Evolution of Crop-dairy Production Systems in South India from 1971 to 2002

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Abstract: It is widely believed that not only a Green Revolution in a crop sector but also a White Revolution in a dairy sector has generated the great momentum of agricultural development in India since the late 1960s. However, due to the dominance of sector-specific analyses, the importance of the interaction between these two sectors has been neglected in the existing literature. The interaction is important in that the dairy sector provides manure to crop production while the crop sector supplies fodder to the dairy. Using household data collected in Tamil Nadu, India for three decades from 1971, we show the increase of fodder production as a byproduct of Green Revolution in 1970s enabled subsequent White Revolution in 1980s and the byproduct of the White Revolution, i.e. increased manure availability, is enhancing the recent revival of organic farming system for sustainable agricultural development.

Key Words: Green revolution, White revolution, agricultural system, India.

JEL codes: M3, O13, Q12, Q13, Q56

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1. Introduction

It is well known that not only a Green Revolution (GR) in a crop sector but also a White Revolution (WR) in a dairy sector has generated the great momentum of agricultural development in India since the late 1960s. The interaction between these two sectors is important in that the crop sector supplies fodder to the dairy while the dairy sector provides manure to crop production. The great success of the GR in 1960s and 1970s had increased fodder availability, which, in association with the strong institutional support to the dissemination of crossbred cows (crossbreeds between European and local cattle), had enabled the WR in the 1980s. Consequently the relative price of manure to chemical fertilizer started declining in the late 1990s. Together with the recent concern about the declining land fertility, this declining price trend encourages farmers to return to organic fertilizer from chemical fertilize. In this regard, through the provision of byproducts (i.e. fodder and manure) as crucial inputs, one sector's development support the other sector's development. However, most of existing studies focus on either sector. A comprehensive picture on the agricultural development can not be drawn without looking at the two sectors simultaneously.

The purpose of this paper is to investigate how the interaction between the two sectors has changed over time. We use household level data in Tamil Nadu, India from 1971 to 2002. This long-term data set allows us to see the evolutionary process of the interaction between Green and White Revolutions.

The outline of the paper is as follows: Section 2 describes the data used in this

paper and reports the descriptive results of the change in yield, manure application, chemical fertilizer application in rice, sorghum, and pearl millet sectors as well as the changes in milk production, the number of cows by type. In Section 3, we conceptualize the framework of this study to elaborate the transformation of farming system in Tamil Nadu based on the analyses of the previous section. The findings are summarized and their policy implications are discussed in Section 4.

2. Descriptive Analyses

2.1 Data

The data has been collected annually by Tamil Nadu Agricultural University since 1971 with the aim of surveying cultivation costs of principal crops. The sampling method is a three stage stratified random sampling. First, prefectures are allocated to six agro-climatic zones in proportion to the total area of relevant crops, and then prefectures in each zone are selected with probability proportional to zone-wise crop area. Second, villages in each prefecture are selected with probability proportional to prefecture-wise crop area. Third, in each selected village, farming households are selected in accordance with the size of land holdings. The five size classes are operational holdings with area less than one hectare, between 1 and 2 hectares, between 2 and 4 hectares, between 4 and 6 hectares, and greater than 6 hectares. In each size class, two households are selected by simple random sampling, generating sample of 10 farmers in each village. If in any villages, a particular size class does not contain even two households, more households are selected from adjacent size group to make up the deficit. The survey year corresponds to the cropping

calendar, starting July and ending June of the following year. For simplicity hereafter we refer only the beginning year of survey year. For example, the annual data of the coverage from 1971-July to 1972-June is indicated as the data in 1971 survey year.

