*Ind. Jn. of Agri. Econ.*
*Vol. 64, No. 2, April-June 2009*

**ARTICLES**

# Instability in Indian Agriculture During Different Phases of Technology and Policy

**Ramesh Chand and S.S. Raju***

I

INTRODUCTION

Agriculture growth and instability have remained the subject of intense debate in the agricultural economics literature in India. While the need for increasing agricultural production or growth are obvious, the increase in instability in agricultural production is considered adverse for several reasons. It raises the risk involved in farm production and affects farmers' income and decisions to adopt high paying technologies and make investments in farming. Instability in production affects price stability and the consumers, and it increases vulnerability of low income households to market. Instability in agricultural and food production is also important for food management and macro economic stability.

Adoption of green revolution technology, which is considered a watershed event in the post-Independence agriculture era in India has attracted special interest of researchers in terms of its impact on growth and instability of farm output. It is widely acknowledged that the new and improved technology helped India in achieving substantial increase in food production in a short period and brought the country close to attaining food self sufficiency by the early 1980s. However, the impact of new technology on instability in agricultural and food production has not been quite clear and has remained a matter of concern. Most of the studies which covered 10 to 20 years since the adoption of new technology concluded that instability in agricultural production had increased with the adoption of new technology (Mehra, 1981; Hazell, 1982; Ray, 1983a; Rao *et al.* 1988). In contrast to the findings of these studies, Mahendra Dev (1987) reported a progressive but marginal decline in instability in foodgrain production at the all India level, and mixed results at state level. All these studies covered the period upto late 1970s or mid-1980s which represent the initial phase of green revolution technology.

Another set of studies on instability in Indian agriculture, extended over a longer post-green revolution period, or, covering the recent years, appeared recently. One of

---

*ICAR National Professor and Senior Scientist, respectively, National Centre for Agricultural Economics and Policy Research, New Delhi-110 012.

The authors are grateful to anonymous referee for his valuable suggestions to improve the coverage and quality of the paper. We also acknowledge the computational assistance provided for the paper by Sanjeev Garg.

these studies (Larson *et al.,* 2004) conclude that green revolution has been instrumental in increasing production of foodgrains and other crops in India but this has come at a cost of greater instability in production and yield. This study estimated the impact of green revolution technology on production variability by comparing the instability in agricultural production during the period 1950-51 to 1964-65 with the period 1967-68 to 2001-02. The study did not differentiate between different phases of technology adoption like early and limited adoption and the phase of widespread adoption. In contrast to the findings of this study, another study by Sharma *et al.* (2006) using same methodology as used by Larson *et al.,* (2004) conclude that the production of individual crops and total foodgrains had become more stable during 1990s compared to the 1980s. This highlights the fact that variability in crop production may turn out to be different if the post green revolution period is divided into different sub periods. The study by Sharma *et al.* starts from the year 1980-81; it did not cover the initial phase of green revolution nor did it cover pre-green revolution period. Therefore, the findings of this study could not be used to draw inference on the effect of green revolution technology on production variability.

The survey of literature on the subject shows that different studies provide conflicting evidence of changes in instability in agricultural output due to adoption of new technology. No attempt has been made to examine whether instability in production, which increased in the initial years of green revolution according to most of the studies, witnessed any significant change with its spread to more farmers, more areas and to more crops. It is important to draw this distinction as the use of modern inputs associated with improved technology witnessed much higher increase after 1987-88 compared to 1967-68 to 1987-88. This paper is an attempt to clear the confusion about changes in instability in agricultural production due to adoption of new technology. It estimates the instability in agriculture by dividing the entire post green revolution period into two phases (a) two decades from 1968 to 1988, representing initial phase of improved technology, and (b) two decades after 1988, representing the period of wider technology dissemination, and compares it with the pre-green revolution period. This would help in settling the issue whether adoption of improved technology of green revolution in the long run raised or reduced variability in production, and whether short term and long term effect of improved technology on production instability are different.

The instability is estimated for aggregate of crop sector as well as for the sub-sectors and important commodities at the national and state level. The paper is organised into five sections including Introduction. The second section provides a brief review of various studies on instability in Indian agriculture and discuss the need to update the analysis on instability. Data and Methodology used in earlier studies and the present study are presented in Section III. Section IV presents the estimates of instability at all India and state levels. Conclusions and policy implications are presented in the final section.

## II

## REVIEW OF LITERATURE

The potential of green revolution technology in increasing productivity and production of various crops in India was recognised in the very early stages of adoption of this technology. Alongwith this, a concern arose whether increase in production, brought about by improved crop technology, was accompanied by a rise in year-to-year variability in production. The first serious attempt to examine the effect of new seed-fertiliser technology, known as green revolution technology, on year-to-year fluctuations in crop output was made by Mehra (1981). The study compared variability in production, across crops and regions in India, during the period 1949-50 to 1964-65 with the period 1964-65 to 1978-79, to find the changes in instability in the period before and after introduction of high yielding technologies. The analysis shows that during the ten years period since the adoption of new technology the standard deviation and coefficient of variation of production of all the crop aggregates increased as compared with the period 1949-50 to 1964-65. Variability was measured in terms of deviations between actual and estimated trend values. The sum of these squared deviations was termed as variance; and the under-root of this variance was divided by mean of the variable which was termed as coefficient of variation.[1] The so called "Coefficient of variation" was then compared between the two periods to test if there was a significant change in the variance or standard deviation prior to and after introduction of new crop technology.

