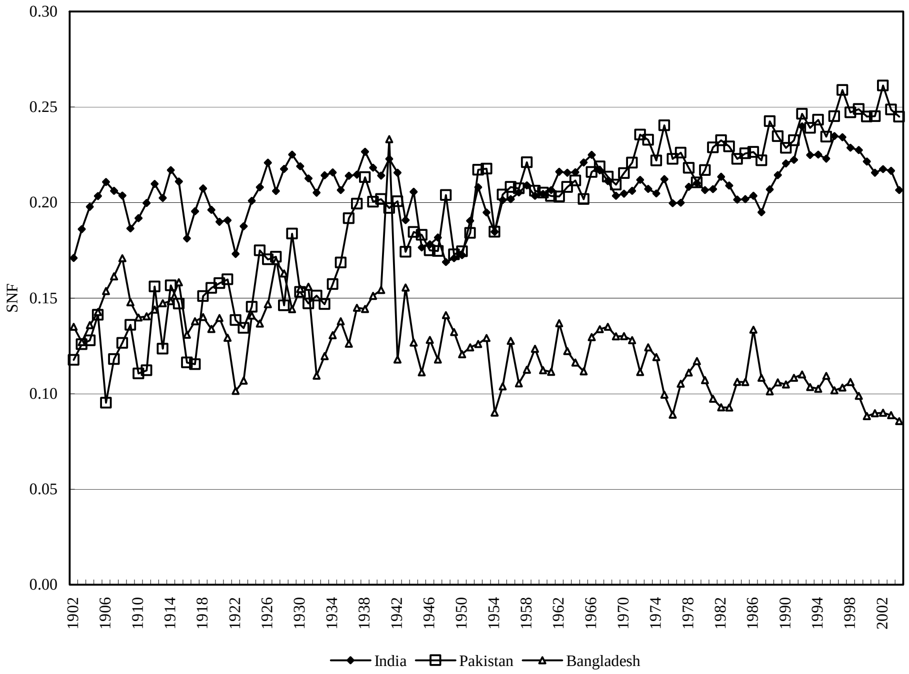


Figure 6 Area Share of Non-Foodgrains in Total Acreage in India, Pakistan, and Bangladesh, 1901/02-2003/04.

The movement of the sum of shares of non-foodgrain crops, *SNF*, shows again the contrast between Bangladesh on the one hand and India and Pakistan on the other (Figure 6). In Bangladesh, *SNF* is declining throughout the study period, while in India and Pakistan, it stagnated initially and then it continued to rise in the second half of the 20th century. In India and Pakistan, the rising *SNF* shows that there is a strong tendency toward growing non-food, pure cash crops. The declining *SNF* in Bangladesh seems to cast doubt on our previous interpretation that Bangladesh entered the diversified production pattern earlier than India and Pakistan did. However, if we exclude the share of rice, the movement of *SNF* in Bangladesh became similar to those in India and Pakistan. Here again, Bangladesh is exceptional because the rice is highly dominant.

Looking from a different angle, a contrast among the three countries could be attributed to India's more diversified geography. Using Timmer's (1997) stylization, Bangladesh's agriculture is more like a household economy in a relative sense than Pakistan's is, and Pakistan's agriculture is more like a household economy in a relative sense than India's is. Furthermore, India's food policy has been more regulatory than Pakistan's or Bangladesh's, less exposed to international trade, especially until the Economic Reforms in the early 1990s. These factors might have resulted in a weaker tendency to specialize in a few crops in India than in the other two countries. Whether these conjectures are correct or not should be examined more carefully through investigating production diversification at the household level and food consumption diversification at the national level, which is left for further research.

### 5.2 *Contribution of crop shifts to aggregate land productivity*

To investigate whether these changes in crop mix were consistent with those indicated by comparative advantage and market development, decomposition (3) was implemented. The results are reported in Table 4.

