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**Long-term Agricultural Growth in India, Pakistan,
and Bangladesh from 1901/02 to 2001/02**

Takashi Kurosaki

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HITOTSUBASHI UNIVERSITY

Research Project **PRIMCED**
Institute of Economic Research
Hitotsubashi University
2-1 Naka, Kunitatchi Tokyo, 186-8601 Japan
<http://www.ier.hit-u.ac.jp/primced/e-index.html>

Long-term Agricultural Growth in India, Pakistan, and Bangladesh from 1901/02 to 2001/02[#]

Takashi Kurosaki*

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Abstract: This paper investigates the growth performance of agriculture in India, Pakistan, and Bangladesh in the twentieth century. The use of unusually long-term data that correspond to the current borders for the period 1901-2002 and the focus on crop shifts as a source of growth distinguish this study from the existing ones. The empirical results show a sharp discontinuity between the pre- and the post- independence periods in all three countries: growth rates in total output, labor productivity, and land productivity 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, of which approximately one third was attributable to shifts to more lucrative crops.

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* Institute of Economic Research, Hitotsubashi University, 2-1 Naka, Kunitachi, Tokyo 186-8603 Japan. Phone: 81-42-580-8363; Fax.: 81-42-580-8333. E-mail: kurosaki@ier.hit-u.ac.jp.

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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 paper to investigate the source of agricultural growth during the last century focusing on changes in land use. The importance of agriculture in poverty reduction was re-emphasized in the *World Development Report 2008* (World Bank 2008) as well.

Another factor that motivated this paper is the recent emergence of India as a fast growing tiger economy. This makes it more interesting to understand the long-run performance of Indian economy in comparison to other countries. In the recent literature, such an attempt is found, for example, between India and China by Bosworth and Collins (2008) and between India and the UK by Broadberry and Gupta (2010). Although informative, these comparisons ignore the huge heterogeneity in agro-climatic conditions between the countries compared. In contrast, the three countries in South Asia analyzed in this paper are much more comparable in terms of geographic characteristics. Furthermore, the three countries were under the same political regime until 1947. When the Indian Subcontinent was divided into India and (United) Pakistan in August 1947, the boundaries were drawn not based on the

economic rationale but based on the religious population shares in 1931 through a complicated political process (e.g., see Sadullah et al. 1993). The complete absence of economic considerations such as market or irrigation or electricity networks at the time of Partition provides us with a unique opportunity to investigate the impact of political regime changes on agricultural performance using a framework of natural experiments.

Based on these motivations, this paper examines changes in long-term agricultural performance in India, Pakistan, and Bangladesh 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 1901-2001 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) 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

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, 2011), using government statistics and revising the author's previous estimates. Using the previous versions of these datasets, Kurosaki (1999) and Kurosaki (2002) compared 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, Kurosaki (2006) extended the analysis for India and Pakistan using data until 2004, and Kurosaki (2009) included Bangladesh in the comparison. The most significant difference of this paper from these previous ones is the use of the value-added series for the entire crop sector (all previous papers used the gross output value series for the major crops subsector).

land, which is immovable by definition.

The rest of the article is organized as follows. The next section describes the data used in this paper. Section 3 explains the analytical framework. 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 Data

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

As explained in detail by Kurosaki (2011), we compiled statistics beginning from 1901/02³ that corresponds to the current international borders. We began with individual crop data. As we went back to the earlier periods, both the availability and reliability of existing information on agricultural production declined. Therefore, individual crop statistics were compiled for the major agricultural commodities that are important in contemporary India, Pakistan, and Bangladesh, and for which detailed data on production and prices are available from the British period.

For India, considering the coverage of Sivasubramonian's (1960) important contribution to this field, data for eighteen crops were compiled.⁴ These include foodgrains⁵ (rice, wheat, barley, *jowar*

³“1901/02” refers to the agricultural year beginning on July 1, 1901, and ending on June 30, 1902. In figures with limited space, it is shown as “1902.”

⁴Sivasubramonian (2000) later expanded the crop coverage of Sivasubramonian (1960) by adding indigo, fodder crops, and three other categories: “other foodgrains and pulses,” “other oilseeds,” and “other crops.” Indigo is not included in this paper since it is no longer an important crop in the Subcontinent. The other four categories of crop groups are not included in this paper since Sivasubramonian's (2000) estimates for these crop groups are more or less the extrapolation of the eighteen crops already covered. We incorporated into our data compilation minor crops as a whole (see below).

[sorghum], *bajra* [pearl millet], maize, *ragi* [finger millet], and *gram* [chickpea]); oilseeds (linseed, sesamum, rape and mustard, and groundnut); and other crops (sugarcane, tea, coffee, tobacco, cotton, and jute and mesta). Pakistan’s agricultural sector in its national accounts comprises subsectors of major crops, minor crops, and livestock. We compiled crop data for all twelve crops included in the major crops subsector: rice, wheat, barley, *jowar*, *bajra*, maize, and *gram* as foodgrains; and rape and mustard, sesamum, sugarcane, tobacco, and cotton as non-foodgrains. For Bangladesh, sixteen crops were included: *aman* rice (the major paddy crop grown during the monsoon season and harvested in the winter), *aus* rice (the paddy crop grown during the early monsoon season), *boro* rice (the paddy crop grown during the dry season), wheat, barley, maize, and *gram* as foodgrains; linseed, sesamum, rape and mustard, and groundnut as oilseeds; and sugarcane, tea, tobacco, cotton, and jute as other crops. In all three countries, these crops currently account for more than two thirds of the total output value from crops and their contribution was higher during the colonial period.

To obtain statistics that correspond to the current international borders before 1947, we first divide data for the United India compiled by Sivasubramonian (2000) into three countries using information derived from Blyn (1966), 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* (see Kurosaki 2011, for detail). 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).

Although individual crop statistics are of interest *per se*, we need aggregate statistics to analyze the growth performance of agriculture. Therefore, we first aggregate the individual crop output values into a gross value series denoted by Q_t^k where subscript t denotes agricultural year while super script k denotes country (India, Pakistan, and Bangladesh). For this purpose, we use fixed prices in three benchmark years—we estimated implicit prices for 1938/39, 1960 (1960/61 for India and 1959/60 for Pakistan and Bangladesh), and 1980/81 by dividing the real output value of each commodity in constant prices by its production quantity. In this paper, we use the base-year prices of 1960 as default

⁵“Foodgrains” are defined as crop groups containing cereals (e.g., rice, wheat, coarse grains, etc.) and pulses (e.g., chickpea, pigeon pea, etc.). The term is widely used in India, Pakistan, and Bangladesh in discussing the national food balance, since cereals and pulses comprise the most important part of local diets.

and use other prices as robustness checks.

Since Q_t^k shows gross output values from major crops in real prices, we need two adjustment to obtain the standard measure of growth accounting, Y_t^k , i.e. the value added series from agricultural sector (crops subsector only, to be more precise) in real prices. To convert Q_t^k into Y_t^k , the output values from minor crops must be added, and the value of inputs such as seeds, chemical fertilizer, pesticides, fuels, and irrigation costs must be deleted. The neglect of the intermediate inputs is especially problematic, since the ratio of costs of modern inputs to the total output value has been increasing in recent years, reflecting the modernization of agriculture and the spread of “Green Revolution” technology.

We estimated two intermediate parameters: the share of values attributed to major crops in the total output values from all crops and the share of value added in the total output values. Then by definition, Y_t^k is the multiple of Q_t^k and these two share parameters. As explained by Kurosaki (2011) in detail, we estimated these share parameters by extrapolating estimates by Sivasubramonian (2000). We thus obtain estimates for Y_t^k .

Two most important production factors in agriculture are labor and land. In this paper, we analyze partial productivities with respect to these two factors. As a main measure of labor input in agriculture, we employ the number of persons engaged in agriculture (L_t^k). As a related measure potentially subject to less measurement error, we also estimated the total population ($L_t'^k$). The data source of our estimates is population census, which started in the Subcontinent in 1871. Since then, the census has been conducted every ten years to collect basic information on the population and occupations. We carefully estimate series of L_t^k and $L_t'^k$ in a comparative way (Kurosaki 2011).

As a main measure of land input, we employ the total cultivated area, denoted by A_t^k . The total cultivated area is defined as the sum of the net area sown and the current fallow. For the pre-Partition period, we compiled our own estimates after incorporating Sivasubramonian’s (2000) estimates into the colonial statistics such as *Agricultural Statistics of India* (see Kurosaki 2011 for detail).