Soon after this, Hazell (1982) came out with another study which made use of the same data set as used by Mehra (1981) but adopted improved analytical framework to analyse variability.[2] Hazell (1982) confirmed the findings of Mehra (1981), and went a step further in concluding that increase in production instability was an inevitable consequence of rapid agricultural growth and there is little that can be done about it. Both these studies attributed the increase in instability to new seed–fertiliser technology. The result at the regional level shows that in Punjab, where high-yielding varieties (HYV) were grown on more than 80 per cent area under cereals, the yield variability of all the selected crops remained constant or declined. This contradiction between what was observed at the state level and country level indicate that it could be too early to attribute increase in instability in food production, at the country level, to new technology. The area under HYV of cereals in the country had reached only 37 per cent of total area under cereals by 1977-78, which was taken as the last year of adoption of new technology in the studies by Mehra (1981) and Hazell (1982). As the new technology had reached very small area by 1977-78, the conclusion based on experience of this limited period relating to fluctuation in output has a limited relevance.

Another paper around the same time by Ray (1983a) went a little deeper to probe on the causes for instability in Indian agriculture during 1950 to 1980. The paper adopted a very simple but very robust indicator of fluctuations in output. This was given by standard deviation in annual output growth rates over a specified period. The study found that instability in production increased in the 1960s and rose further during the 1970s for most of the crops and crop aggregates. An interesting finding of this paper was that instability in wheat production, which was experiencing the highest coverage under HYV among all crops, also increased markedly during the 1960s but its production increased at a fairly stable rate during 1970s. Based on the detailed analysis of various factors affecting growth and instability, Ray (1983a) strongly refuted the assertion made by Hazell (1982) that "production instability is an inevitable consequence of rapid agricultural growth and there is little that can be effectively done about it". According to Ray (1983a) the magnitude of production instability is essentially a function of the environment which can be considerably moulded through human efforts. The author suggested that the causes for increase in production instability after adoption of green revolution technology were increase in the variability of rainfall and prices and increase in sensitivity of production to variation in rainfall, not the growth in production.

In another similar but more detailed study by Ray and two more authors it was found that the amplitude of fluctuations in output for all categories of crops, except wheat, has increased significantly in the post-green revolution period, 1966 -1985 or 1968 -1985 (Rao *et al*., 1988). The study concluded that since wheat benefited to the greatest extent from green revolution technology the observed increase in variability in foodgrains and all crops output can not be attributed to green revolution technology as such. Like Ray (1983a), this study also attributed rising vulnerability of agricultural output to increase in sensitivity of output to variations in rainfall traceable to the high complementarity of new seed-fertiliser technology with water. Both, Ray (1983a) and Rao *et al.* (1988), on one hand refutes the impact of green revolution technology on variation in output for some crops, and, on the other hand ascribes it to increase in sensitivity of output and complementarity of new technology with irrigation – which are indeed a part of the new technology. However, in conclusion, the authors clearly state that the instability in agricultural production has increased in post-green revolution period (Rao *et al.* 1988, Ch.9, p. 143).

In order to distinguish between the effect of technology and rainfall variations on fluctuation in output, Mahendra Dev (1987) analysed weather adjusted and unadjusted growth rate in foodgrain output for all major states in the country. Based on the standard deviation in year to year change in output, the study concluded that there was a progressive but marginal decline in instability at all India level. At state level, there was decline in some cases and increase in some other states. The other important findings of this study relevant to the debate on instability were: after 1979-80 instability in foodgrain production at all India level dropped to 8.18 per cent but it showed only a marginal decline from 11.41 per cent during 1960-61 to 1969-70 to 11.16 per cent during 1970-71 to 1979-80. Though the decline after 1979-80 refers to a very short period (1980-81 to 1984-85) but it indicates that the instability could turn out to be different after the initial years of adoption of new technology. Second, as the conclusions of the study were different than the earlier studies the author felt these were due to differences in the selection of time periods. To overcome this, Mahendra Dev prepared estimates of instability based on 9 years moving standard deviation in annual growth rates of foodgrain production beginning from 1960-61 to 1969-70 which shows increase in instability in some states and decrease in others. The trend fitted to estimates of instability in all India production of foodgrains during 1960-61 to 1984-85 did not show any significant growth. As this finding was in contrast to the earlier studies, the issue of effect of new technology on year to year fluctuation in agricultural output at the country level remained unsettled.

Another set of studies on this issue appeared recently and they included the period beyond mid 1980s (Larson *et al.*, 2004; Sharma *et al.*, 2006). Both these studies used the measure of instability developed and used by Hazell (1982). Larson *et al.,* (2004) examined instability in area, yield and production for major crops in India by dividing the period 1950-51 to 2001-02 into a pre-green revolution (1951-1965) and post-green revolution (1968-2002) periods. The paper reported that production instability for foodgrains had increased by 153 per cent and yield instability increased by 244 per cent between the two sub periods (Larson *et al.*, Table 2, p. 264). Based on this the authors concluded that widespread adoption of green revolution technology increased instability in yield and production of foodgrains. There was serious inconsistency in the results on instability in foodgrain production reported in this paper. While instability in production of cereals and pulses was reported to have declined between pre and post-green revolution period by 10 and 5 per cent, respectively, the instability in the production of foodgrains, which is the sum of cereals and pulses, was reported to have increased by 153 per cent in the same period.[3] Further, this study did not divide post-1968 period into sub-periods to find out if there was any change in instability with progress of green revolution technology.