For areas currently in India, first, the contribution of total crop shift effects is substantial, explaining more than 20% of post-independence growth in aggregate land productivity. Second, with more detailed period demarcation, it is shown that the relative importance of crop shift effects has been increasing throughout the post-independence period. During the 1950s, less than 5% of land productivity growth was attributable to crop shift effects; during the 1990s, about 40% was due to crop shifts. Third, the dynamic crop shift effect was an important source of productivity growth only during the 1960s. In other periods, the static crop shift effect was more important than the dynamic effect. Fourth, during the pre-independence period, crop shift effects played a positive role under adverse conditions of declining crop yields. But for the positive contribution from static crop shift effects, the total land productivity growth rates would have been much more negative in the three decades from the 1920s to 1940s.

Interestingly, in India during the 1990s, the growth due to improvements in crop yields was reduced compared to the 1980s while the growth due to static crop shifts was higher. As a result, the relative contribution of static shift effects was as high as 39% in the 1990s. This is the highest figure for all the post-independence decades. Therefore, it can be concluded that the changes in crop mix in the 1990s (the decade of economic liberalization in India) were indeed consistent with the comparative advantages of Indian agriculture, leading to an improvement in aggregate land productivity.

The middle rows of Table 4 show the decomposition results for Pakistan. The crop yield effect explained about 70% both in pre- and post- independence periods, while the rest was explained mostly by dynamic shift effect before 1947 and by both dynamic and static shift effects after 1947. The importance of the dynamic shift effect before independence could be attributable to the development of the Canal Colony as an agricultural export base in British India. As is discussed in Section 3, the dynamic crop shift effect becomes more positive when the area under dynamic crops increases relative to the area under non-dynamic crops. During the colonial period, rice and cotton were the dynamic crops in West Punjab and the cultivation of these two crops was regionally concentrating into advantageous districts (Kurosaki, 2003).

Decade-wise, the importance of crop shift effects in Pakistan was highest during the 1950s and it has been declining since then. This pattern in Pakistan after independence is opposite to India’s. In Pakistan, during the 1950s, more than 45% of land productivity growth was attributable to crop shift effects; during the 1980s and 90s, less than 20% was due to crop shifts.

During the 1950s, the contribution of the static shift effect was in a magnitude close to that of yield improvements. These results show that land reallocation toward high value crops was the main engine of agricultural growth during the pre-Green Revolution period after independence in Pakistan. During the 1990s in Pakistan, the growth due to improvements in crop yields declined substantially while the growth due to static crop shifts recovered. As a result, the relative contribution of static shift effects was 16% in the 1990s, a level higher than the post-independence average (13%). Here we find a similarity between India and Pakistan: in both economies, the crop shifts were an important source of land productivity growth in the post-independence period, and especially in the 1990s.

In sharp contrast, the contribution of crop shift effects to the improvement in aggregate land productivity was small in Bangladesh (see the lower rows of Table 4). The crop yield effects explained about 100% of changes in aggregate land productivity in Bangladesh, both in pre- and post- independence periods. One possible interpretation of this finding is that Bangladesh is a region where commercialization occurred earlier so that the room for additional crop shifts to increase the land productivity was small already during the first half of the 20th century. In other words, Bangladesh's agriculture has had a very strong comparative advantage in rice cultivation since the early 20th century (or earlier than that) and this advantage was already exploited when the study period of this paper began.

Looking at the decomposition results for each decade in Bangladesh, however, we find that the static shift effects were important sources of aggregate land productivity growth during the 1950s and 1960s. Examining the crop database, we found that these two decades were a period when sugarcane production expanded and sugarcane had higher values per acre than other crops. Therefore, the decomposition results for Bangladesh are also consistent with prevailing market conditions and farmers' response to comparative advantage.

These results thus indicate that the changes in crop mix were an important source of growth in aggregate land productivity in all three countries of India, Pakistan, and Bangladesh, although the contribution of crop shift effects was small in Bangladesh because of the dominance of rice in cultivation. Throughout the post-independence period, there were substantial contributions from both static and dynamic crop shift effects in India and Pakistan.