From 1971 to 1983, sampling of 40 villages was carried out every year. Although the villages selected in current and previous years are removed from the following years' selection, given the huge population size, we can safely regard the samples of this period as pooled data of 13 rounds of sampling. From 1984 to 2002, sampling of 60 villages was carried out every three years and the same households were surveyed for three years until the next round of sampling. Hence, the samples of this period can be regarded as pooled 3-year panels of 6 rounds of sampling. Two-thirds of the survey years out of 32 years have been compiled for this study. Therefore, we are able to utilize part of the data, and present the preliminary results in this monograph.[1]

2.2 Data Analyses

Figure 1 describes the change in yield of rice for the period 1971-2002. Significant increase in yield especially for the period 1970-90 is observed with the parallel increase in chemical fertilizer in the same period (Figure 2). Since the application of manure declined in the same period (Figure 3), it can be said that the traditional rice production system has been converted to the modern system. It should be noted that the relative price of manure to chemical fertilizer constantly

[1] The data used in this study is the ones for the years 1971, 1972, 1974, 1975, 1977, 1978, 1980, 1981, 1983, 1984, 1986, 1987, 1989, 1990, 1992, 1993, 1995, 1996, 1998, 1999, 2001 and 2002.

increased in the 1980s and 1990s (Figure 4). This explains that the prevalence of the GR was realized due to the decline in the price of the modern inputs such as chemical fertilizers. Meanwhile, the production system has started changing since the late 1990s. Due to the recent decline in the relative price of manure to chemical fertilizer in the late 1990s, the farmers became more likely to use manure over chemical fertilizer (Figure 3). Farmers' concern about the degradation of soil fertility has been accelerating this trend.

We also examined the changes of coarse cereals such as sorghum and pearl millet. Figure 5 shows the changes in yields of sorghum and pearl millet for the period 1971-2002. Gradual increase in yields of the two crops especially in the 1970s is observed. Regarding the application of chemical fertilizers, they were hardly used in the early-1970s, and the amount of the use started increasing as late as 1980s. In contrast, the use of manure declined drastically in the 1970s, and reached the bottom in the 1990s. As is the case of rice, the recent decrease in the relative price of manure to chemical fertilizer in the 2000s induced the farmers to apply more manure (Figure 6 and 7). This trend is more clearly observed in a case of pearl millet than in sorghum.

It is obvious that the Green Revolution in rice and coarse cereals in the 1970s increased not only grain production but also fodder production. This enabled the White Revolution in the 1980s. The White Revolution in a dairy sector has brought the leap in the production. The annual milk production by the surveyed farms quadrupled for the last three decades, and it accelerated in the 1990s (Figure 8). Since the number of milk cows owned by the surveyed farms has not been changed a lot in the range of 550-650 (Figure 9), production increase can be attributed to a rapid

productivity increase. Figure 10 illustrates that the share of the crossbred milk cows rapidly increased in the 1990s, and the figure also indicates more than 80% of the milk cows were crossbred in 2002. Dairy development also increased manure supply because crossbred cows are physically bigger than the local conventional species, and they excrete larger amount of manure. Accordingly, the price of manure declined as is shown in Figure 4.

3. Conceptualization of the Evolution of Crop-dairy Production System

For clear conceptualization of evolutionary process of the interaction, this section sketches the key causal relationship during the three distinct phases of the agricultural development in Tamil Nadu based on the data analyses in the previous section.

In the Phase I, no remarkable interaction between the crop and dairy production was seen, and each sector intensified its production process, respectively (Figure 11). In the Phase II from the 1980s to the early 1990s, the interaction between the crop and dairy sectors emerged (Figure 12). The Green Revolution in rice increased supply of paddy straw for fodder. Production increase of sorghum and millet, together with declined demand for them as food grain, also increased the fodder supply. Cheaper fodder increased the profitability of raising crossbred cows. Strong institutional supports to crossbred dissemination from co-op and the decline of demand for cows for power accelerated the replacement of local to crossbred cows. Consequently, production of milk as well as manure increased.

The dairy development in the 1980s led the currently ongoing evolution towards

"Organic Green Revolution in the Phase III (Figure 13). Under the intensive use of chemical fertilizers in rice production, the soil fertility deteriorated so that the demand for manure is increasing among the farmers concerning about the sustainability. Higher demand for fodders is inducing the development of improved varieties of fodders. The interaction between rice, fodder (sorghum and millet), and dairy sectors is becoming stronger and thus simultaneous development is becoming crucial to move higher stage of agricultural development.

4. Concluding Remarks

Using household data collected in Tamil Nadu, India for three decades from 1971, we show the increase of fodder production as a byproduct of Green Revolution in 1970s enabled subsequent White Revolution in 1980s, and the byproduct of the White Revolution, i.e. increased manure availability, is enhancing the recent revival of organic farming system for sustainable agricultural development.

