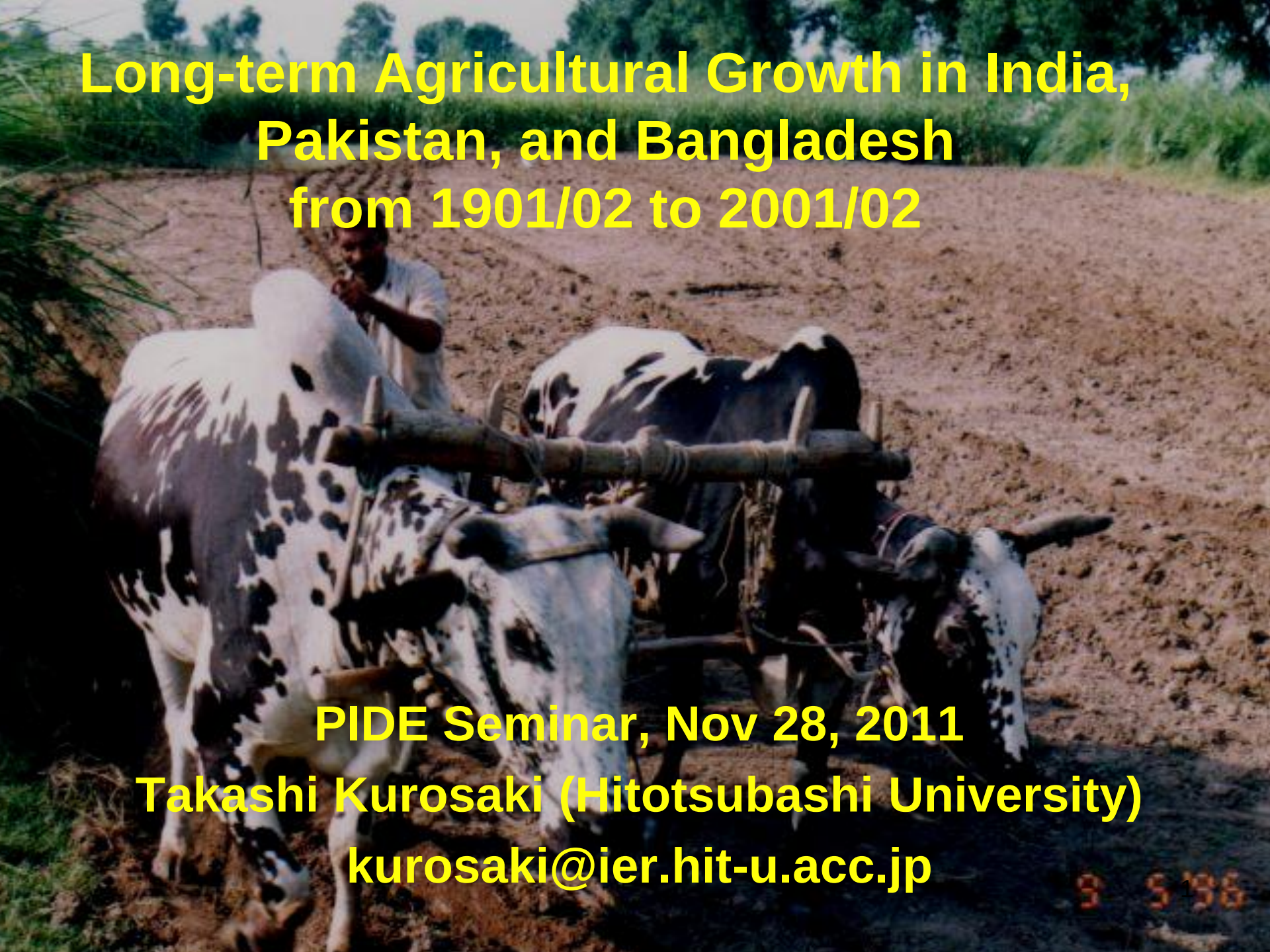

Long-term Agricultural Growth in India, Pakistan, and Bangladesh from 1901/02 to 2001/02

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Background of this research

- **Kurosaki's main research area: Microeconomic modeling of household behavior under incomplete markets, and empirical application of the model to households in South Asia using microeconometric tools. Especially how households can smooth consumption and manage human capital investment under missing insurance markets.**
- **Kurosaki's home institution: Institute of Economic Research, Hitotsubashi University (IER-HU), Tokyo. Famous for the compilation of Japan's LTES (Long-Term Economic Statistics)**

=> Asian Historical Statistics Project (1995-, IER-HU, covering major Asian countries, from the late 19th century to the current.

- **Kurosaki is in charge of agricultural statistics of South Asia in this project. On-going research: combining historical macro data with microdata and applying the microeconometric models.**

Output from the Project

- **12 Volumes of Major Asian Countries, covering the period from the late 19th century or the early 20th century.**
- **Published by Toyo Keizai Publishers, Tokyo, in bilingual form, w/ CD-Rom containing more statistics.**
- **Each volume is assigned to each country. Statistics are arranged according to the national income accounting approach.**
- **Already published: Volume 1 Taiwan.**
- **In printing: Volume 4 Korea, Volume 2 Vietnam, Volume 3 China.**
- **Open access to dataset in progress (http://www.ier.hit-u.ac.jp/COE/index.html)**

1. Introduction

- **Re-emphasis on agriculture as key to poverty reduction (WDR 2008: *Agriculture for Development*)**
- **The largest number of the poor in rural South Asia: Key to achieve MDGs**
- **Thus, agriculture in South Asia is critically important (HCI higher in rural areas and highest among landless agricultural workers; Food budget share high for the poor)**

=> Quantitative investigation of agricultural performance and the sources of growth in India, Pakistan, Bangladesh.