Table 4 Contribution of Crops Shifts to Land Productivity Growth in India, Pakistan, and Bangladesh.

| | *Q/A* (%) | | | | Contribution share (%) | | |
|---|---|---|---|---|---|---|---|
| | Pure yield effects | Static shift effects | Dynamic shift effects | Total | Pure yield effects | Static shift effects | Dynam ic shift effects |
| India | | | | | | | |
| 1901/02 - 11/12 | 0.92 | -0.05 | -0.06 | 0.81 | 113.4 | -6.3 | -7.1 |
| 1911/12 - 21/22 | -0.24 | -0.10 | 0.07 | -0.27 | 88.5 | 36.4 | -24.9 |
| 1921/22 - 31/32 | 0.03 | 0.27 | -0.08 | 0.23 | 14.1 | 119.1 | -33.3 |
| 1931/32 - 41/42 | -0.36 | 0.30 | -0.06 | -0.11 | 324.5 | -277.5 | 53.0 |
| 1941/42 - 51/52 | -1.49 | 0.30 | -0.02 | -1.21 | 123.0 | -24.5 | 1.5 |
| 1951/52 - 61/62 | 2.76 | 0.14 | -0.01 | 2.89 | 95.3 | 5.0 | -0.3 |
| 1961/62 - 71/72 | 1.55 | 0.15 | 0.20 | 1.90 | 81.6 | 8.0 | 10.3 |
| 1971/72 - 81/82 | 1.83 | 0.35 | 0.09 | 2.28 | 80.6 | 15.4 | 4.0 |
| 1981/82 - 91/92 | 3.10 | 0.44 | 0.14 | 3.68 | 84.2 | 12.1 | 3.7 |
| 1991/92-2001/02 | 0.87 | 0.59 | 0.06 | 1.51 | 57.5 | 38.7 | 3.7 |
| 1901/02 - 47/48 | -0.15 | 0.01 | 0.15 | 0.00 | n.a. | n.a. | n.a. |
| 1947/48-2003/04 | 2.79 | 0.21 | 0.63 | 3.63 | 76.7 | 5.8 | 17.5 |
| Pakistan | | | | | | | |
| 1901/02 - 11/12 | 1.84 | -0.19 | 0.09 | 1.74 | 105.4 | -10.8 | 5.4 |
| 1911/12 - 21/22 | 0.06 | -0.05 | 0.02 | 0.02 | 254.3 | -226.2 | 71.9 |
| 1921/22 - 31/32 | -0.35 | 0.03 | 0.02 | -0.31 | 113.4 | -8.5 | -4.9 |
| 1931/32 - 41/42 | 1.51 | 0.16 | 0.32 | 1.99 | 75.8 | 8.2 | 16.0 |
| 1941/42 - 51/52 | -0.80 | 0.18 | 0.03 | -0.58 | 136.6 | -30.6 | -6.0 |
| 1951/52 - 61/62 | 1.03 | 0.85 | 0.03 | 1.92 | 53.8 | 44.4 | 1.8 |
| 1961/62 - 71/72 | 3.37 | 0.52 | 0.28 | 4.16 | 80.8 | 12.5 | 6.7 |
| 1971/72 - 81/82 | 1.72 | 0.63 | 0.13 | 2.49 | 69.2 | 25.4 | 5.4 |
| 1981/82 - 91/92 | 2.35 | 0.07 | 0.21 | 2.63 | 89.3 | 2.5 | 8.2 |
| 1991/92-2001/02 | 1.19 | 0.23 | 0.02 | 1.43 | 82.8 | 16.1 | 1.1 |
| 1901/02 - 47/48 | 0.55 | -0.03 | 0.22 | 0.74 | 74.5 | -4.0 | 29.6 |
| 1947/48-2003/04 | 2.50 | 0.48 | 0.61 | 3.59 | 69.7 | 13.3 | 17.0 |
| Bangladesh | | | | | | | |
| 1901/02 - 11/12 | 1.38 | -0.28 | -0.11 | 0.99 | 139.5 | -28.3 | -11.1 |
| 1911/12 - 21/22 | -1.08 | 0.00 | 0.00 | -1.09 | 99.5 | 0.3 | 0.2 |
| 1921/22 - 31/32 | 0.32 | 0.09 | 0.05 | 0.47 | 68.8 | 19.7 | 11.5 |
| 1931/32 - 41/42 | -1.99 | 0.73 | -0.06 | -1.32 | 151.2 | -55.7 | 4.5 |
| 1941/42 - 51/52 | 0.71 | -0.50 | -0.16 | 0.05 | 1339.2 | -944.5 | -294.7 |
| 1951/52 - 61/62 | 1.35 | 0.20 | 0.02 | 1.57 | 86.0 | 12.7 | 1.3 |
| 1961/62 - 71/72 | 0.09 | 0.20 | 0.00 | 0.28 | 32.4 | 69.1 | -1.5 |
| 1971/72 - 81/82 | 2.04 | -0.20 | 0.14 | 1.98 | 103.2 | -10.2 | 7.1 |
| 1981/82 - 91/92 | 2.19 | 0.22 | -0.07 | 2.35 | 93.4 | 9.5 | -2.9 |
| 1991/92-2001/02 | 2.46 | -0.19 | 0.05 | 2.32 | 106.0 | -8.0 | 2.0 |
| 1901/02 - 47/48 | -0.18 | 0.01 | 0.00 | -0.17 | 107.6 | -6.8 | -0.8 |
| 1947/48-2003/04 | 2.15 | -0.02 | 0.04 | 2.18 | 98.8 | -0.8 | 2.0 |