We may draw lessons from the experience of Tamil Nadu to less favorable Asian and African countries. Otsuka and Yamano (2005) suggest that a new farming system based on the use of manure produced by improved dairy cows is promising in Sub-Sahara Africa where the existing chemical fertilizer prices are inordinately high. Our results suggest preceding (or simultaneous) increase in fodder production is crucial for the development of dairy sector and the increase of manure supply.

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Figure1: Changes in Yield (Rice)

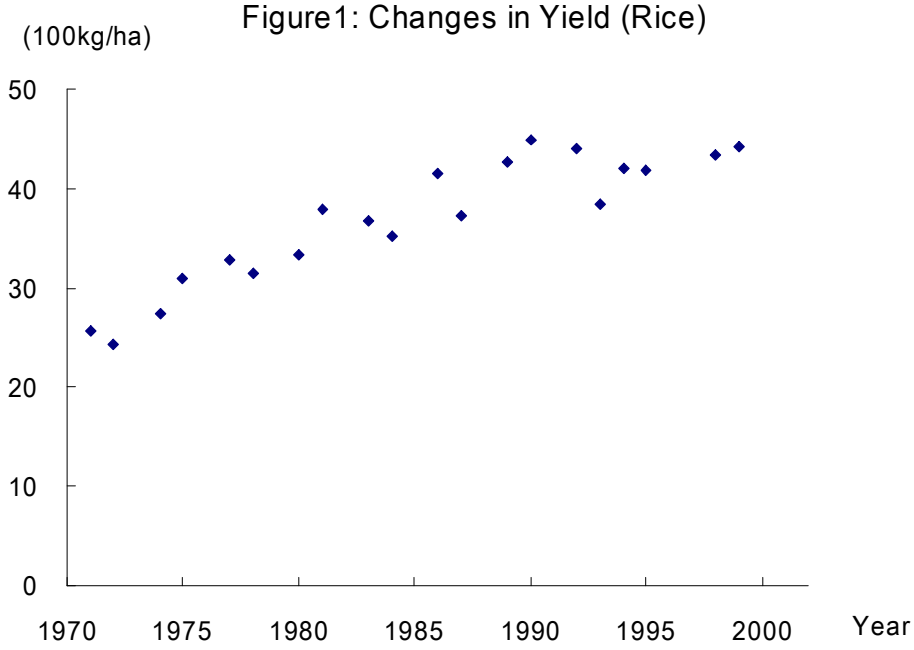

Figure 2: Changes in Chemical Fertilizer Appliction (Rice)

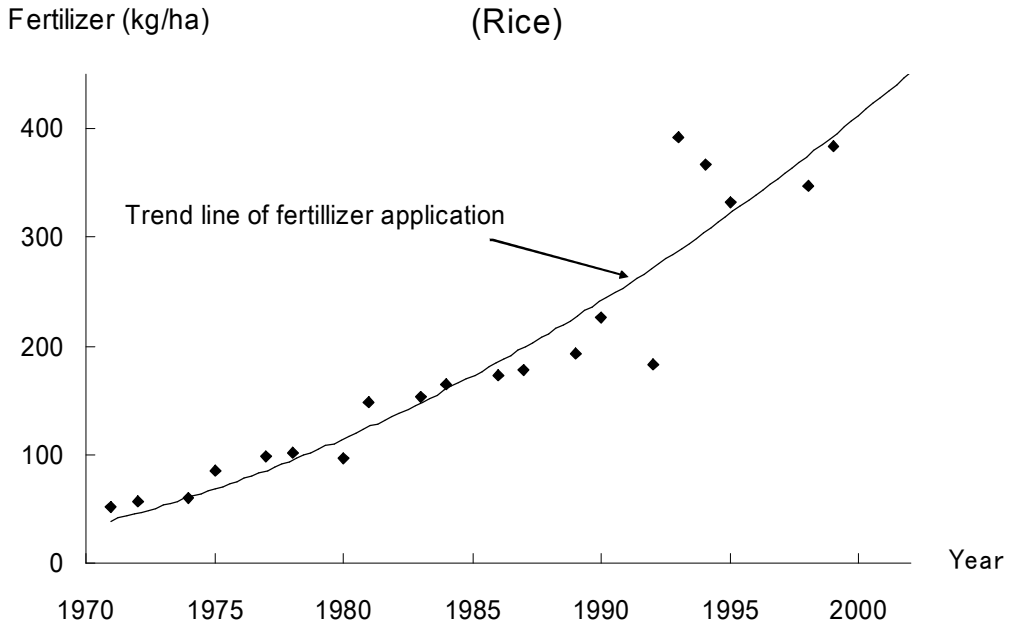

Figure 3: Changes in Manure Appliction (Rice)