In contrast to the choice by Larson *et al.*, 2004 to keep entire post-Green revolution period as one set, Sharma *et al*., 2006 estimated variability in production and yield by choosing smaller set of years, viz., 1981-82 to 1990-91 and 1991-92 to 2000-01. This is helpful if the variable (instability) changes over time. The authors concluded that the production of individual crops and total foodgrains had become more stable in the 1990s compared with the 1980s. As this study was based on a limited period of 1980-81 to 1991-92, it did not provide any clue about the effect of new crop technology on variability in agricultural or food production. Further, the results of the two studies on instability are somewhat contradictory in the sense that Larson *et al.*, reports a rise in the instability over time whereas Sharma *et al.*, reports a decline in instability over time.

The review of literature indicates that there is no consensus in the literature on changes in instability in agricultural production in different periods and there is a complete gap in research about the changes in instability of agricultural production in relation to progress in spread of new technology in the country.

## III

## DATA AND METHODOLOGY

Two sets of data have been used in this paper to measure instability. These include (a) index number of area, production and yield of food grains, non-food grains and all crops, and (b) physical production of individual commodities or group of commodities and their decomposition into area and yield.

The entire post-Independence period beginning with the year 1950-51 is divided into three phases. These are termed as (1) pre-green revolution period (2) first phase of new technology or green revolution and (3) wider dissemination of technology period. The years separating each phase were identified after looking at raw data series on gross domestic product (GDP) agriculture and crop output. A visual examination of the series shows that the first break in output growth occurred in mid 1960s. Therefore, the first phase is taken as 1951 to 1965. The output during 1966 and 1967 was much lower than the trend and a new trend started from the year 1968. This phase continued till 1988, after which the trend in output witnessed upward jump. Therefore, the second phase was taken from 1968 to 1988. The third phase covered the period 1989 to 2006 or 2007 depending upon the availability of the data.

### *Measures of Instability*

The measure that is used to estimate instability in a variable over time should satisfy two minimum properties. It should not include deviations in the data series that arise due to secular trend or growth. Two, it should be comparable across data sets having different means.

One way to exclude variations in a data series due to the trend, is, to fit a suitable trend (for example like $Y_t$=a+bT +$e_t$; where Y is dependent variable like yield, area or production, T refers to time/year, a is intercept and b is slope) and de-trend the series. This is done by computing residuals [$e_t$ =Y-(a+bT)], i. e., deviations between actual and estimated trend values, and estimating instability based on $e_t$. As mean of $e_t$ is always zero, their standard deviation is used to measure instability. The main problem with this is comparability across data sets having different mean values. This necessitates use of coefficient of variation, instead of standard deviation, to measure dispersion. As “mean” of detrended residuals is zero, it is not possible to compute CV of residuals ($e_t$), however, researchers have developed some methods to compute CV that is based on residuals. Mehra (1981) used standard deviation in residuals divided by mean of the variable (area, production or yield) to compute and compare instability in agricultural production before and after the introduction of new technology. The author termed the estimate as coefficient of variation even though it does not follow standardised definition of CV.[4] Hazell (1982) developed a new method to make use of residuals to estimate instability, which was slightly different than the measure developed by Mehra (1981). Hazell detrended the data and constructed a variable ($Z_t$) which was computed by adding mean of the dependent variable to residuals $e_t$ as under: $Z_t = e_t + \bar{Y}$. Coefficient of variation of $Z_t$ was used as a measure of instability.[5] The measures of instability proposed by Mehra (1981) and Hazell (1982) are based on detrended data, they are unit free and imparts comparability. However, these methodologies have been criticised for measuring instability around an arbitrarily assumed trend line which greatly influences the inference regarding changes in instability[6] (Ray, 1983a, p. 463).

Ray (1983b) developed a very simple measure of instability given by standard deviation in annual growth rates. The method satisfies the properties like instability based on detrended data and comparability. Moreover, the methodology does not involve actual estimation of trend, computation of residuals and detrending, but all these are taken care in the standard deviation of annual growth rate. This method also does not suffer from the limitations like arbitrary choice of assumed trend line initially proposed and used by Hazell (1982) and subsequently applied by Larson *et al.*, and Sharma *et al.*

This paper preferred to use the method proposed by Ray (1983b) and applied by Ray (1983a), Mahendra Dev (1987) and Rao *et al.*, (1988) to estimate instability in agricultural production. This method is given by:

Instability index = Standard deviation of natural logarithm ($Y_{t+1}/Y_t$)

where, $Y_t$ is the area/production/yield in the current year and, $Y_{t+1}$ is for the next year. This index is unit free and very robust, and it measures deviations from the underlying trend (log linear in this case). When there are no deviations from trend, the ratio of $Y_{t+1}/Y_t$ is constant and thus standard deviation is zero. As the series fluctuates more, the ratio of $Y_{t+1}$ and $Y_t$ also fluctuates more, and standard deviation increases.

### *Effect of Choice of Period on Instability*

It is pertinent to point out that the selection or length of period can result in significant changes in instability particularly if two sub-periods with different dimensions of instability are pooled into one. This is demonstrated in Table 1 for foodgrains at all India level. The table presents estimates of instability (C.V.) derived from detrended yield, detrended production and production taken as product of the detrended area and detrended yield, as used by Hazell (1982), Larson *et al.* (2004) and Sharma *et al*. (2006).

Instability in foodgrain yield measured by the CV in detrended yield was 4.50 in pre green revolution period (same as reported by Larson *et al.* 2004) and, it increased to 5.06 in the post green revolution period that covers the period 1968 to 1988. Variability in yield dropped to 3.72 after 1989 indicating a decline of 26.5 per cent in the second phase of green revolution as compared to the first phase and a decline of 17.3 per cent compared to pre green revolution period. If both these sub periods are pooled then instability in yield turns out to be 5.50 which is 22.2 per cent higher than the pre-green revolution period. These differences lead to totally different types of inference about the effect of improved technology on instability in foodgrain productivity. According to pooled data for post-green revolution (1968 to 2007) the spread of new technology was accompanied by an increase in yield variability, whereas, dividing post green revolution period into two sub-periods shows increase in variability in the initial years of adoption of new technology and a sharp decline with spread of new technology after 1988. Another conclusion that follows from these results is that there could be a complete change in the effect of factors like new technology between short and long term.