3 Analytical Framework

As the first step to analyze the changes in agricultural productivity, a time series model for Y_t^k is estimated for each country as

$$\ln Y_t^k = a^k + b^k t + u_t^k, \quad (1)$$

for $k = I$ (India), P (Pakistan), and B (Bangladesh), where a^k and b^k are parameters to be estimated, and u_t^k is an error term. Equation (1) is estimated using ordinary least squares (OLS) and then re-estimated after replacing Y by Y/L or Y/A . The larger the coefficient estimate for b^k , 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.

At the same time, based on the identity $Y_t^k \equiv A_t^k (Y_t^k/A_t^k)$, we can also implement a conventional decomposition into extensive and intensive expansion, namely,

$$\Delta \ln Y_t^k = \Delta \ln A_t^k + \Delta \ln (Y_t^k/A_t^k),$$

where Δ indicates the time difference. The first term of the right hand side shows the contribution of extensive expansion (i.e., an increase in the cultivated area) while the second term shows the contribution of intensive expansion (i.e., an increase in output per cultivated area). In this paper, we further decompose the second term so that our decomposition formula is

$$\Delta \ln Y_t^k = \Delta \ln A_t^k + \Delta \ln (A_t'^k/A_t^k) + \Delta \ln (Y_t^k/A_t'^k), \quad (2)$$

where $A_t'^k$ is the sum of areas under crops (gross cropped area). Therefore, $A_t'^k/A_t^k$ is a measure of land use intensity. The decomposition (2) thus shows that the intensive expansion comprises the contribution of land use intensity changes (i.e., an increase in the ratio of gross cropped area to the cultivated area) and the contribution of land productivity growth in the narrower sense (i.e., an increase in output per gross cropped area).

Then in the next step, we extend equation (1) as

$$\ln Y_t^k = (a_0^k + a_1^k D_t) + (b_0^k + b_1^k D_t) t + u_t^k, \quad (3)$$

where D_t is a time dummy variable. From this model, we can obtain the difference-in-difference (DID)

estimator $b_1^I - b_1^P$, for example, when D_t is set to one when t is greater than 1947. The DID estimator then 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_0^k and $a_0^k + a_1^k D_t$) and the potential growth rate (captured by b_0^k) can differ. We are not interested in such a difference. Our interest is on the between-country difference in b_1^k . If the two regions were exposed to similar exogenous changes in environment, technology, and markets, then the DID estimator $b_1^I - b_1^P$ 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 $b_1^I - b_1^P$ can be interpreted as the net impact of the regime change and changes in environment, technology, and markets. Since the growth rate is a sort of double difference estimator, our interest on the between-country difference in b_1^k could be described as a triple difference approach.

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.

Given description in changes in agricultural performance from equations (1)-(3), we then focus on one factor in improving agricultural productivity, which is under-analyzed in the existing literature, i.e., the contribution of crop shifts. As descriptive tools for crop changes, we examine three measures. The first is the Herfindahl Index of crop acreage, which is defined as $H_t^k = \sum_i (S_{it}^k)^2$, where S_{it}^k is the acreage share of crop i in the sum of the principal crops in year t and country k . The Herfindahl Index is 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 value of 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_t^k , is defined as the sum of areas under rice and wheat divided by the sum of areas under foodgrains (cereal and pulses). 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_t^k , is defined as the sum of S_{it}^k 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 crop shift effects, and dynamic crop shift effects (Kurosaki 2003). Let y_i denote per-acre

output in year t . Its growth rate from period 0 to period t can be decomposed as

$$(y_t - y_0)/y_0 = [\sum_i S_{i0}(y_{it} - y_{i0}) + \sum_i (S_{it} - S_{i0})y_{i0} + \sum_i (S_{it} - S_{i0})(y_{it} - y_{i0})]/y_0, \quad (4)$$

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 (4) 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 Nevertheless, we cannot attribute all of the two types of crops shifts to market factors. Farmers’ response to market incentives is only one of necessary conditions for crop shifts to contribute to aggregate land productivity growth. Another important factor is technological constraint on crop choices. In the context of South Asian agriculture, irrigation is key to allowing farmers to choose crops in a flexible way.

4 Growth Performance in Agriculture of India, Pakistan, and Bangladesh

4.1 Growth in total output and labor productivity

The long-term trends of Y (total value-added) 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.

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 value-added in Bangladesh declined while that in Pakistan increased. India stood in between. In the post-1947 period, the total value-added 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 (4) 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 parametrically, Table 1 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 value-added 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, Y grew at 1.24% per annum in Pakistan and at 0.37% in India, and it declined at 0.30% in Bangladesh, all of which were statistically significant. After the Partition, Y increased in every decade in all three countries. The growth rates were generally higher in Pakistan than in India and Bangladesh. When the whole post-1947 period is taken, Y grew at 3.46% per annum in Pakistan, at 2.28% in India, and at 1.73% in Bangladesh. The column “C.V.” in Table 1 shows how variable was the production around the fitted values in terms of the coefficient of variation. The value-added 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 production after the Partition is observed in all three countries.

Although these growth rates, except for the negative growth in the pre-1947 period in Bangladesh, seem impressive, the growth performance became more moderate if we look at labor productivity, which is a better measure for evaluating the welfare of population engaged in agriculture than the total production measure. The long-term trends of Y/L (agricultural value-added per labor) are shown in Figure 2,⁷ and parametrically-estimated growth rates are reported in the middle columns of Table 1. Using growth rates of Y/L , the pre-Partition contrast across three countries become more clear-cut: statistically-significant positive growth in Pakistan (+0.76%), insignificant growth in India, and statistically-significant negative growth in Bangladesh (−0.62%). Since 1947, labor productivity grew at statistically-significant growth rates in all three countries.

4.2 Contribution of land productivity improvement to agricultural growth

The growth of total output (Y) can be decomposed into the contributions from area expansion, land

⁷ To make it comparable to Figure 1, we plot Y/L on the vertical axis in index with 1959/60 = 1 in Figure 2. To explicitly incorporate the difference in the reference level among the three countries easily, we can instead plot Y/L on the vertical axis in the absolute term in fixed prices (i.e., Rs. per labor). The adjusted figures are highly similar to Figure 2, as shown in Appendix Figure 1.

use intensity changes, and changes in production per cropped land, as shown in equation (2). The decomposition results are shown in Table 2. During the colonial period, the area expansion (extensive expansion) explained about two-thirds of agricultural growth in India and Pakistan while the rest was intensive expansion. Within the intensive expansion, an interesting contrast is found between India and Pakistan: the contribution of land productivity in the narrow sense was the main force in intensive expansion in India while the contribution of land use intensity increases was the main force in intensive expansion in Pakistan. Regarding Pakistan, rapid expansion of the Canal Colony may have been responsible for this. After the Partition, in all of India, Pakistan, and Bangladesh, the main source of agricultural growth was the contribution of land productivity in the narrow sense. It explained 64 to 78% of the total agricultural growth. Unlike India and Bangladesh, the contribution of extensive expansion was still substantial (24% of the total growth) in Pakistan even after independence. Table 2 thus clearly shows that the room for extensive expansion dried up in Bangladesh before 1900, which was much earlier than in India, where the room for area expansion dried up during the post-independence period, while Pakistan's agriculture still maintains the room for extensive expansion. The drastic improvement in land productivity after the Partition is shown in a parametric way in the right columns of Table 1 as well.

Since the improvement in land productivity is the main force of growth in all three countries after the Partition, we examine the changes in land productivity for shorter periods, using Figure 3 and Table 1. First, the shape of Figure 3⁸ 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.

To show this formally, a series of tests are conducted for a structural change of unknown timing for

⁸ To make it comparable to Figure 1, we plot Y/A on the vertical axis in index with 1959/60=1 in Figure 3. To explicitly incorporate the difference in the reference level among the three countries easily, we can instead plot Y/A on the vertical axis in the absolute term in fixed prices (i.e., Rs. per hectare). The adjusted figures, which are shown in Appendix Figure 2, show that the absolute level of per-acre productivity is much higher in Bangladesh than in India and Pakistan and the difference between India and Pakistan is small. Appendix Figure 2 thus gives a quite different impression from Figure 3 reported here. Nevertheless, the difference does not affect parametric analysis in Tables 1 and 3 since the difference in the reference level does not affect our estimates for growth rates.

the entire 20th century, following the procedure by Hansen (2001). First, a time series model of (3) is estimated by OLS. For all candidate breakdates for D_t , 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 Y/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).

Coefficient estimates for b^k in equation (1) reported in Table 1 also show that, during the 1950s, the positive growth coefficients in land productivity are statistically significant in India and Pakistan. In Bangladesh, improvement in land productivity came much later.