Literature on long-term agricultural performance in the Subcontinent

- **Pre-1947 analysis for undivided India (e.g., Sivasubramonian, 1960; 2000), for British India (Blyn, 1966; Guha, 1992), areas currently in India (Roy, 1996)**
- **Comparison of Indian Punjab and Pakistan Punjab (e.g., Prabha, 1969; Dasgupta, 1981; Sims, 1988)**
- **Comparison of West Bengal and East Bengal (e.g., Islam, 1978; Boyce, 1987; Rogaly et al., 1999; Banerjee et al., 2002)**

This paper's contribution

The coverage of this study is new:

(1) Comparison of areas currently in India, Pakistan, Bangladesh, including the pre-1947 period.

(2) Very long-term: 1901/02-2001/02.

Methodological innovation:

(1) Time series model for growth, focusing on difference-in-difference in growth rates (Partition as a *natural experiment*).

(2) New decomposition to *quantify the contribution of crop shifts on aggregate land productivity*, un-noticed source of growth in the literature.

2. Data

- **Geographical difficulty: Areas currently in India, Pakistan, Bangladesh = British Provinces & Princely State) before Partition 1947. Punjab, Bengal, and Assam were partitioned.**

(i) Data sources

Pre-1947

- **Sivasubramonian (2000)**
- **Blyn (1966)**
- ***Agricultural Statistics of India***
- ***Estimates of Area and Production of India***
- ***Report on the Season and Crops (RSC)***
- **Crop-cutting survey reports (Mahalanobis)**

Post-1947

- ***Agricultural Statistics***
- ***National Accounts Statistics***

(ii) Individual crop statistics

- **Individual crop statistics were compiled first. Then their sum is extrapolated to cover all of the crop sector.**
- **Individual crops cover:**
  - **India 18 crops = rice, wheat, barley, jowar (sorghum), bajra (pearl millet), maize, ragi (finger millet), gram (chickpea), linseed, sesamum, rape & mustard, groundnut, sugarcane, tea, coffee, tobacco, cotton, jute & mesta**
  - **Pakistan 12 crops (major crops subsector in GDP stat) = rice, wheat, barley, jowar, bajra, maize, gram, rape & mustard, sesamum, sugarcane, tobacco, cotton**
  - **Bangladesh 16 crops = aman rice, aus rice, boro rice, wheat, barley, maize, gram, linseed, sesamum, rape & mustard, groundnut, sugarcane, tea, tobacco, cotton, jute**
- **These crops covered more than 2/3 of gross crop output.**

(iii) Pre-1947 Estimation

Step 1 = Sivasubramonian (2000)**Si***, ***i*=*India*, *Pakistan*, *Bangladesh*, where**

- ***Si* = Govt. of India (1948) for 1936/37 to 1945/46**
- ***Si* = Avg.[Govt. of India (1948) for 1936/37 to 1945/46]****Ai*, for other years, where**
- ***Ai* = Blyn (1966)'s index for "greater Bengal" or "greater Punjab" re-converted into Avg.[1936/37 to 1945/46]=1.**

Step 2 = Independent estimates based on *RSC* for districts currently in Pakistan and Bangladesh

- **Adopt several assumptions by Sivasubramonian (2000), such as using the reported area and yield without adjustment, and extrapolating British Province figures to the neighboring Princely States if no statistics are available for these States.**

(iii) Pre-1947 Estimation (cont'd)

Step 3 = Comparison of Step 1 and Step 2 series

- **For Pakistan, they show similar trends but the Step 2 Series is more precise => Adopt Step 2 series as the estimates for Pakistan.**
- **For Bangladesh, Assam data are missing so that comparability was not high**
- **As far as East Bengal is concerned, Step 1 series is comparable to Step 2 for major crops => Adopt Step 1 (India+Pakistan) – Step 2 (Pakistan) as the estimates for India**

Step 4 = Adjustment for Bangladesh pre-1947

- **Following Islam's (1978) "revision factors", Step 1 series for the pre-1947 Bengal statistics were adjusted. Extrapolate them to corresponding to Bangladesh areas.**

(iv) Aggregation

- **Q = aggregated output value from major crops at fixed prices (1938/39, 1960, 1980/81)**
- **S_1 = The share of Q in the total crop sector (the difference is output value from minor crops)**
- **S_2 = The value-added ratio in the crop sector**
- **Y = Value-added in the crop sector = $Q/S_1 \times S_2$**

<Measures of partial productivity>

- **Y/L (labor productivity), where L is agricultural labor force and estimated as $L=L' \times S_3 \times S_4$, where L' is the total population, S_3 = crude activity rate, and S_4 is the share of agriculture in working population.**
- **Y/A (land productivity), where A is the total area cultivated**