Source: Estimated by the author using the dataset described in the text.

Note: Annual growth rates were estimated using the method explained in the text (see eq. (3)). Since both the estimate model and the data treatment for smoothing are different, the total growth rates of land productivity in this table are slightly different from those in Table 2.

## 6 Conclusion

Based on a production dataset from India, Pakistan, and Bangladesh for the period 1901-2004, this article investigated changes in land use, associating the changes with long-term agricultural performance, focusing on the contribution of crop shifts to improvement in agricultural productivity. The empirical results showed a discontinuity between the pre- and the post-independence periods in all of the three countries. Total output growth rates rose from zero or very low figures to significantly positive levels, which were sustained throughout the post-independence period. The improvement in aggregate land productivity explained the most of this output growth.

This article also quantified the effects of crop shifts on aggregate land productivity, a previously unnoticed source of productivity growth. It was found that the crop shifts contributed to the productivity growth, especially during periods with limited technological breakthroughs. The contribution of the crop shifts was larger in India and Pakistan than in Bangladesh, where rice is highly dominant as the staple crop. Underlying these changes were the responses of farmers to changes in market conditions and agricultural policies. Agriculture in these countries experienced a period of concentration of crops, when agricultural transformation in terms of output per agricultural worker was proceeding. These trends continued until the early 1980s in Bangladesh, until the early 1990s in Pakistan, and until the early 2000s in India. The performance in the latest periods suggests that agriculture in the region seems to have entered a new phase of diversified production and consumption at the country level (Timmer, 1997). The contrast in the beginning time of the new phase can be attributed to the difference in farmers' exposure to international prices created by the difference in trade and industrial policies of these countries.

In all three countries in the post-1947 period, however, the growth rate of aggregate land productivity was not high enough to cancel the negative growth rate of land availability per capita. The net result was that the growth rate of agricultural output per capita was much smaller than that of output per acre, resulting in a slow pace of poverty reduction in these countries. The crop shift effects identified in this article were not sufficiently strong in this sense. Reducing population growth rates and absorbing more labor force outside agriculture are required to make the growth rate of per-capita agricultural output comparable to that of per-acre agricultural output.

Although this paper showed the importance of crop shifts in improving aggregate land productivity, the overall impact is underestimated, because only major crops were covered. Incorporating non-traditional crops into the framework of this paper would be highly desirable. To quantify the structural determinants of these changes and their net effects on the welfare of rural population, further research is needed, such as analysis of production costs, investigation of livestock activities, etc. These are left for future study.

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