4.3 *Difference-in-difference*

From Table 1, it was found that the level of growth rates 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 (3) was estimated, whose results are reported in Table 3.

When the pre-1947 and post-1947 performances are compared for Y (total agricultural value-added), Pakistan's growth acceleration was slightly larger than India's but the difference is only marginally significant in the statistical sense. In effect, there is no significant difference across the three countries—in all of them, the growth rate acceleration in Y was around 2 percentage points after

the Partition. When the DID in Y/L (labor productivity) is compared, the additional growth after the Partition is less in India than in Pakistan or Bangladesh. The improvement in Bangladesh was the largest, although its difference in acceleration compared with Pakistan is not statistically significant. When the pre-1947 and post-1947 performances are compared for Y/A (land productivity), there is no significant difference at all across the three countries. The pattern that there was no significant difference in terms of Y and Y/A while Bangladesh performed better than others in terms of Y/L was found robustly when other base-year prices were used.

From these DID results, one is tempted to conclude that the agricultural performance in India was adversely affected by the political regime change in 1947, and the adverse impact of the politics was less in Bangladesh. 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 India than in Bangladesh, with Pakistan 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 (Y and Y/L) or slightly increased (Y/A) after 1971, while Bangladesh's growth rates remained unchanged (Y/L) or were substantially increased (Y and Y/A). The DID is statistically significant for two measures (Y and Y/L) out of the three.⁹ 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

⁹ The better performance of Bangladesh relative to Pakistan in terms of growth acceleration was found robustly when different base-year prices were used. Depending on specifications, Y/L also showed a statistically significant difference in favor of Bangladesh.

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 such as the Zamindari abolition. 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 Bangladesh improved after 1947, and further 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 Y/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.” Figure 4 shows that the per-acre yields of rice and wheat were very modestly increased until the late 1960s.

The first two points confirm research results found in the existing literature. The overall growth rates during the pre-1947 period reported in Sivasubramonian (2000) lie within the range of our estimates 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 production 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 value-added per acre did increase during the 1950s in India and Pakistan 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 5 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.

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. There is a difference in recent trends, however, between India and Pakistan. In India, the level of concentration accelerated in the 1990s, while in Pakistan, 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.

Fourth, the movement of the index in Bangladesh is highly different from that in India and Pakistan. After the Partition, the trend in H seems to be a negative one throughout the post-Partition period, but with a recent reversal in trends. In analyzing Bangladesh's crop mix changes, the treatment of three major varieties of rice makes a big difference. If we do not distinguish the three, there is no trend in H but always at the very high level, since rice is such a dominant crop in Bangladesh. In Figure 5, we show two plots, one including *aman* (the traditionally most important rice crop in Bangladesh) and the other excluding *aman*, both of which includes *aus* and *boro* as different crops. Since variation in H is dominated by the movement of square of the *aman* share if we include *aman*, the plot excluding *aman* (and distinguishing *aus* and *boro*) in Figure 5 provides more useful information regarding dynamic changes in Bangladesh's agriculture.

Although speculative, based on Figure 5, we interpret that the structural transformation toward a mature market economy, *a la* Timmer (1997), occurred first in Bangladesh, followed by Pakistan, and finally occurring in India in the early 2000s. According to Timmer's (1997) stylization, when the agriculture of a country enters the stage with a mature market economy, both production and consumption become diversified at the national level.

The changes in crop composition are shown more concretely in Figures 6 and 7. 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 6). Therefore, there is a strong tendency to shift to the two Green Revolution crops instead of

various kinds of coarse grains or pulses. This indicates a move toward monotonic consumption in terms of staple grains. However, the trend of *SRW* in Bangladesh is weak because of the dominance of rice crops.

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 7). 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 (4) was implemented. The results are reported in Table 4.

First, for areas currently in India, the contribution of total crop shift effects is substantial,

explaining 28% 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.

For Bangladesh, the treatment of three major rice varieties is again critical in analyzing crop shift dynamics. If we treat them as a single crop of rice, the contribution of crop shift effects to the improvement in aggregate land productivity was almost zero in both pre- and post-Partitions periods (see the last two rows in Table 4). 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. However, since the crop shift from *aus* to *boro* and from *aman* to *boro* was critically important in improving per-acre yield of rice in Bangladesh in recent years, the contribution of crop shift effects to the improvement in aggregate land productivity becomes substantial when we treat the three rice varieties as different crops. Especially after 1947, the crop shift effects explained about 32% of changes in aggregate land productivity in Bangladesh. This contribution of crop shifts came both from static and dynamic crop shift effects. Looking at the decomposition results for each decade in Bangladesh, large contribution of crop shifts occurred not only in the 1980s (the period known for the *boro* rice expansion) but also in the 1960s. Examining the crop database, we found that this decade was a period when sugarcane production expanded and sugarcane had higher values per acre than other crops.

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. Throughout the post-independence period, there were substantial contributions from both static and dynamic crop shift effects in the three countries.

6 Conclusion

Based on a production dataset from India, Pakistan, and Bangladesh for the period 1901/02-2001/02, this paper investigated agricultural growth performance and then quantified four sources of agricultural growth: area expansion, change in land use intensity, improvement in individual crop yields per acre, and crop shifts toward high value-added crops. The focus on the last factor is a unique contribution of this paper. The empirical results showed a discontinuity between the pre- and the post- independence periods in all of the three countries. Total production 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 substantial, explaining about one third of aggregate land productivity growth after 1947 in these three countries. The contribution could have been underestimated at zero if the shift among rice varieties were ignored in Bangladesh. Underlying these changes were the responses of farmers to changes in market conditions and agricultural policies, enabled by technical changes such as irrigation.

In all three countries in the post-1947 period, however, the welfare benefit of agricultural growth to the population was smaller than indicated by the high land productivity growth, because the room for extensive expansion in agriculture disappeared and population growth rates remained high. The net result was that the growth rate of agricultural value-added per labor 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. Absorbing more labor force outside agriculture is required to make the growth rate of agricultural labor productivity comparable to that of land productivity.

Although this paper showed the importance of crop shifts in improving aggregate land productivity, the overall impact of resource reallocation within agriculture is underestimated, because the livestock subsector was not covered. Incorporating the livestock subsector into the framework of this paper would be highly desirable, which is left for future study.

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Figure 1: Agricultural value-added (Y) in India, Pakistan, and Bangladesh, 1901/02-2001/02