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

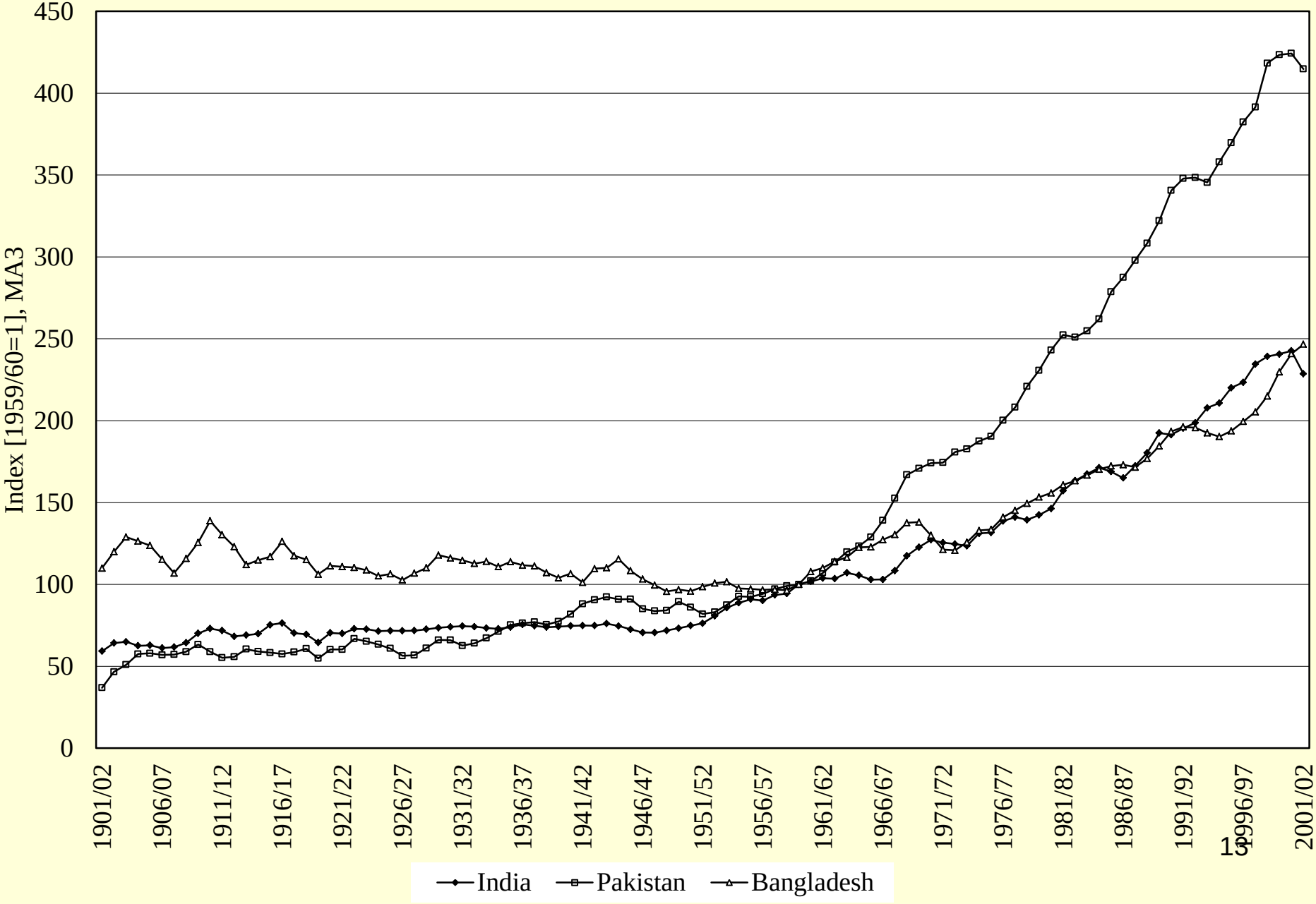


Figure 2: Agricultural labor productivity (Y/L) in India, Pakistan, and Bangladesh, 1901/02-2001/02