TABLE 1. COEFFICIENT OF VARIATION IN DETRENDED YIELD AND PRODUCTION OF FOODGRAINS IN INDIA DURING DIFFERENT PERIODS

*(per cent)*

| Period (1) | Production (2) | Production = Detrended A*detrended Y (3) | Yield (4) |
|---|---|---|---|
| 1951-65 | 6.11 | 5.73 | 4.50 |
| 1968-88 | 6.32 | 6.43 | 5.06 |
| 1989-2007 | 4.94 | 5.02 | 3.72 |
| 1968-2002 | 5.47 | 5.51 | 5.30 |
| 1968-2007 | 6.30 | 6.52 | 5.50 |

*Source*: *Agricultural Statistics at a Glance 2008*, Ministry of Agriculture, Government of India, New Delhi.

Almost similar pattern is observed in the case of production of foodgrains whether we use data on detrended production or we use detrended production data obtained by multiplying detrended area and detrended yield. Instability in foodgrain production during 1951 to 1965 was 6.11 (same as reported by Larson *et al.*, 2004), and it increased with the introduction of new technology in India. Foodgrains production show much higher fluctuations in post green revolution period compared to pre green revolution period when no distinction is made between different sub periods. When a distinction is drawn by splitting post green revolution period into sub periods the conclusion on effect of new technology on production variability changes altogether (Table 1). This formed the basis for us to examine the instability in agricultural production by dividing the period after introduction of new technology into two phases.

## IV

## RESULTS AND DISCUSSION

The main focus of this paper is to examine how year to year fluctuations in crop output changed from one period to another period, and what is the effect of new agricultural technology on the instability in crop output. Accordingly, instability in area, production and yield of important crops and crop aggregates has been studied at the national level as well as state level during different periods. These periods are clearly distinguishable in terms of major policy initiatives taken in the country and adoption of new agricultural technology.

*Institutional Measures and Diffusion of Technology*

The pre-green revolution period (1951 to 1965) is marked by major policy initiatives like land reforms and development of irrigation infrastructure. Legislations for the abolition of *Zamindari* were enacted by all the states and the whole process was completed within the decade 1950-60 (Dandekar, 1994). Under this, 20 million tillers gained control over the land they were cultivating. The tenancy reforms also provided for regulation of rent and security of tenure, beside conferment of ownership on tenants. Another land reforms measure was the legislation to impose ceilings on the maximum land that a household could own. Apart from these, efforts were also made to minimise the exploitation of cultivators by money lenders and traders by expanding the co-operative credit system (Rao, 1996).

From mid-1960s (green revolution period) focus of policies shifted to adoption of new agricultural technology. It was considered vital to provide remunerative prices to the farmers to encourage use of modern inputs and adoption of new technology. To achieve this, new institutions like Food Corporation of India and Agricultural Prices Commission, later renamed as Commission on Agricultural Costs and Prices (CACP) were created. The CACP was entrusted with the task of announcing minimum support prices (MSP) for selected commodities and the Food Corporation of India implemented the MSP by procuring paddy and wheat at those prices. Public sector market interventions was also extended to some other crops by creating national and state level institutions (Acharya, 2001). This period also witnessed strong emphasis on agricultural R&D, expansion of institutional credit, and creation of modern input manufacturing industry.

After mid-1980s, policy intervention became more and more price centric. This period witnessed a major surge in subsidies and a sharp fall in public investments in agriculture (Chand, 2008). Another significant policy change in this period relates to liberalisation of agriculture trade.

Adoption of green revolution technology in the mid-1960s started with shift in area from traditional varieties to high-yielding crop varieties. By the year 1987-88 high-yielding varieties (HYVs) of cereals were grown on 55 per cent of total area under cereals in the country. However, the spread of HYV across states was highly uneven as can be seen from Table 2. The coverage of HYVs was below 42 per cent in 7 out of 17 major states whereas it was more than 75 per cent in Punjab, Haryana and Tamil Nadu. After 1987-88 new agriculture technology spread to wider areas. By the year 1996-97, 14 out of 17 states cultivated HYVs of cereals on more than 70 per cent of area. The major expansion took place in those states where area under HYVs remained low in the first phase of green revolution. The coefficient of variation in coverage under HYVs among major states declined to almost half between 1987-88 and 1996-97.