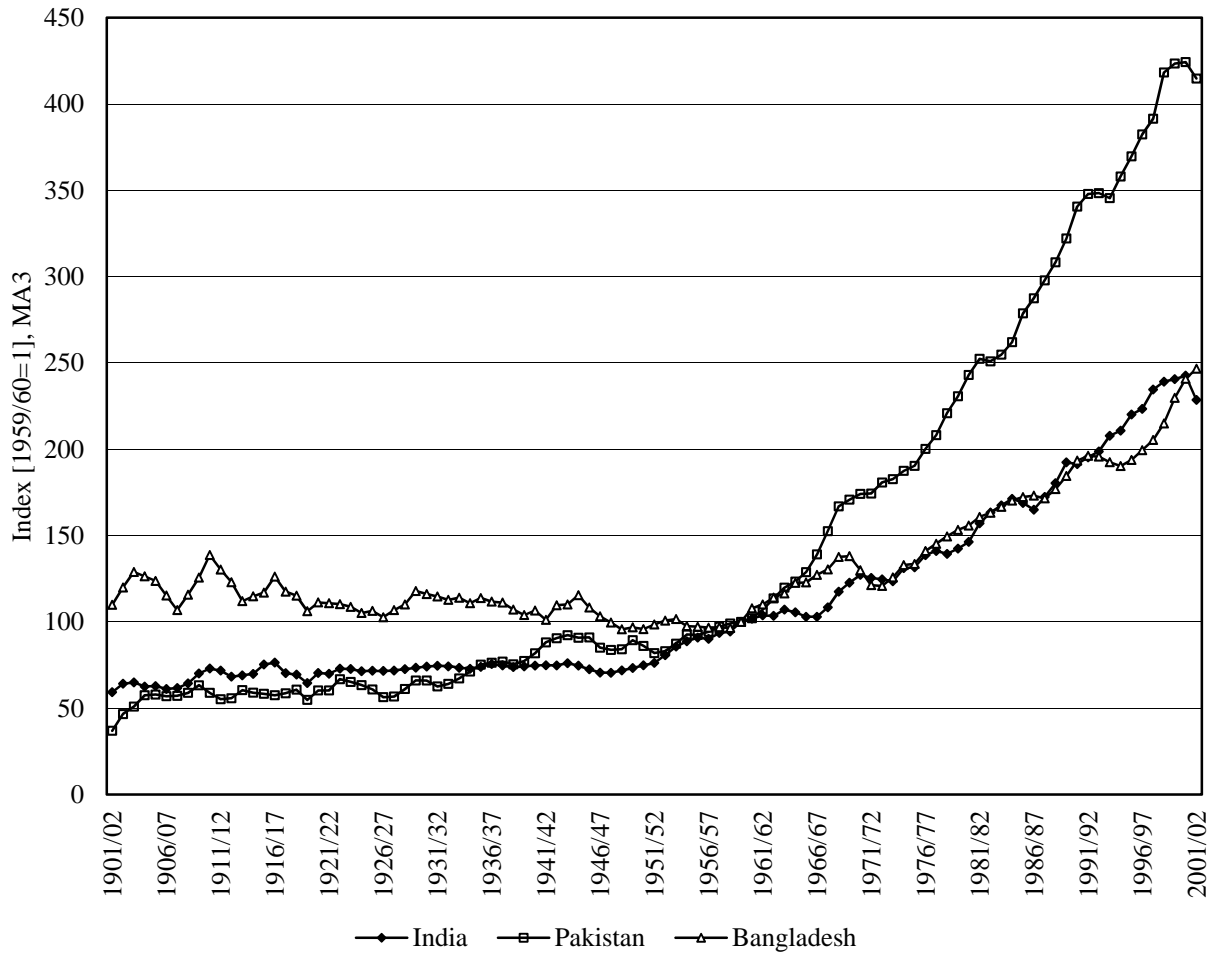


Figure 2: Agricultural labor productivity (Y/L) in India, Pakistan, and Bangladesh, 1901/02-2001/02

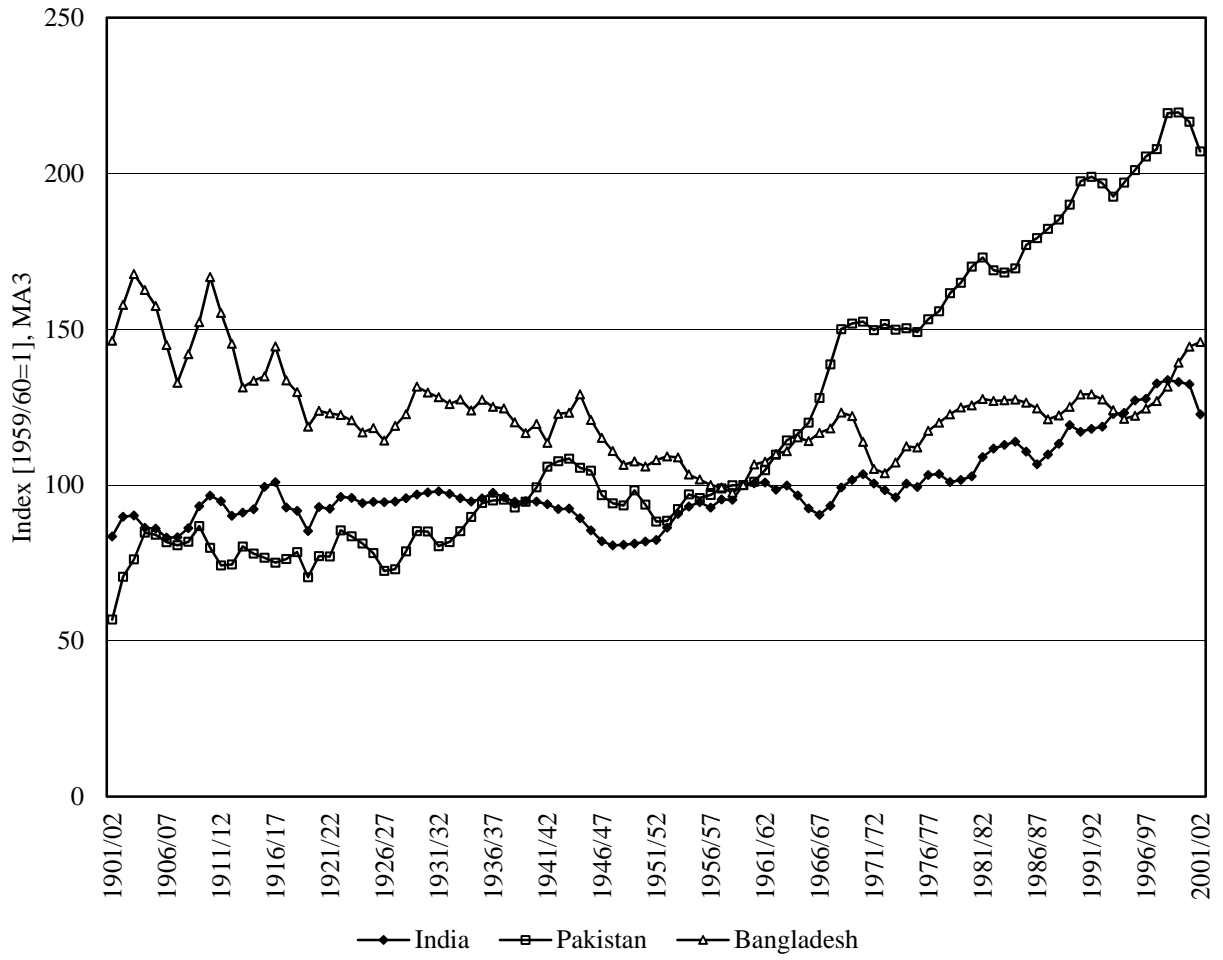


Figure 3: Aggregate land productivity (Y/A) in India, Pakistan, and Bangladesh, 1901/02-2001/02

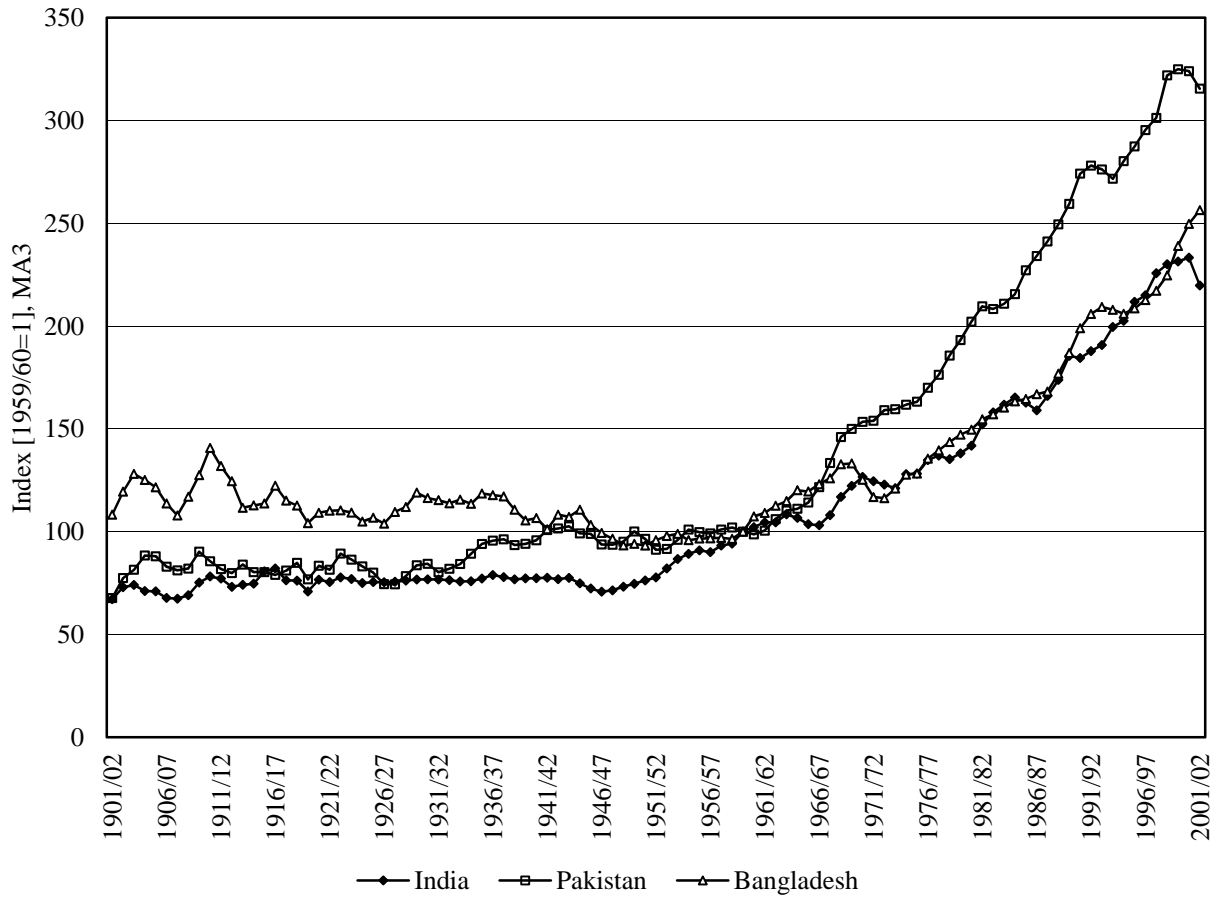


Figure 4: Green Revolution -- Per-acre yield of rice and wheat in India, Pakistan, and Bangladesh, 1901/02-2001/02