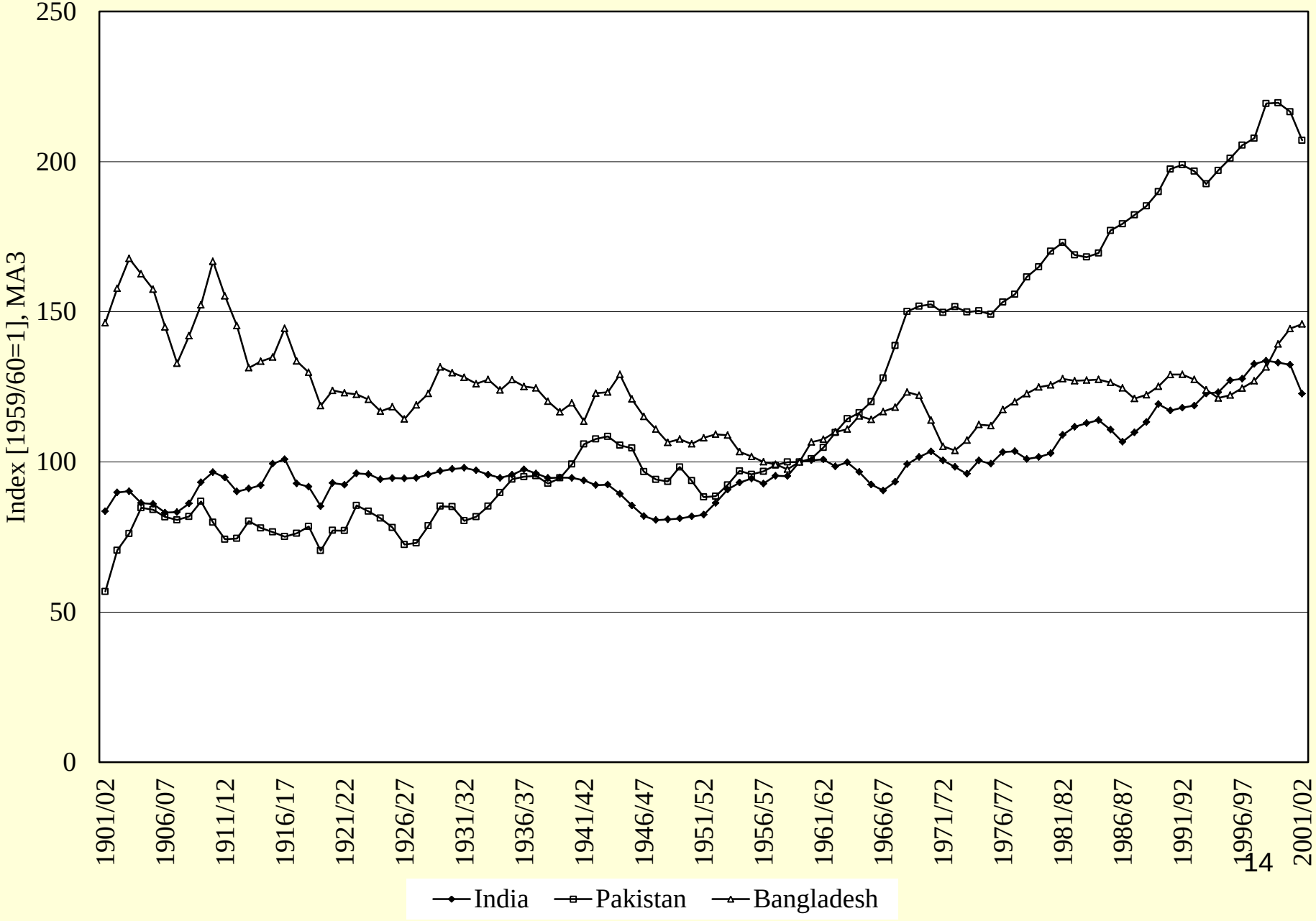
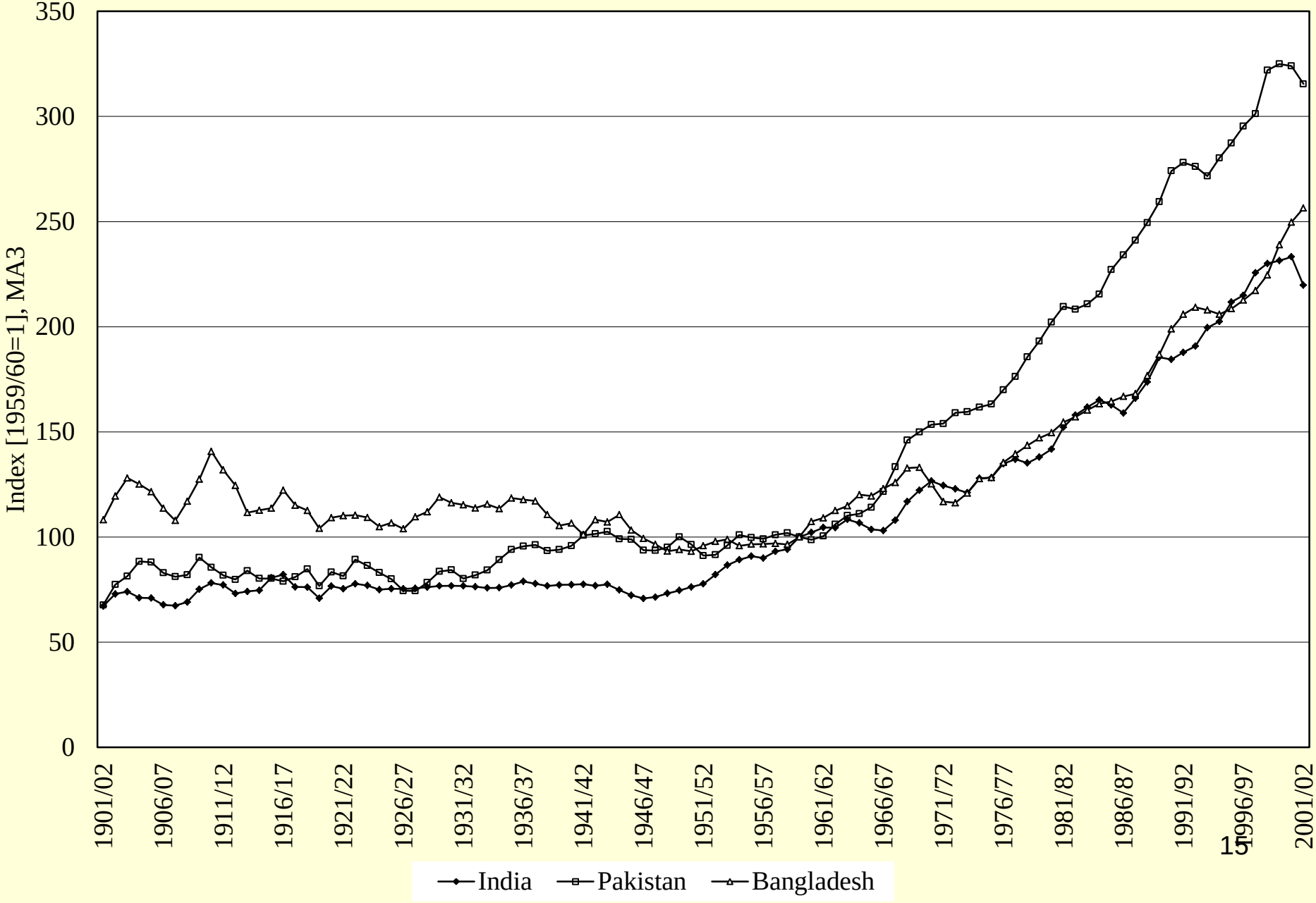