TABLE 2. SPREAD OF NEW TECHNOLOGY IN INDIAN AGRICULTURE AS REVEALED BY AREA UNDER HYVS AND FERTILISER USE

| | Area under HYV's of cereals ( per cent) | | Fertiliser use: NPK (kg/ha) | |
|---|---|---|---|---|
| State | 1987-88 | 1996-97 | 1987-88 | 2005-06 |
| (1) | (2) | (3) | (4) | (5) |
| Andhra Pradesh | 56.2 | 82.5 | 92.3 | 247.2 |
| Assam | 39.1 | 58.9 | 8.8 | 71.1 |
| Bihar | 71.2 | 83.1 | 65.0 | 140.8 |
| Gujarat | 40.8 | 72.8 | 47.0 | 129.9 |
| Haryana | 79.7 | 78.1 | 121.8 | 320.0 |
| Himachal Pradesh | 51.8 | 76.1 | 43.9 | 88.7 |
| Jammu & Kashmir | 63.5 | 83.3 | 53.2 | 122.7 |
| Karnataka | 35.0 | 75.3 | 52.9 | 145.2 |
| Kerala | 41.1 | 92.2 | 82.5 | 93.9 |
| Madhya Pradesh | 38.6 | 63.4 | 26.3 | 66.6 |
| Maharashtra | 61.0 | 85.5 | 40.8 | 112.5 |
| Orissa | 38.1 | 67.0 | 25.5 | 68.8 |
| Punjab | 92.4 | 96.9 | 267.4 | 397.6 |
| Rajasthan | 28.2 | 42.4 | 18.6 | 53.3 |
| Tamil Nadu | 75.7 | 100.7 | 117.5 | 215.7 |
| Uttar Pradesh | 61.7 | 83.4 | 99.8 | 204.5 |
| West Bengal | 51.9 | 77.5 | 105.1 | 207.7 |
| C.V. (Per cent) | 33.1 | 18.3 | 81.6 | 60.8 |
| | | ALL INDIA | | |
| Year | Area under HYV (per cent) | | NPK (kg/ha) | |
| 1967-68 | 6.1 | | 11.0 | |
| 1987-88 | 54.6 | | 65.6 | |
| 1996-97 | 75.6 | | 100.2 | |
| 2006-07 | N.A. | | 153.0 | |

*Source:* 1. *Agricultural Statistics at a Glance*, Ministry of Agriculture, Government of India, New Delhi (various issues).

2. *Indian Agriculture in Brief*, Ministry of Agriculture, Government of India, New Delhi (various issues).

At the national level, area under HYVs of cereals increased from 54 million hectares during 1987-88 to 76 million hectares during 1996-97. During these 10 years the percentage area under HYVs increased from 55 per cent to 76 per cent of total area under all cereals.

Another important indicator of technology is the use of inorganic fertiliser. Per hectare use of fertiliser (NPK) increased by mere 0.28 kg per year in the pre-green revolution period. During the two decades of first phase of green revolution (1967-68 to 1987-88), fertiliser use per hectare of net sown area increased by 55 kg or 2.75 kg per year. The next 19 years show increase of 87 kg or 4.58 kg per year. Like HYVs, growth in fertiliser use after 1987-88 was much higher in those states where fertiliser use was low. This is indicated by decline in coefficient of variation in per hectare fertiliser use across states from 81.6 to 60.8 per cent between 1987-88 and 2005-06.

The progress of area under HYV and fertiliser shows that improved technology spread to much wider areas after 1987-88. Accordingly, instability has been examined by dividing the entire period after 1950-51 into three sub-periods.

### *Instability at National Level*

The estimates of instability in area, production and productivity of foodgrains, non-foodgrains and all crops estimated from the all India index numbers are presented in Table 3. The Table contains two sets of results, one covering all years of the three sub-periods and the second excluding two extreme years 1979-80 and 2002-03 which experienced very serious droughts. Crop output in these two years dropped by 13 and 12 per cent over the previous year respectively. Droughts were experienced in some other years also, like 1987-88, but their intensity was moderate.

TABLE 3. INSTABILITY IN AREA, PRODUCTION AND YIELD OF FOOD GRAINS AND NON FOOD GRAINS GROUP OF CROPS AND ALL CROPS IN DIFFERENT PERIODS AT ALL INDIA LEVEL

*(per cent)*

| | | Including extreme years | | | Excluding extreme years 1979-80 and 2002-03 | | |
|---|---|---|---|---|---|---|---|
| Crop group (1) | Period (2) | Area (3) | Production (4) | Yield (5) | Area (6) | Production (7) | Yield (8) |
| Food grains | 1951 to 1965 | 2.51 | 10.05 | 9.05 | 2.51 | 10.05 | 9.05 |
| | 1968 to 1988 | 3.39 | 10.31 | 8.05 | 3.49 | 8.64 | 6.08 |
| | 1989 to 2007 | 3.26 | 8.70 | 6.38 | 1.96 | 5.46 | 4.45 |
| Non- foodgrains | 1951 to 1965 | 3.96 | 7.59 | 7.04 | 3.96 | 7.59 | 7.04 |
| | 1968 to 1988 | 3.54 | 6.87 | 5.01 | 3.40 | 6.36 | 4.68 |
| | 1989 to 2007 | 4.33 | 7.75 | 6.65 | 3.18 | 5.76 | 4.43 |
| All crops | 1951 to 1965 | 1.86 | 8.30 | 7.93 | 1.86 | 8.30 | 7.93 |
| | 1968 to 1988 | 3.19 | 8.35 | 6.43 | 3.23 | 6.95 | 4.97 |
| | 1989 to 2007 | 3.06 | 7.96 | 6.61 | 1.36 | 5.02 | 4.65 |

*Source*: Same as in Table 2.

Instability in area under food grains was quite low during the pre-green revolution as growth rates show standard deviation of 2.51 per cent. The instability in area increased to 3.39 in the first phase of green revolution and slightly declined after 1988. Instability in yield of food grains was more than three times the instability in area during the pre green revolution. Adoption of new technology marked decline in instability in yield from 9.05 to 8.05 per cent between pre-green revolution and first phase of green revolution. When improved technology spread to larger areas the variability in productivity declined further. Instability in production of food grain shows small increase with the adoption of new technology from 10.05 to 10.31. However, when the extreme year of 1979-80 was excluded from the data set, the variability in food grain output show large decline. Instability in food grain production witnessed significant decline after 1988. The decline is found more pronounced when the extreme year 2002-03 is excluded from the data set. Variability in food grain production after 1989 was 14 per cent lower compared to pre-green revolution period and 16 per cent lower compared to the first phase of green revolution. When extreme years are removed the decline in variability during 1989-2007 turned out to be 46 per cent lower than pre-green revolution period and 33 per cent lower compared to the first phase of green revolution.