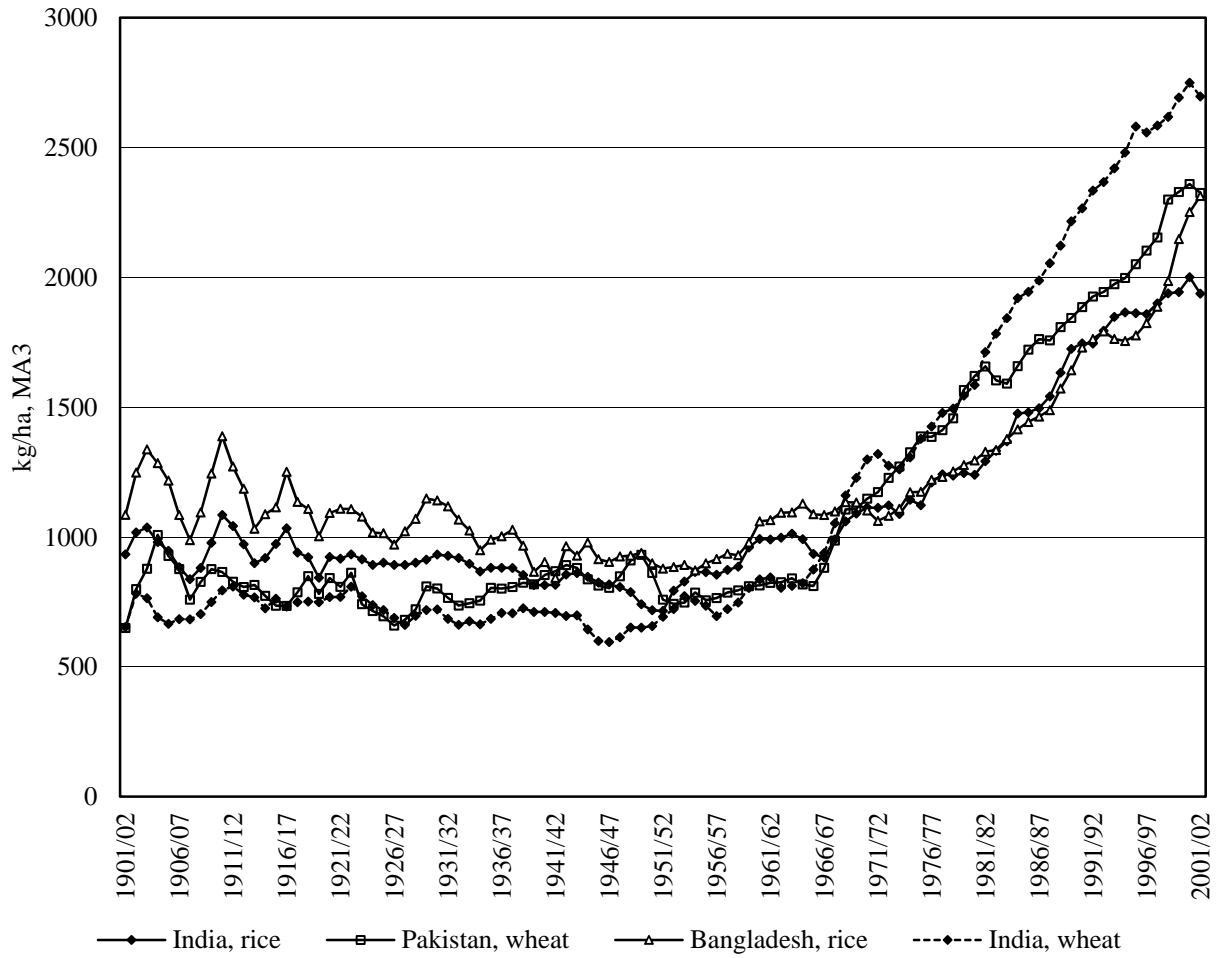


Figure 5: Change in crop mix, I -- Crop concentration in India, Pakistan, and Bangladesh, 1901/02-2001/02

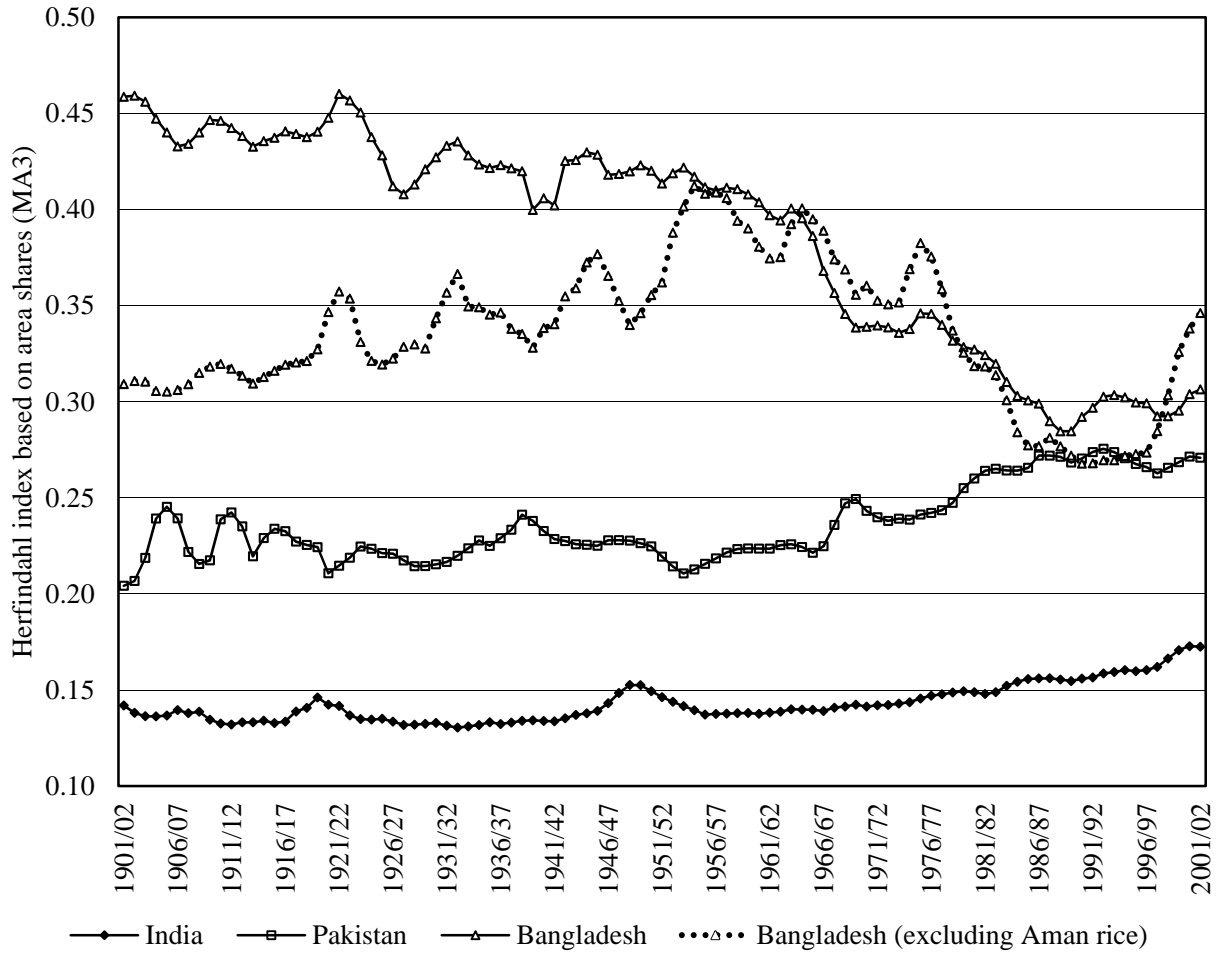


Fig 6: Changes in crop mix, II -- Acreage share of rice & wheat in areas under total foodgrains in India, Pakistan, Bangladesh, 1901/02 to 2001/02