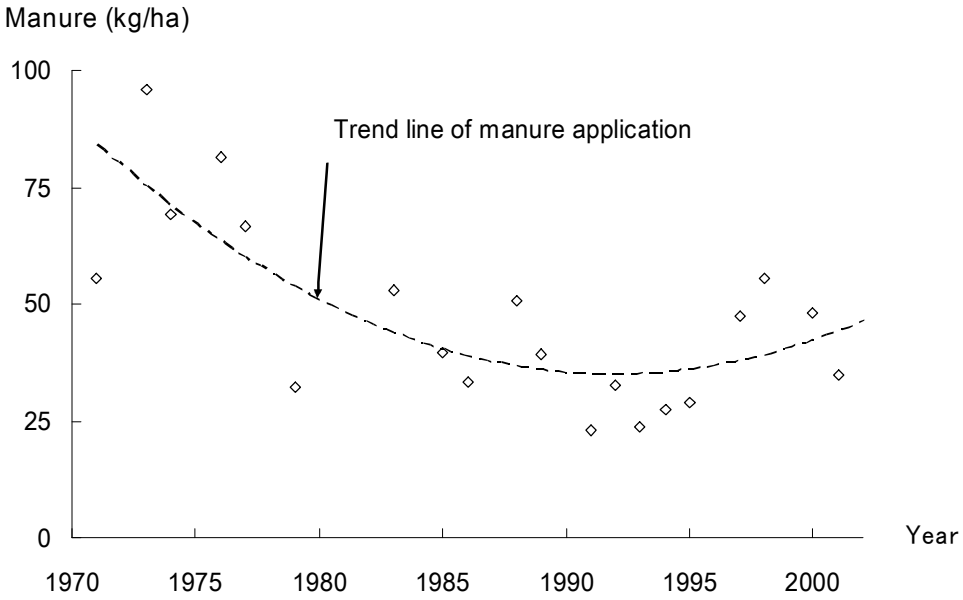

Figure 4: Relative Price of Manure to Chemical Fertillizer

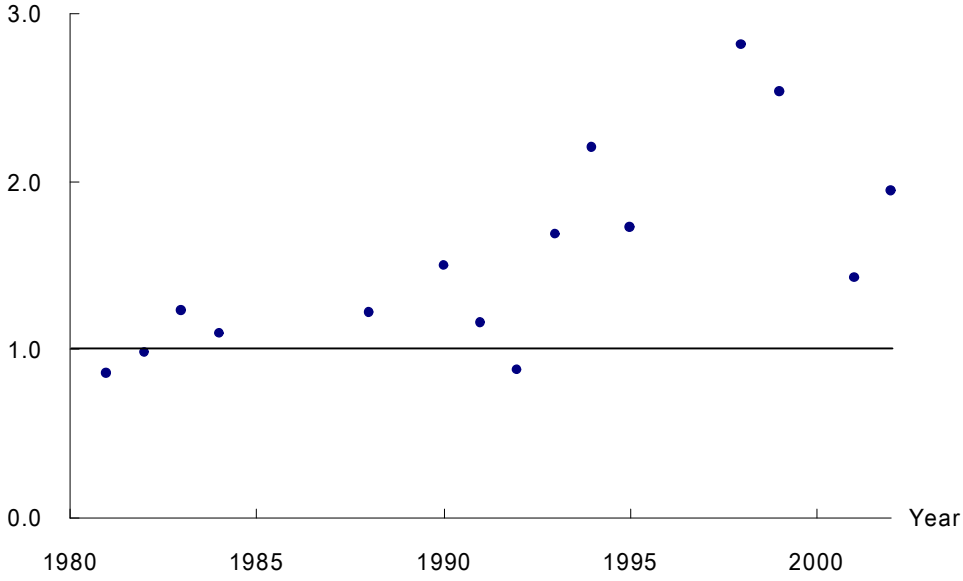

Figure 5: Change in Yield (Sorghum and Pearl Millet)