These results are in complete disagreement with the findings of the earlier studies by Mehra, 1981; Hazell, 1982; Ray (1983a,b) and Rao *et al.*, 1988. The reason is that all these studies covered the initial 10 to 15 years of adoption of green revolution technology. With the passage of time, adoption of green revolution technology spread to much larger area and a large number of improvements in various aspects of technology took place. As the benefit of these advancements got translated at farm, the variability in yield of food grains declined and that led to decline in variability of food grain production as well. Other factors which might have contributed to the decline in variability in food grain yield and production seem to be: (i) expansion of irrigation, (ii) improvement in availability of other inputs and institutional credit and (iii) policy of minimum support prices that provided stable economic environment to induce investments in production.

Instability in area and production of non-foodgrain crops shows a different pattern as compared to foodgrains. Instability in area under non-foodgrain crops declined from 3.96 in the pre-green revolution to 3.54 in the first phase of green revolution period but increased thereafter. Similarly, instability in production of non-food grain declined from 7.59 to 6.87 between pre green revolution and first phase of green revolution. In the third period, i.e., after 1988, instability in output of non-food grain crops not only increased but also turned out to be higher even as compared to pre green revolution period. However, when extreme years 1979-80 and 2002-03 are taken out then instability in area as well as production of non-foodgrain crops showed decline as we move up from one period to the other period.

It is also interesting to observe that instability in area under non-foodgrain crops remained higher than instability in area under food grain crops in all the three periods, while instability in productivity was lower than food grain in the first and the second period but not in the third period. The net impact of instability in area and yield on production clearly indicates that food grain production remained more unstable as compared to combined production of non-foodgrain crops.

The area under all crops, i.e., including food grain and non-foodgrains, shows a big increase in instability during 1968 to 1988 as compared to the period 1952 to 1965. The period after 1988 shows slightly lower instability as compared to first phase of green revolution but it was much higher as compared to the pre green revolution period. Instability in productivity of crop sector on the whole declined by about 20 per cent between pre green revolution period and first phase of green revolution. Instability in index of yield of all crops increased by 2.8 per cent after 1988 but it was lower by 17 per cent as compared to pre green revolution period. Instability index in crop production was 8.30 during 1951 to 1965 and remained at this level during 1968 to 1988. Instability in production declined by 5 per cent in the third phase, i.e., during 1989 to 2007. Instability in production of total crops shows a very sharp decline over time when the two extreme years are taken out from the data sets.

The index number approach was followed to compare instability in production between groups of food grain and non-food grain crops. Due to large heterogeneity in non-foodgrain crops, aggregation of output of individual crops can give a misleading picture of output of the group. Therefore, their production is better captured by index number. This problem is much less severe for food grains and oilseeds. Therefore, quantity of output was used to estimate instability in production of individual crops and different sub-groups of food grain and oilseed crops. The results for food grains, cereals, pulses and oilseeds are presented in Table 4. Changes in area, production and yield in the same period can be seen from Annexure 1.

TABLE 4. INSTABILITY IN AREA, PRODUCTION AND YIELD OF MAJOR CROP GROUPS IN DIFFERENT PERIODS AT ALL INDIA LEVEL

*(per cent)*

| | Area | | | Production | | | Yield | | |
|---|---|---|---|---|---|---|---|---|---|
| Crop group | 1951-1966 | 1968-1988 | 1989-2007 | 1951-1966 | 1968-1988 | 1989-2007 | 1951-1966 | 1968-1988 | 1989-2007 |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Cereals | 2.30 | 3.00 | 2.95 | 9.58 | 9.43 | 8.21 | 7.75 | 7.33 | 5.51 |
| Pulses | 4.35 | 5.96 | 6.00 | 14.70 | 13.90 | 14.18 | 12.91 | 10.54 | 9.76 |
| Food grains | 2.59 | 3.39 | 3.26 | 10.00 | 9.65 | 8.48 | 8.06 | 7.28 | 5.62 |
| Oilseeds | 5.01 | 5.51 | 6.30 | 12.74 | 17.06 | 18.36 | 12.07 | 13.01 | 15.89 |

*Source*: Same as in Table 2.

Physical production of foodgrains shows decline in instability in the second period compared to first period and in the third period compared to the second period even when the extreme years are included in the data set. Instability in area under cereals as well as pulses turned out to be much higher in the first phase of green revolution compared to pre green revolution period and remained at almost same level during 1989 to 2007.

Instability in area under oilseeds increased by 9 per cent between pre-green revolution and first phase of green revolution and further by 14 per cent during recent period. Instability in yield during the corresponding periods increased by about 8 per cent and 22 per cent. Oilseed production witnessed increase in instability from 12.74 during 1951-1966 to 17.06 during 1968 -1988 and further to 18.36 during 1989-2007. Yield of cereal and pulses was more stable after pre-green revolution period whereas opposite holds true for oilseeds.

Instability in production of total cereals during first phase of green revolution declined by 1.5 per cent and after 1988 the decline turned out to be 13 per cent. In the case of pulses the first phase of green revolution experienced a decline in instability to the extent of 5.4 per cent but post-1988 period witnessed an increase of 2 per cent. Between cereals and pulses the latter shows higher instability in all the periods and in all respects. Instability in production and productivity of oilseeds remained higher than even pulses after 1968.