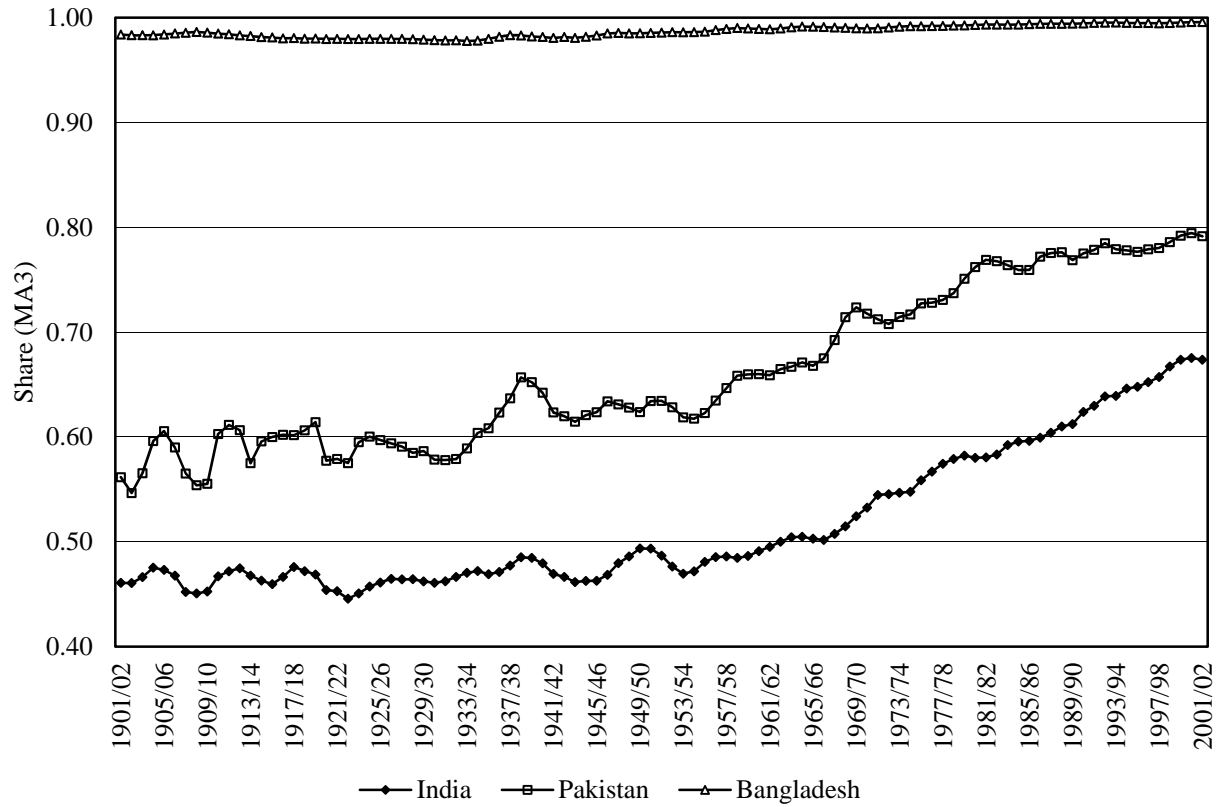


Fig 7: Changes in crop mix, III -- Acreage share of non-foodgrains in total area under crops in India, Pakistan, Bangladesh, 1901/02 to 2001/02

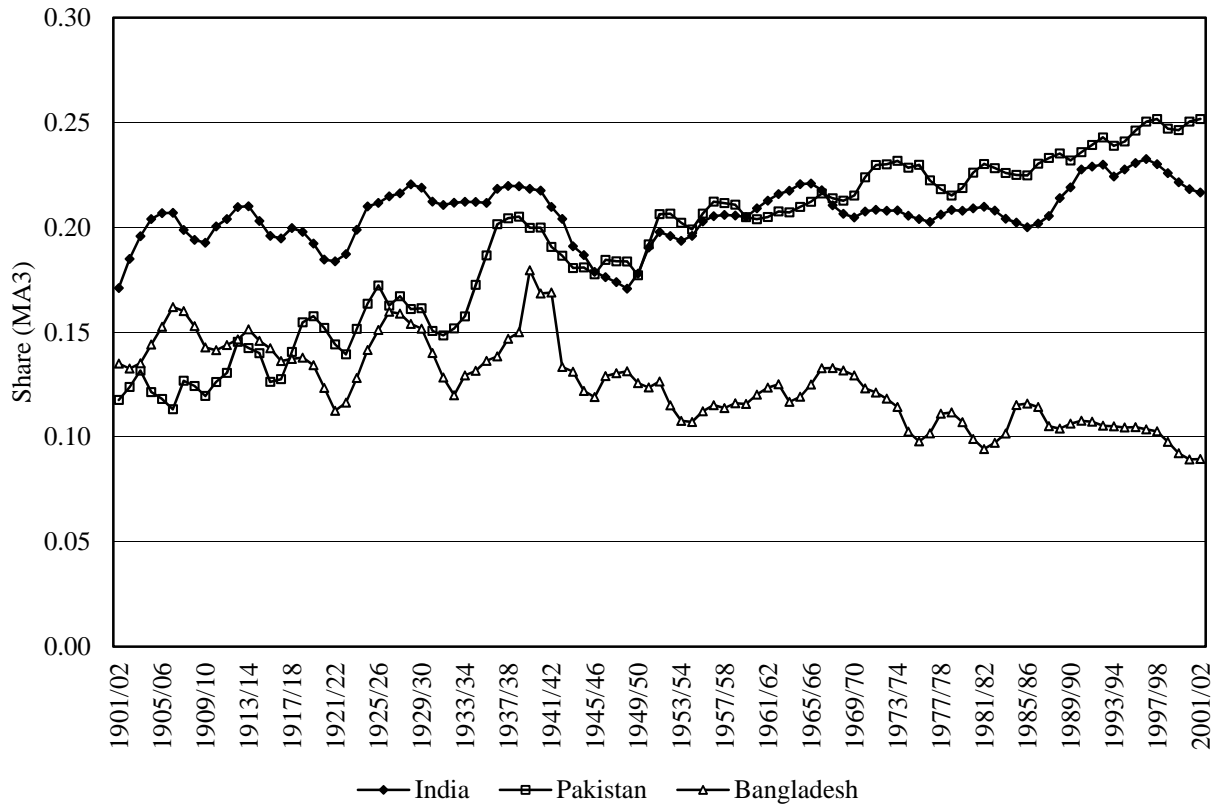


Table 1: Agricultural growth rates in India, Pakistan, and Bangladesh during the 20th century