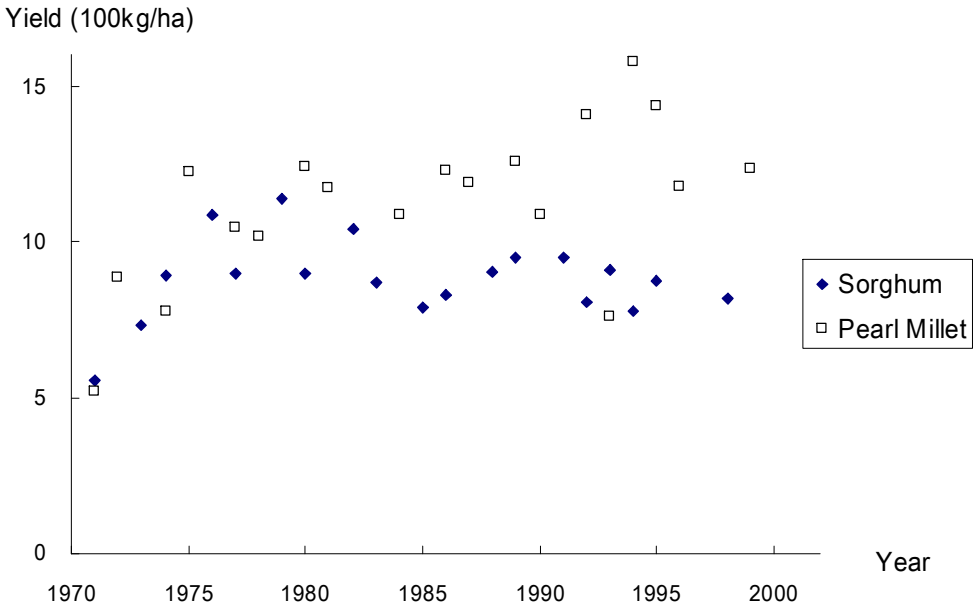

Figure 6: Changes in Fertilizer and Manure Appliction (Sorghum)

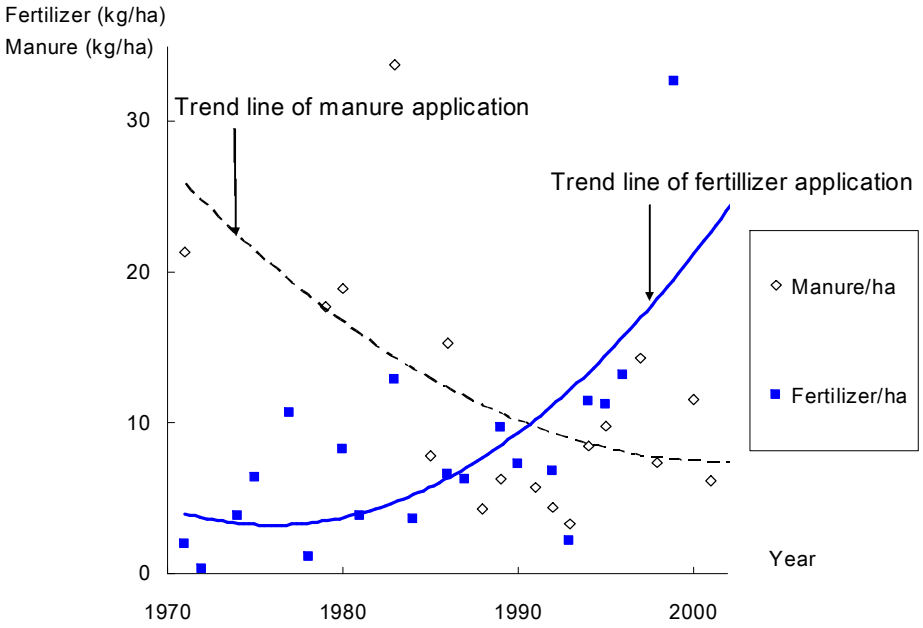

Figure 7: Changes in Fertilizer and Manure Appliction (Pearl Millet)