Figure 3: Aggregate land productivity (Y/A) in India, Pakistan, and Bangladesh, 1901/02-2001/02



3. Gross Output and Land Productivity in India, Pakistan, and Bangladesh

<Analytical framework>

- **Time-series regression**

$$\ln Y_t = a + bt + u_t \ ,$$

where Y is replaced by Y/L or Y/A as well. Growth rate=b, Variability=std.error of regression.

- **Difference-in-Difference extension**

$$\ln Y_t^k = (a^k_0 + a^k_1 D_t) + (b^k_0 + b^k_1 D_t)\, t + u^k_t \ ,$$

where D_t is time dummy for "post-1947" or "post-1971". Comparison of b^k_1 (k=India, Pakistan, Bangladesh) gives "DID" in growth rates.

- **When is the breakdate?** "Structural change of unknown timing" methodology by Hansen (2001) applied to time series of $\ln Y_t^k$.

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 - 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 - 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 - 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%

Results of estimating the structural change of unknown timing for Q/A

	1st break	2nd break
India	1950/51***	none
Pakistan	1951/52***	1934/35**
Bangladesh	1949/50***	none

Notes: "Ann.gr.rate" is the annual growth rate, estimated by a time-series regression of ln(Y) on time trend. "CV" is the coefficient of variation, calculated from residuals in the same time-series regression.

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

	Annual growth rate in *Y* (%)				Relative contribution (%)			
		Growth rate in *Y/A* (intensive expansion)				Growth rate in *Y/A* (intensive expansion)		
	Growth rate in *A* (extensive expansion)	Land use intensity (gross cropped area/cultivated area)	Output per gross cropped area	Total	Growth rate in *A* (extensive expansion)	Land use intensity (gross cropped area/cultivated area)	Output per gross cropped area	
India								
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 - 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 - 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	

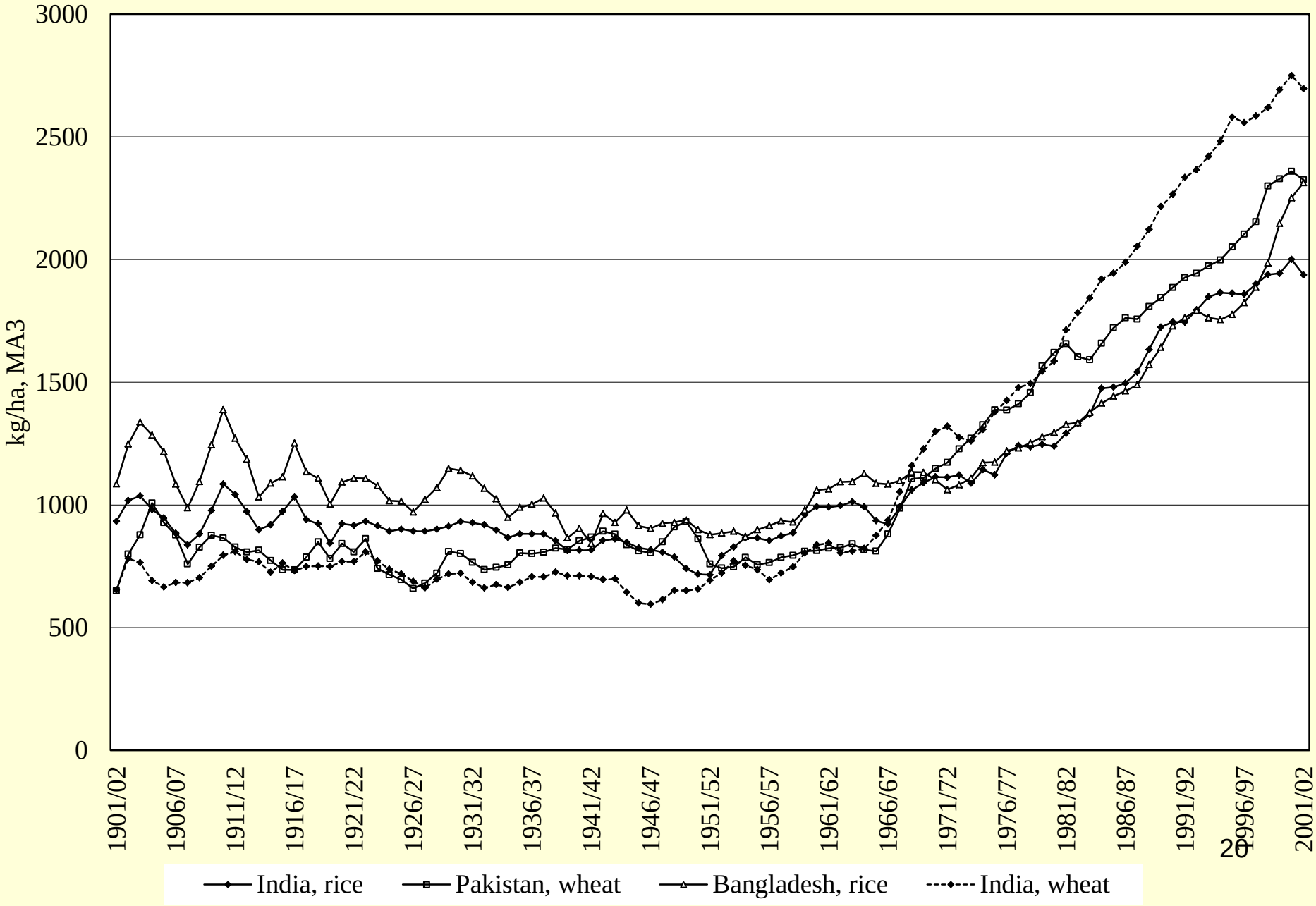
Notes: Annual growth rate is calculated from the comparison of the initial and last years.