	Y (total value-added)		Y/L (labor productivity)		Y/A (land productivity)	
	Ann.gr.rate	CV	Ann.gr.rate	CV	Ann.gr.rate	CV
India						
1901/02 - 1910/11	1.36%	8.9%	0.63%	8.9%	0.52%	9.3%
1911/12 - 1920/21	-0.70%	11.9%	-0.69%	11.9%	-0.39%	11.8%
1921/22 - 1930/31	0.09%	2.5%	0.08%	2.5%	-0.22%	2.9%
1931/32 - 1940/41	0.27%	3.2%	-0.09%	3.2%	0.40%	3.0%
1941/42 - 1950/51	-0.25%	3.8%	-1.78% ***	3.8%	-0.34%	4.3%
1951/52 - 1960/61	2.99% ***	4.3%	2.02% ***	4.3%	2.77% ***	4.1%
1961/62 - 1970/71	2.30% **	7.9%	0.32%	7.9%	2.11% **	7.9%
1971/72 - 1980/81	1.96% **	7.0%	0.53%	7.0%	1.72% *	7.0%
1981/82 - 1990/91	2.08% ***	5.3%	0.68%	5.3%	2.04% ***	5.3%
1991/92 - 2000/01	2.63% ***	4.1%	1.52% *	4.1%	2.65% ***	4.1%
1901/02 - 1946/47	0.37% ***	7.3%	0.11%	7.8%	0.14% *	7.3%
1947/48 - 2000/01	2.28% ***	5.7%	0.81% ***	6.4%	2.15% ***	5.8%
Pakistan						
1901/02 - 1910/11	4.36% **	14.5%	2.92%	14.5%	1.81%	13.2%
1911/12 - 1920/21	-0.21%	14.2%	-0.77%	14.2%	-0.71%	13.9%
1921/22 - 1930/31	-0.61%	10.3%	-0.49%	10.3%	-1.30%	9.2%
1931/32 - 1940/41	2.79% ***	5.3%	2.19% ***	5.3%	2.02% *	5.5%
1941/42 - 1950/51	-0.51%	6.5%	-1.63% *	6.5%	-0.46%	5.8%
1951/52 - 1960/61	2.76% ***	5.6%	1.84% **	5.5%	1.16%	7.0%
1961/62 - 1970/71	5.77% ***	4.6%	4.57% ***	4.6%	4.88% ***	5.3%
1971/72 - 1980/81	3.58% ***	3.0%	1.30% ***	3.0%	2.87% ***	3.1%
1981/82 - 1990/91	3.34% ***	4.3%	1.46% **	4.3%	2.95% ***	4.1%
1991/92 - 2000/01	2.56% ***	5.2%	1.35% *	5.2%	2.07% **	5.6%
1901/02 - 1946/47	1.24% ***	12.8%	0.76% ***	12.5%	0.47% ***	11.2%
1947/48 - 2000/01	3.46% ***	7.0%	1.84% ***	7.3%	2.70% ***	7.9%
Bangladesh						
1901/02 - 1910/11	0.60%	13.1%	-0.56%	13.1%	0.91%	12.0%
1911/12 - 1920/21	-1.52%	10.6%	-2.30% *	10.6%	-1.94%	10.6%
1921/22 - 1930/31	0.55%	7.4%	0.62%	7.5%	0.72%	7.2%
1931/32 - 1940/41	-1.00%	6.6%	-0.94%	6.5%	-0.89%	7.3%
1941/42 - 1950/51	-1.64%	8.8%	-1.76%	8.8%	-1.83% *	7.6%
1951/52 - 1960/61	0.23%	6.3%	-0.92%	6.4%	0.63%	5.9%
1961/62 - 1970/71	2.67% ***	3.7%	1.44% ***	3.7%	2.33% ***	3.7%
1971/72 - 1980/81	3.65% ***	3.9%	2.88% ***	3.9%	3.61% ***	3.9%
1981/82 - 1990/91	1.78% ***	3.1%	-0.17%	3.1%	2.51% ***	3.5%
1991/92 - 2000/01	2.39% ***	5.7%	1.38% *	5.8%	2.01% ***	4.8%
1901/02 - 1946/47	-0.30% ***	9.4%	-0.62% ***	10.3%	-0.29% ***	9.4%
1947/48 - 2000/01	1.73% ***	6.5%	0.50% ***	6.4%	1.85% ***	7.1%

Notes: "Ann.gr.rate" is the annual growth rate, estimated by a time-series regression of equation (1). "CV" is the coefficient of variation, calculated from residuals in the same time-series regression. Statistically significant at the 1% ***, 5% **, and 10% * levels.

Source: Calculated by the author using the dataset described in the text (same for the following tables).

Table 2: Decomposition of aggregate agricultural growth into extensive and intensive expansion

	Annual growth rate in Y (%)				Relative contribution (%)		
	Growth rate in A (extensive expansion)	Growth rate in Y/A (intensive expansion)		Total	Growth rate in A (extensive expansion)	Growth rate in Y/A (intensive expansion)	
		Land use intensity (gross cropped area/cultivated area)	Output per gross cropped area			Land use intensity (gross cropped area/cultivated area)	Output per gross cropped area
India							
1901/02 - 1911/12	0.53	0.55	0.84	1.92	27.7	28.5	43.8
1911/12 - 1921/22	-0.04	0.25	-0.47	-0.26	13.6	-96.9	183.3
1921/22 - 1931/32	0.47	0.22	-0.05	0.63	73.6	34.3	-7.9
1931/32 - 1941/42	-0.06	0.21	-0.11	0.04	n.a.	n.a.	n.a.
1941/42 - 1951/52	0.16	1.37	-1.35	0.18	87.7	756.6	-744.2
1951/52 - 1961/62	0.12	0.42	2.55	3.08	3.8	13.6	82.6
1961/62 - 1971/72	0.15	0.31	1.44	1.90	8.0	16.4	75.6
1971/72 - 1981/82	0.24	0.35	1.66	2.25	10.6	15.6	73.7
1981/82 - 1991/92	0.07	-0.70	2.81	2.18	3.2	-32.2	129.0
1991/92 - 2001/02	0.00	0.20	1.37	1.57	0.2	12.9	86.9
1901/02 - 1947/48	0.24	0.24	-0.10	0.38	64.4	62.1	-26.5
1947/48 - 2001/02	0.10	0.39	1.69	2.18	4.4	17.8	77.7
Pakistan							
1901/02 - 1911/12	2.13	0.25	1.64	4.02	53.0	6.2	40.8
1911/12 - 1921/22	0.90	0.12	-0.15	0.88	102.6	14.0	-16.6
1921/22 - 1931/32	0.54	0.07	-0.24	0.38	144.6	18.0	-62.6
1931/32 - 1941/42	1.13	0.49	1.81	3.42	33.0	14.2	52.8
1941/42 - 1951/52	0.28	-0.32	-0.69	-0.73	-38.4	44.1	94.3
1951/52 - 1961/62	1.71	-0.71	1.67	2.68	63.9	-26.3	62.5
1961/62 - 1971/72	0.60	0.83	3.44	4.87	12.4	17.1	70.5
1971/72 - 1981/82	0.61	0.87	2.22	3.70	16.5	23.5	60.0
1981/82 - 1991/92	0.38	0.67	2.15	3.21	12.0	20.9	67.1
1991/92 - 2001/02	0.50	0.09	1.18	1.76	28.2	4.9	66.9
1901/02 - 1947/48	1.07	0.10	0.61	1.78	60.3	5.4	34.3
1947/48 - 2001/02	0.71	0.35	1.89	2.96	24.1	12.0	63.9
Bangladesh							
1901/02 - 1911/12	-0.26	0.99	0.97	1.71	-15.2	58.2	57.0
1911/12 - 1921/22	0.17	-0.56	-1.23	-1.62	-10.6	34.6	76.0
1921/22 - 1931/32	-0.12	0.01	0.45	0.35	-33.5	2.7	130.9
1931/32 - 1941/42	0.05	0.08	-1.39	-1.25	-4.0	-6.6	110.7
1941/42 - 1951/52	0.27	-0.48	-0.06	-0.27	-101.7	179.8	21.9
1951/52 - 1961/62	-0.19	-0.03	1.33	1.11	-16.9	-3.1	120.0
1961/62 - 1971/72	0.29	0.69	-0.01	0.97	29.7	70.9	-0.6
1971/72 - 1981/82	0.02	1.05	1.75	2.82	0.6	37.3	62.0
1981/82 - 1991/92	-0.87	0.91	1.95	1.99	-43.9	45.8	98.1
1991/92 - 2001/02	0.09	0.52	1.68	2.29	4.0	22.7	73.3
1901/02 - 1947/48	0.03	-0.05	-0.20	-0.21	-15.3	23.3	92.0
1947/48 - 2001/02	-0.13	0.63	1.18	1.68	-7.6	37.5	70.1

Notes: The decomposition is based on equation (2). Since the annual growth rates in this table are calculated by growth accounting methods using MA3 data, they are not exactly the same as the regression based growth rates in Table 1.

Table 3: Regional disparity in the acceleration in growth rates and the state

	<i>Y</i>	<i>Y/L</i>	<i>Y/A</i>
1. Impact of the Partition 1947			
(a) Acceleration in growth rates since 1947 (parameter b_1)			
India	1.91% ***	0.69% ***	2.01% ***
Pakistan	2.21% ***	1.08% ***	2.23% ***
Bangladesh	2.03% ***	1.12% ***	2.14% ***
(b) Statistical test (chi2 statistics) for the difference in acceleration			
India=Pakistan ($b_1^I = b_1^P$)	3.69 *	5.16 **	2.23
Pakistan=Bangladesh ($b_1^P = b_1^B$)	1.35	0.05	0.32
Bangladesh=India ($b_1^B = b_1^I$)	1.04	9.51 ***	1.34
India=Pakistan=Bangladesh	3.80	10.15 ***	2.73
2. Impact of the Bangladesh's Independence 1971			
(a) Acceleration in growth rates since 1971 (parameter b_1)			
Pakistan	-0.13%	-0.88% ***	0.79% ***
Bangladesh	0.35% *	0.07%	0.84% ***
(b) Statistical test (chi2 statistics) for the difference in acceleration			
Pakistan=Bangladesh ($b_1^P = b_1^B$)	4.08 **	13.02 ***	0.05