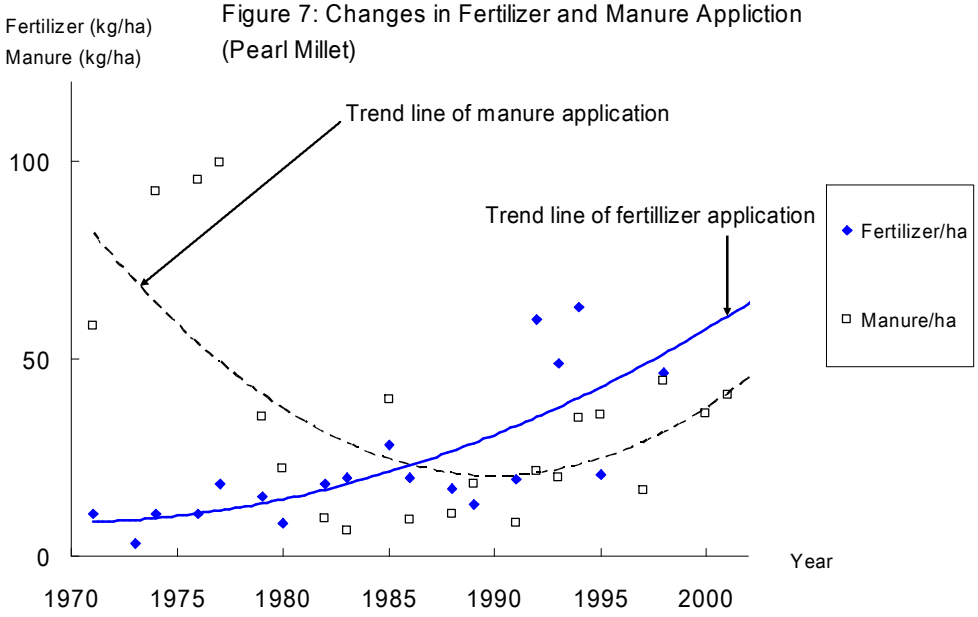

Figure 8: Change in Milk Production, 1971-2002

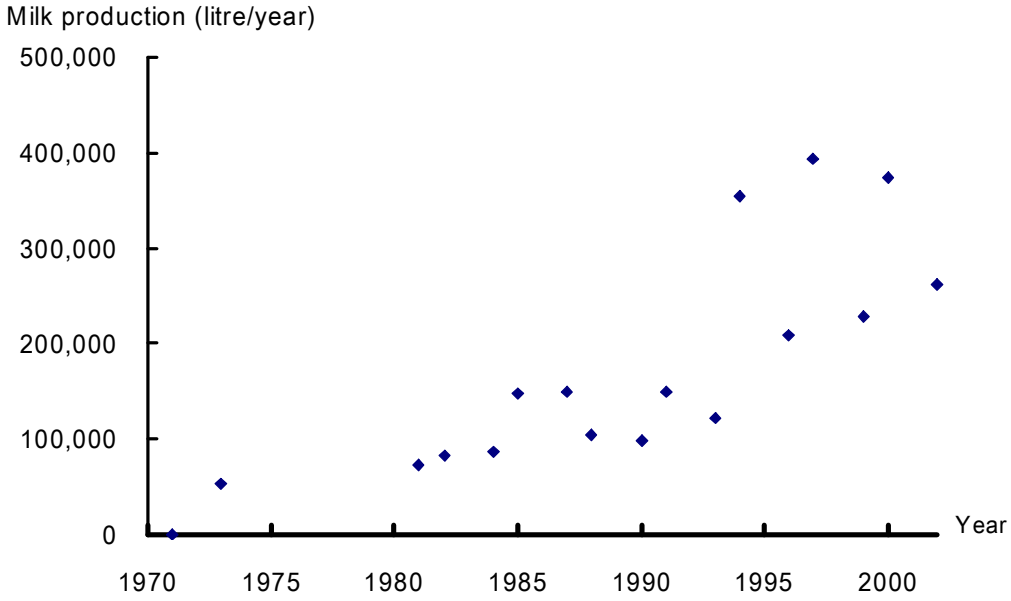

Figure 9: Number of Milk Cows

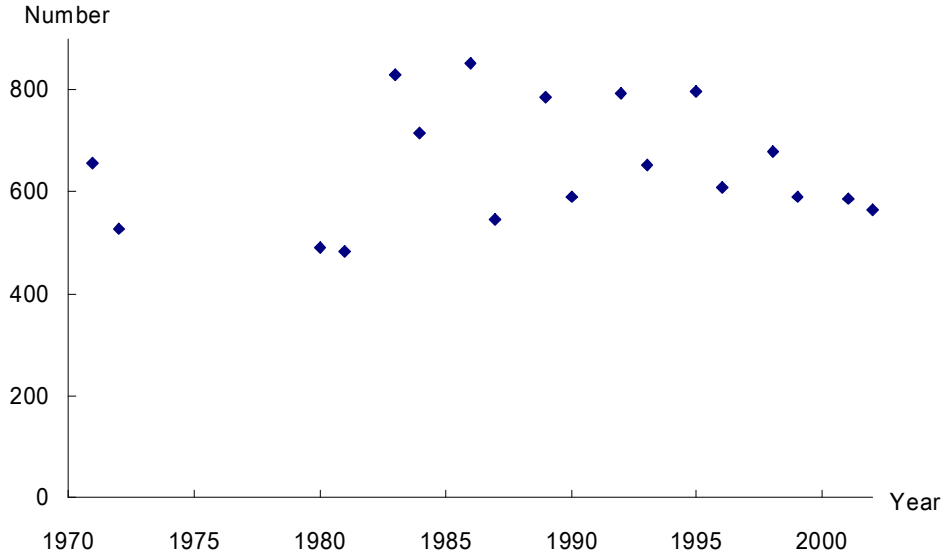