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

	Y	*Y/L*	*Y/A*
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	**3.8**	**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: 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).

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



4. Changes in Crop Mix and Their Contribution to Land Productivity

<Important findings from Section 3>

- **The rapid improvement in aggregate land productivity (*Y/A*) occurred before the Green Revolution**
- **The movement of *Y/A* often differs from that of per-acre rice or wheat yields**

=> Role of *changes in crop mix*?

- **Herfindahl index (concentration index)**

$$H = \text{Sum}_i \{S_i^2\},$$

where S_i is acreage share of crop *i*.

- **Share of rice and wheat areas in foodgrains areas**
- **Share of non-foodgrain crops in the major crops**

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

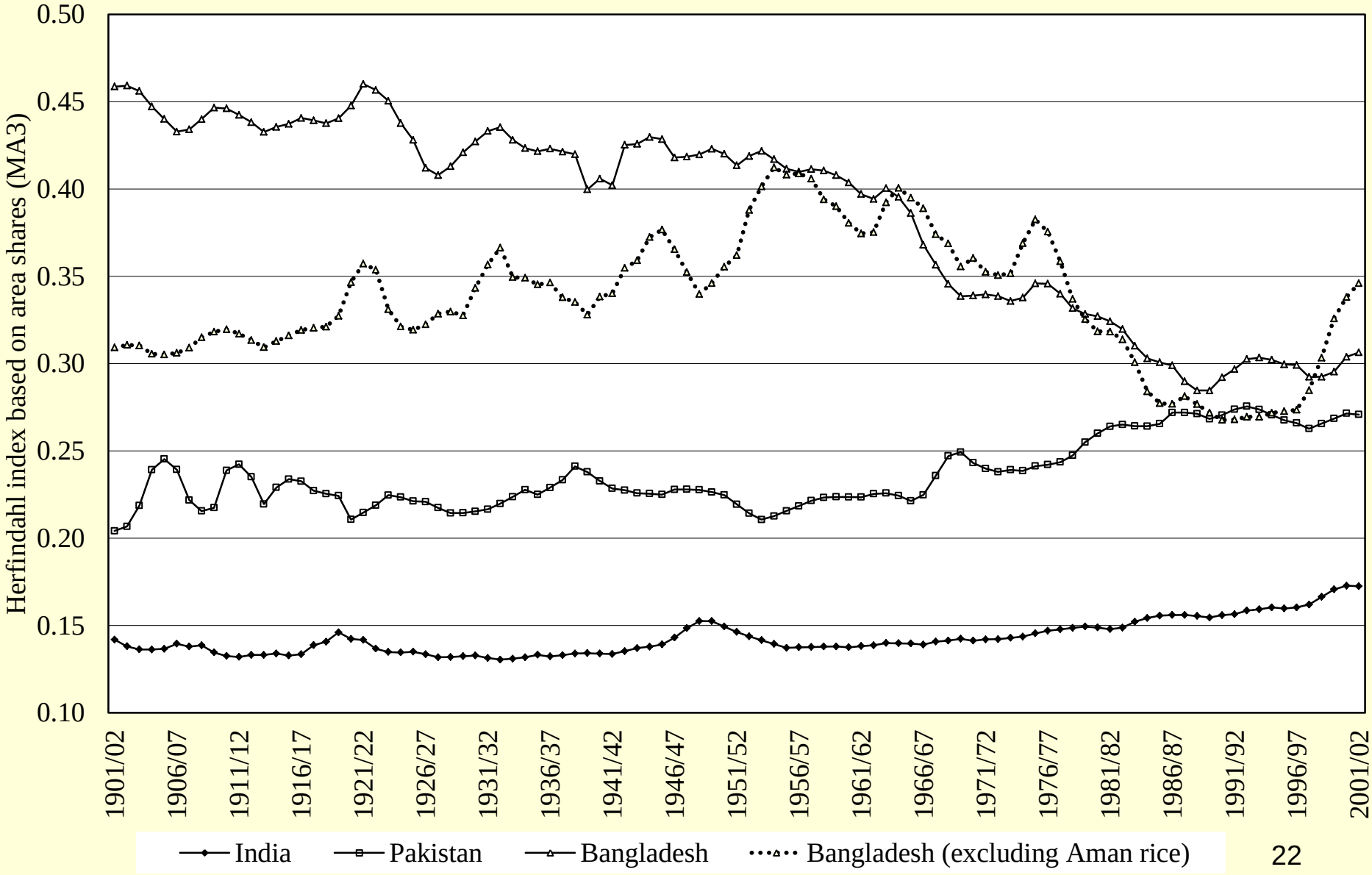


Fig 6: Changes in crop mix, II -- Acreage share of rice & wheat in areas under total foodgrains in India, Pakistan, Bangladesh, 1901/02 to 2001/02

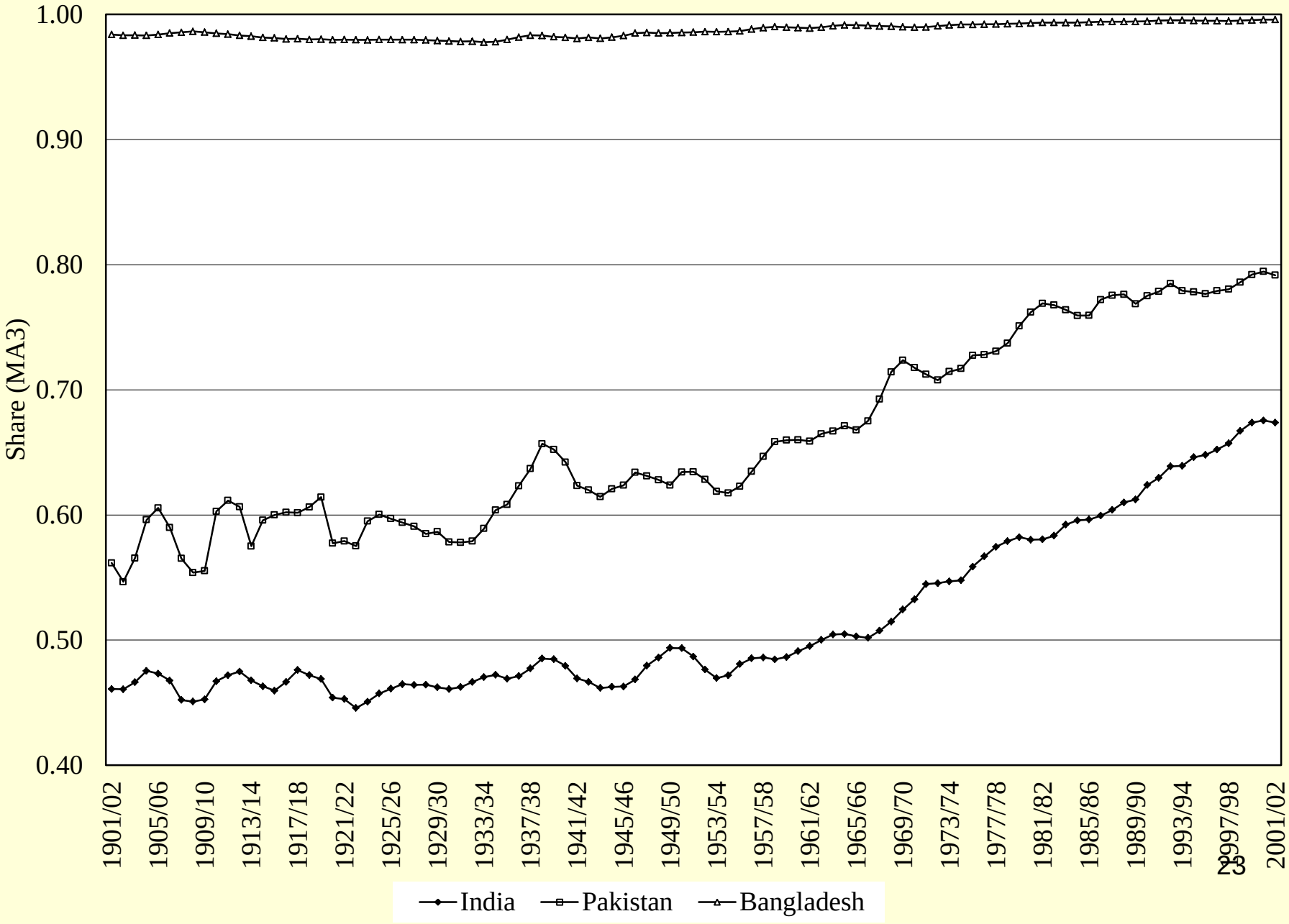
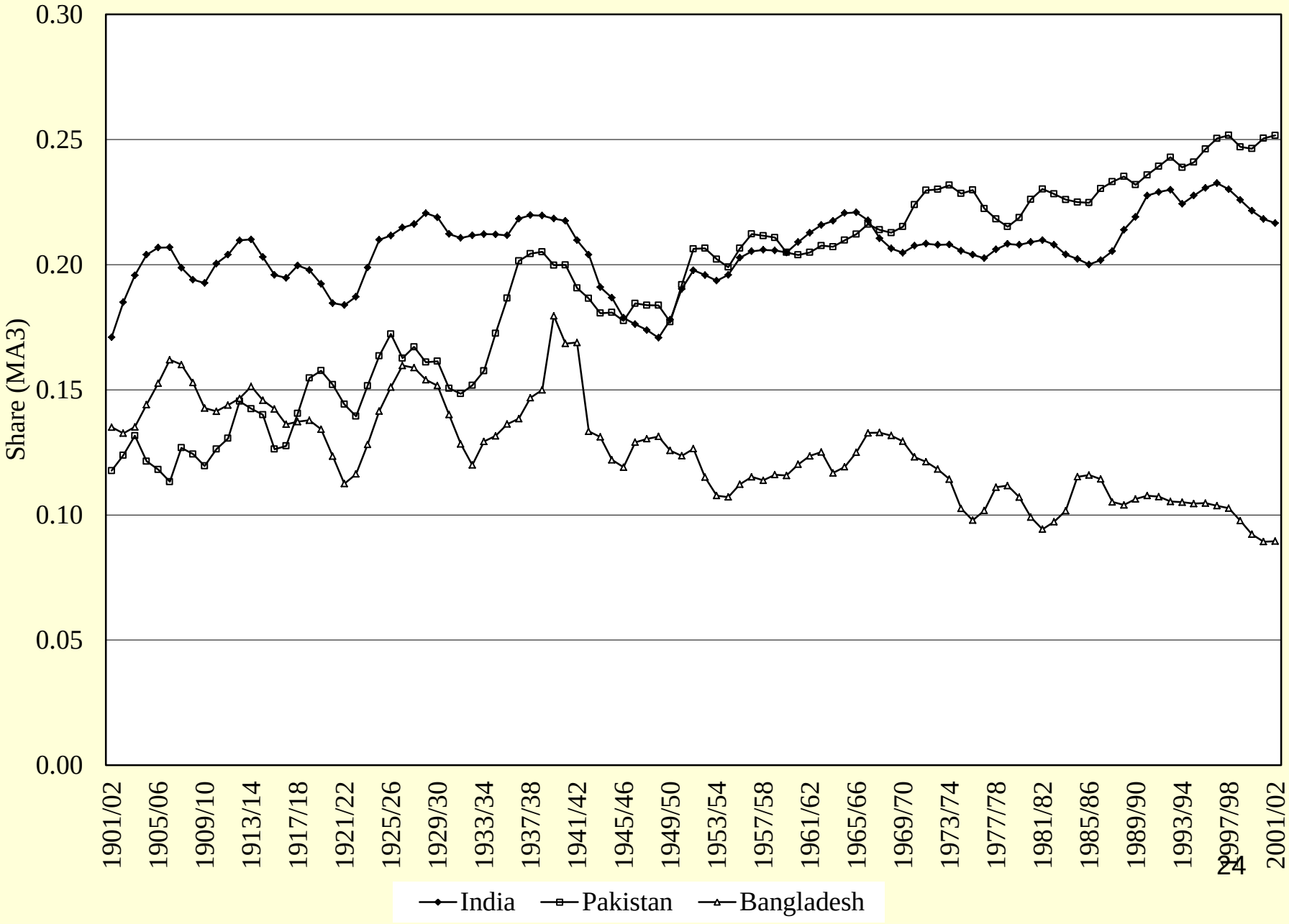