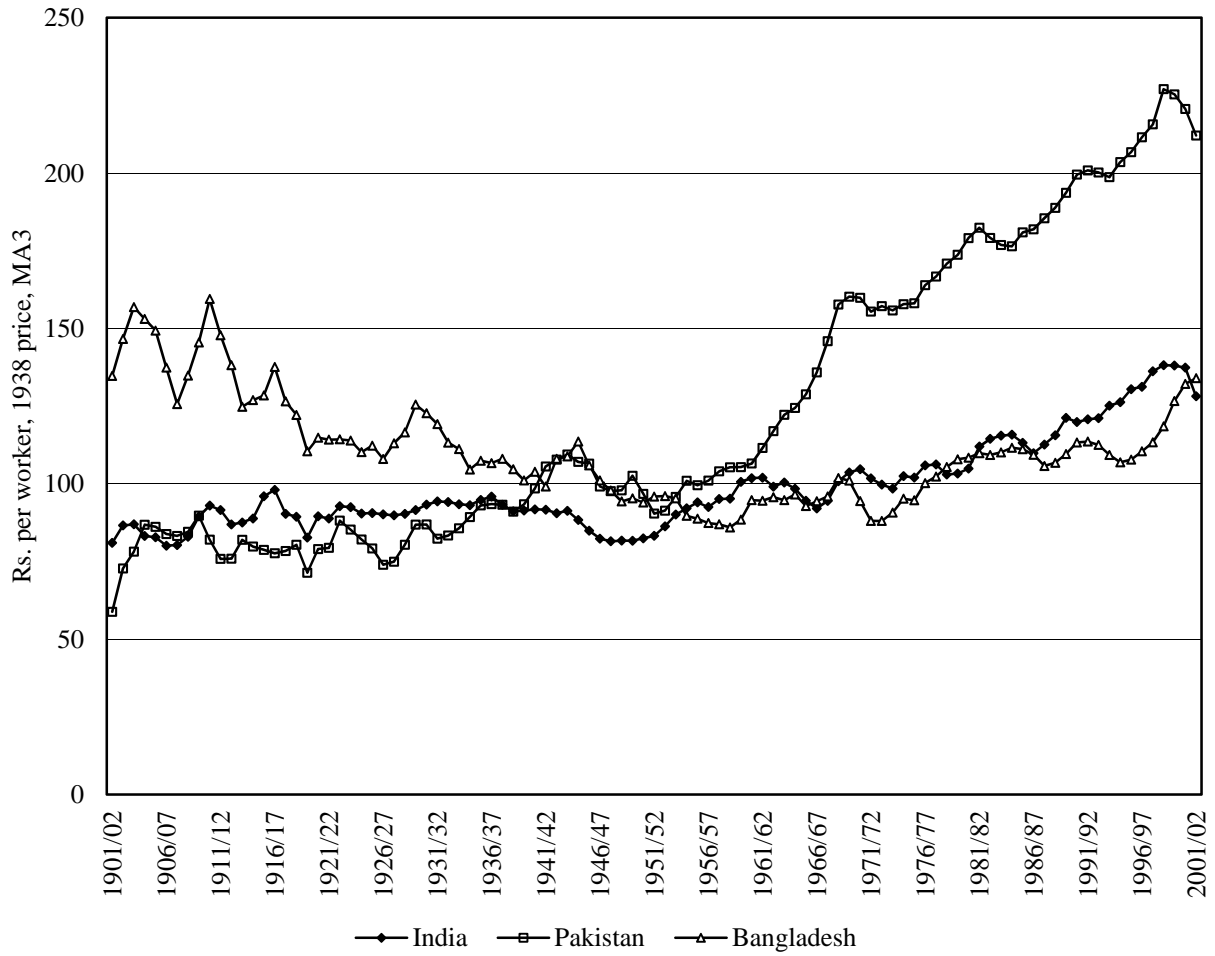
Notes: Based on a DID model shown in equation (3). Acceleration in growth rates were estimated by SUR (system of equations corresponding to each country). For part (a), the number of observations is 100 (1901/02 to 2000/01). For Part (b), the number of observations is 54 (1947/48 to 2000/01).

Table 4: Contribution to crop shifts to the aggregate land productivity

	Annual growth rates (%) of land productivity (Q/A')				Relative contribution (%)		
	Individual crop yield effect	Static crop shift effect	Dynamic crop shift effect	Total	Individual crop yield effect	Static crop shift effect	Dynamic crop shift effect
India							
1901/02 - 1911/12	0.92	-0.05	-0.06	0.81	113.4	-6.3	-7.1
1911/12 - 1921/22	-0.24	-0.10	0.07	-0.27	88.5	36.4	-24.9
1921/22 - 1931/32	0.03	0.27	-0.08	0.23	14.1	119.1	-33.3
1931/32 - 1941/42	-0.36	0.30	-0.06	-0.11	324.5	-277.5	53.0
1941/42 - 1951/52	-1.49	0.30	-0.02	-1.21	123.0	-24.5	1.5
1951/52 - 1961/62	2.76	0.14	-0.01	2.89	95.3	5.0	-0.3
1961/62 - 1971/72	1.55	0.15	0.20	1.90	81.6	8.0	10.3
1971/72 - 1981/82	1.83	0.35	0.09	2.28	80.6	15.4	4.0
1981/82 - 1991/92	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 - 1947/48	-0.15	0.01	0.15	0.00	n.a.	n.a.	n.a.
1947/48 - 2001/02	2.38	0.26	0.66	3.30	72.1	8.0	20.0
Pakistan							
1901/02 - 1911/12	1.84	-0.19	0.09	1.74	105.4	-10.8	5.4
1911/12 - 1921/22	0.06	-0.05	0.02	0.02	n.a.	n.a.	n.a.
1921/22 - 1931/32	-0.35	0.03	0.02	-0.31	113.4	-8.5	-4.9
1931/32 - 1941/42	1.51	0.16	0.32	1.99	75.8	8.2	16.0
1941/42 - 1951/52	-0.80	0.18	0.03	-0.58	136.6	-30.6	-6.0
1951/52 - 1961/62	1.03	0.85	0.03	1.92	53.8	44.4	1.8
1961/62 - 1971/72	3.37	0.52	0.28	4.16	80.8	12.5	6.7
1971/72 - 1981/82	1.72	0.63	0.13	2.49	69.2	25.4	5.4
1981/82 - 1991/92	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 - 1947/48	0.55	-0.03	0.22	0.74	74.5	-4.0	29.6
1947/48 - 2001/02	2.46	0.48	0.63	3.57	68.9	13.4	17.7
Bangladesh, treating 3 different rice as different "crops"							
1901/02 - 1911/12	1.42	-0.31	-0.11	0.99	142.9	-31.6	-11.4
1911/12 - 1921/22	-1.04	-0.05	0.00	-1.09	96.0	4.2	-0.2
1921/22 - 1931/32	0.37	0.03	0.06	0.47	79.8	7.4	12.9
1931/32 - 1941/42	-2.00	0.74	-0.05	-1.32	151.8	-55.9	4.1
1941/42 - 1951/52	0.79	-0.58	-0.16	0.05	n.a.	n.a.	n.a.
1951/52 - 1961/62	1.41	0.15	0.01	1.57	90.0	9.6	0.4
1961/62 - 1971/72	-0.40	0.57	0.10	0.28	-139.4	202.5	36.9
1971/72 - 1981/82	1.86	-0.04	0.16	1.98	93.9	-2.1	8.3
1981/82 - 1991/92	1.29	1.10	-0.05	2.35	55.0	47.0	-2.0
1991/92 - 2001/02	1.81	0.34	0.16	2.32	78.3	14.7	7.0
1901/02 - 1947/48	-0.16	-0.02	0.01	-0.17	96.4	10.4	-6.8
1947/48 - 2001/02	1.39	0.29	0.37	2.04	67.9	14.1	18.0
Bangladesh, treating 3 different rice as 1 crop							
1901/02 - 1947/48	-0.18	0.01	0.00	-0.17	107.6	-6.8	-0.8
1947/48 - 2001/02	2.02	-0.04	0.06	2.04	98.8	-2.0	3.2

Notes: When the aggregate land productivity growth rate was less than 0.1% in absolute terms, we do not show decomposition results but indicate "n.a.".

Appendix Figure 1: Agricultural labor productivity (Y/L) in India, Pakistan, and Bangladesh, 1901/02-2001/02, in absolute terms



Appendix Figure 2: Aggregate land productivity (Y/A) in India, Pakistan, and Bangladesh, 1901/02-2001/02, in absolute terms