Figure 10: Change in Share of Hybrid Cows

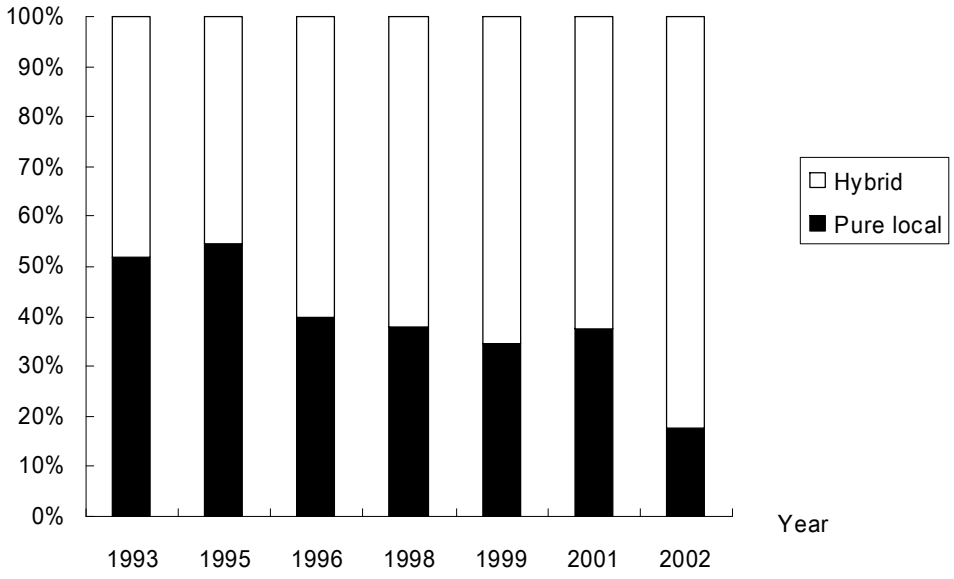

Figure 11: Phase I (1970s) - Early intensification process (no discernible interaction)