Fig 7: Changes in crop mix, III -- Acreage share of non-foodgrains in total area under crops in India, Pakistan, Bangladesh, 1901/02 to 2001/02



New decomposition to quantify the impact of crop shifts on aggregate land productivity (Kurosaki, 2003 *AJAE*)

- $(Y_t - Y_0)/Y_0 = [\text{Sum}_i \{S_{i0} (Y_{it} - Y_{i0})\}$
  $+\text{Sum}_i \{(S_{it} - S_{i0})Y_{i0}\} + \text{Sum}_i \{(S_{it} - S_{i0})(Y_{it} - Y_{i0})\}]/Y_0$,

  where the 1st= "crop yield effects", the 2nd= "static crop shift effects", and the 3rd= "dynamic crop shift effects"

  - *Crop yield effects*: If no change in crop mix, an improvement in per-acre yield of individual crops improves the aggregate land productivity.
  - *Static crop shift effects*: If no change in individual crops' per-acre yield, crop shifts into more lucrative crops improves the aggregate land productivity.
  - *Dynamic crop shift effects* (cross-term of the two): Shifts into crops whose per-acre yield is improving improves the aggregate land productivity.

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 - 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 - 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 - 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

5. Summary and Conclusion

- **Turnaround of growth rates at around 1950 in India, Pakistan, and Bangladesh. The turnaround occurred in all of *Y*, *Y/L*, and *Y/A*.**
- **Level leader = Pakistan, DID leader = Bangladesh**
- **A substantial part (about 1/3) of the improvement in aggregate land productivity was attributed to crop shifts in India, Pakistan, and Bangladesh. In India and Pakistan, the crop shift effects were especially important in 1950s and 1990s.**
- **Contribution of crop shifts to agricultural growth in Bangladesh would be underestimated if three varieties of rice are treated as a single crop.**

=> Institutional and policy changes have significant effects on agricultural growth, through farmers' response to newer opportunities. Technological factors (esp. irrigation) are important in facilitating their response.