Instability in area, production and yield of individual crops is presented in Table 5. Coconut shows minimum instability among all the selected crops in almost all respects during pre-green revolution period and during the first phase of green revolution. In terms of instability in production it remained at the bottom level even during the third period. However, sugarcane yield shows least instability followed by wheat in the third period. Maize shows minimum instability in area among the selected crops which also declined over time. Among cereals, bajra showed highest instability in all the periods and in all respects. Adoption of green revolution technology reduced yield instability in wheat by 38 per cent. The main factor for this was increase in wheat area brought under irrigation which increased from 43 per cent during 1965-66 to 77 per cent during 1987-88.

TABLE 5. INSTABILITY IN AREA, PRODUCTION AND YIELD OF SELECTED CROPS IN DIFFERENT PERIODS BETWEEN 1950-51 AND 2006-07 AT ALL INDIA LEVEL

(*per cent)*

| | Area | | | Production | | | Yield | | |
|---|---|---|---|---|---|---|---|---|---|
| Year<br>(1) | 1951-1966<br>(2) | 1968-1988<br>(3) | 1989-2007<br>(4) | 1951-1966<br>(5) | 1968-1988<br>(6) | 1989-2007<br>(7) | 1951-1966<br>(8) | 1968-1988<br>(9) | 1989-2007<br>(10) |
| Paddy | 2.13 | 3.38 | 2.74 | 12.18 | 13.62 | 9.63 | 10.96 | 11.05 | 7.24 |
| Wheat | 6.61 | 4.59 | 3.69 | 12.93 | 8.97 | 7.12 | 10.56 | 6.58 | 5.00 |
| Jowar | 3.93 | 3.80 | 5.08 | 16.11 | 13.32 | 20.20 | 14.84 | 11.32 | 17.03 |
| Bajra | 5.89 | 10.10 | 11.41 | 18.30 | 39.54 | 40.48 | 15.32 | 32.55 | 3.72 |
| Maize | 3.44 | 3.06 | 2.80 | 10.81 | 18.44 | 11.77 | 9.19 | 16.74 | 10.13 |
| Gram | 8.05 | 10.42 | 15.69 | 20.14 | 21.68 | 21.56 | 17.95 | 16.94 | 10.91 |
| Arhar | 3.71 | 5.31 | 3.72 | 18.81 | 14.34 | 16.91 | 18.97 | 14.28 | 15.97 |
| Groundnut | 9.52 | 4.12 | 5.85 | 14.07 | 23.00 | 29.81 | 15.19 | 20.18 | 28.27 |
| Rapeseed/ Mustard | 7.97 | 9.66 | 13.76 | 20.31 | 21.26 | 21.88 | 20.98 | 18.20 | 16.63 |
| Coconut | 3.12 | 3.11 | 3.13 | 7.21 | 6.87 | 5.64 | 5.82 | 5.81 | 5.81 |
| Cotton | 5.71 | 4.76 | 7.47 | 17.25 | 16.51 | 17.84 | 15.31 | 14.52 | 15.84 |
| Sugarcane | 10.90 | 9.27 | 7.59 | 14.67 | 11.64 | 9.28 | 9.47 | 6.78 | 4.71 |
| Potato | 3.70 | 6.95 | 5.62 | 16.24 | 14.00 | 13.39 | 13.81 | 10.72 | 11.18 |
| Tobacco | 11.17 | 10.48 | 16.41 | 15.24 | 13.29 | 19.80 | 9.35 | 7.29 | 7.45 |

*Source*: Same as in Table 2.

In paddy, the initial years of adoption did not help in reducing instability in yield or production. On the contrary, the first phase of green revolution showed higher instability as compared to the pre-green revolution period. The main reason for difference in variability between wheat and rice is that expansion of irrigation in rice was far lower than wheat. Between 1965 and 1988 the coverage of rice area under irrigation increased from 37 per cent to 43 per cent only. Wider dissemination of technology after 1988 helped in reducing instability in yield as well as production of rice. Instability in production of bajra more than doubled while in maize it increased by 70 per cent in the first phase of green revolution. The period after 1988 witnessed very sharp decline in variability of maize production but variability in production of bajra remained high (around 40 per cent). The decline in variability of maize production after 1988 resulted from decline in yield instability. Despite this, instability in maize production remained higher than pre-green revolution period. Instability in jowar yield and production showed decline during 1968 to 1988 but a big increase during 1989 to 2007.

Among pulses, instability in area under gram increased over time but instability in its yield declined sharply after 1988. Because of these counteracting factors instability in production of gram in all the three periods remained around 21 per cent. Area under arhar shows remarkably low instability but its yield show quite high year to year variability. There was decline in variability in arhar output from 18.8 per cent during 1951-1966 to 14.34 per cent during 1968-1988 which again increased to 16.91 per cent during 1989–2007.

Variability of groundnut show two interesting features. One, variability in its area declined to less than half during the first phase of green revolution and then increased by 42 per cent after 1988. Variability in its productivity increased from 15.19 during 1951-1966 to 20.18 during 1968-1988 and, further to 28.27 during 1989-2007. Almost similar increase was experienced in the case of production. The experience of rapeseed and mustard is totally different than that of groundnut. Variability in its area show substantial increase over time, whereas, productivity shows a decline in variability. Production of rapeseed and mustard shows inter year variability of about 21 per cent with small increase over time.

Inter year variation in production of coconut was quite small and showed a decline over time. Similarly, sugarcane, another perennial crop shows decline in instability in area, yield and production, over time. In the case of cotton, variability in area witnessed decline during 1968-1988 as compared to pre-green revolution but then increased steeply. Variability in yield of cotton varied around 15 per cent with little change between different periods. Its production shows variability around 17 per cent.