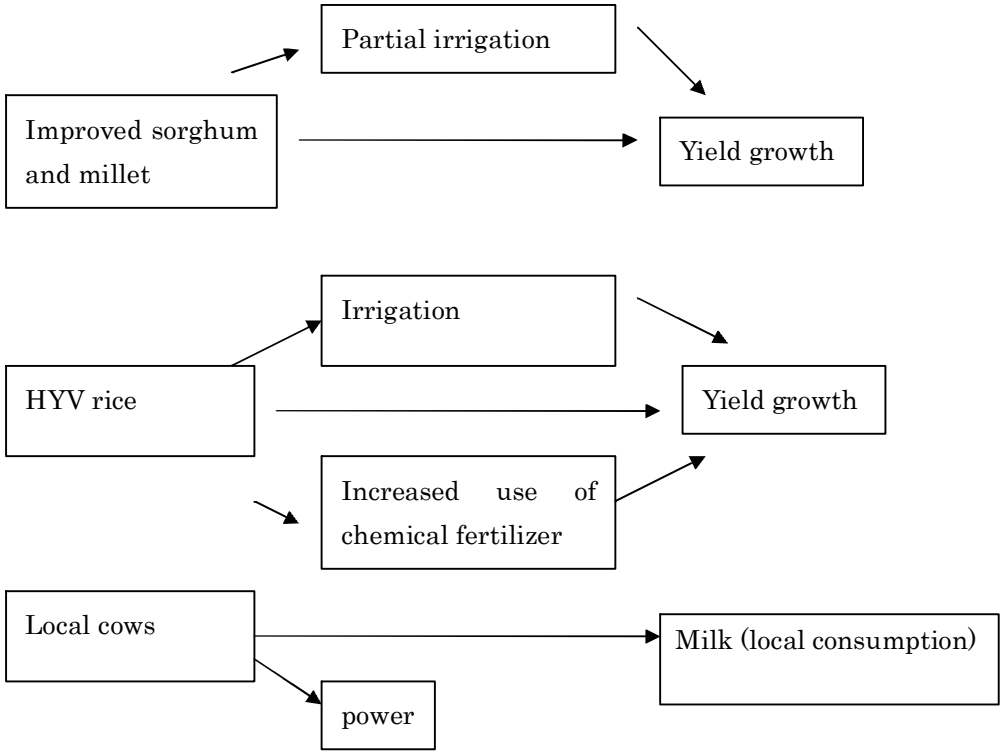

Figure 12: Phase II (Early 1980s to Early 1990s) - Development of integrated farming system

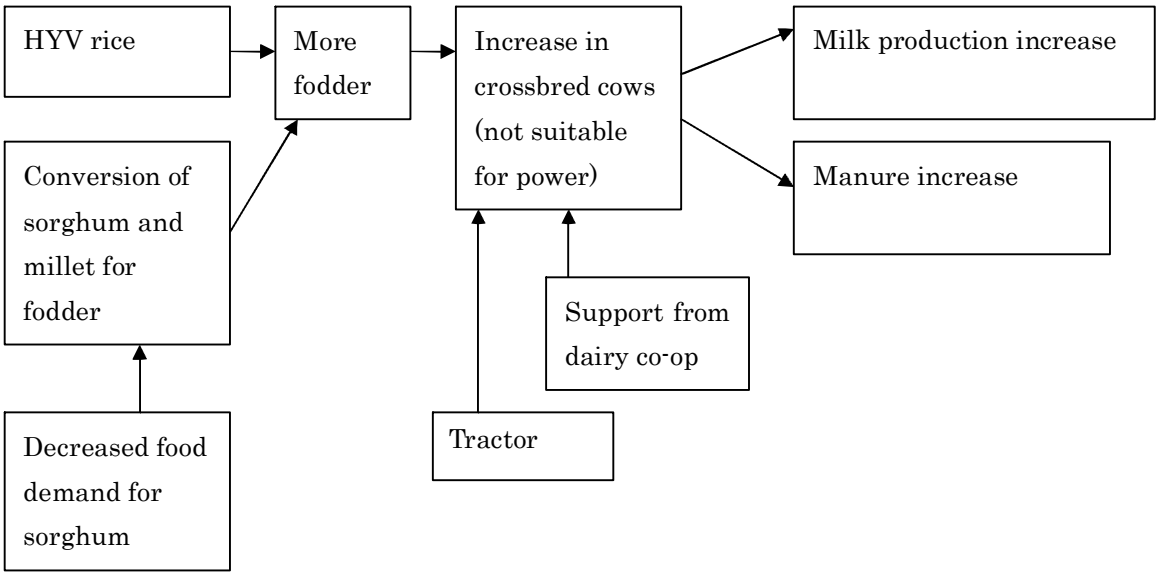

Figure 13: Phase III (Recent periods) - Evolution towards “Organic Green Revolution”