Area variability in potato during post green revolution turned out to be much higher as compared to pre-green revolution period. However, its production shows decline in instability over time. Instability in area and production of tobacco followed a small decline in the first phase of green revolution but then increased sharply.

Instability in production across crops is found to depend significantly on irrigation coverage of a crop. Crops like wheat, sugarcane and paddy are grown mostly under irrigated condition which imparts lot of stability to their production. It may be noted that area covered under irrigation is more than 90 per cent for sugarcane, around 88 per cent for wheat and 53 per cent for rice. In contrast, irrigation coverage of bajra is below 10 per cent, for maize around 20 per cent, for gram around 31 per cent and for groundnut around 17 per cent.

Changes in instability in some cases show a common pattern with changes in area, production and yield. Some of these patterns are captured by comparing estimates of instability presented in Table 5 with trend in area, production and yield presented in Annexure 1. In most of the crops, area and instability moved in the same direction after 1987-88. This implies that expansion of production base for a crop brings in stability whereas shrinking production base becomes more unstable. Gram, rapeseed and mustard and cotton were the exception to this pattern.

*Instability at State Level*

Instability in crop production is expected to vary over space, i.e., across regions and states. There is lot of variation in climatic conditions, natural resource endowments, institutions, infrastructure, population density and several other factors across states. Because of these variations, the pattern of agricultural growth and development and response to various stimulus and inducements vary greatly across states. Accordingly, instability in agriculture is expected to show different patterns in different agro-ecological settings prevailing in different states. Some states may exhibit same pattern as seen at national level while others may turn out to be totally different than at the national level.

The state level estimates of instability in area, production and yield were prepared for food grains for two periods, viz., 1968 to 1988 and 1989 to 2006. These two periods represent first phase of green revolution and period of wider dissemination of technology respectively. The results are presented in Table 6.

The area under food grains show high instability in the first phase of green revolution in Gujarat, Karnataka, Rajasthan and Tamil Nadu. Out of these states, year to year variation followed a decline in Gujarat and Karnataka but it witnessed small increase in Tamil Nadu and a very high increase in Rajasthan. The other states which witnessed increase in variation in area under food grains are Andhra Pradesh, Orissa, Kerala, Jammu and Kashmir and Uttar Pradesh. Despite the increase, instability in food grains area was quite low in Uttar Pradesh and Jammu and Kashmir. The states which show below 4 per cent year to year deviation from growth trend are Bihar, Kerala, Himachal Pradesh, Punjab, Uttar Pradesh and West Bengal.

Compared to area, variations in yield were much larger. Instability in yield of food grains exceeds 20 per cent in Gujarat, Maharashtra, Orissa and Rajasthan in both the periods. It varied around 10 in Andhra Pradesh, Bihar, Himachal Pradesh, Jammu and Kashmir. Yield variability in food grain in Haryana, Uttar Pradesh and West Bengal reduced to less than half after 1988. Large increase in yield instability is shown in Andhra Pradesh, Assam, Madhya Pradesh, Orissa and Rajasthan.

TABLE 6. STATE WISE INSTABILITY IN FOOD GRAINS PRODUCTION DURING 1968-2006

| State<br>(1) | Period<br>(2) | Area<br>(3) | Production<br>(4) | Yield<br>(5) |
|---|---|---|---|---|
| Andhra Pradesh | I | 5.99 | 12.94 | 8.87 |
| | II | 8.04 | 16.82 | 9.61 |
| Assam | I | 4.87 | 12.16 | 9.69 |
| | II | 4.11 | 11.22 | 11.97 |
| Bihar including Jharkhand | I | 4.66 | 16.43 | 12.92 |
| | II | 3.33 | 14.16 | 11.77 |
| Gujarat | I | 12.49 | 40.47 | 30.41 |
| | II | 9.76 | 35.54 | 27.66 |
| Haryana | I | 10.23 | 17.54 | 12.68 |
| | II | 5.68 | 8.57 | 6.67 |
| Himachal Pradesh | I | 1.98 | 13.73 | 12.95 |
| | II | 1.39 | 13.04 | 12.79 |
| Jammu and Kashmir | I | 1.60 | 12.19 | 11.78 |
| | II | 2.31 | 8.73 | 9.68 |
| Karnataka | I | 10.15 | 22.27 | 14.11 |
| | II | 4.95 | 17.80 | 14.75 |
| Kerala | I | 3.20 | 6.07 | 4.61 |
| | II | 3.56 | 7.56 | 5.48 |
| Madhya Pradesh including Chhattisgarh | I | 2.54 | 18.70 | 17.55 |
| | II | 5.61 | 23.85 | 19.05 |
| Maharashtra | I | 8.21 | 27.45 | 20.89 |
| | II | 4.28 | 23.16 | 20.76 |
| Orissa | I | 5.97 | 25.34 | 20.42 |
| | II | 7.61 | 32.87 | 28.38 |
| Punjab | I | 3.56 | 5.00 | 5.09 |
| | II | 1.92 | 5.57 | 4.68 |
| Rajasthan | I | 10.97 | 27.89 | 21.33 |
| | II | 18.35 | 38.92 | 23.12 |
| Tamil Nadu | I | 10.19 | 25.97 | 18.35 |
| | II | 11.22 | 20.15 | 13.97 |
| Uttar Pradesh incl. Uttaranchal | I | 1.98 | 14.77 | 13.77 |
| | II | 2.46 | 7.78 | 6.46 |
| West Bengal | I | 4.69 | 15.46 | 12.55 |
| | II | 3.90 | 6.66 | 5.48 |

*Source*: Same as in Table 2.
*Note*: Period I is 1968-88 and Period II is 1989-2006.

Yield instability was the major source of instability in foodgrain production in most of the states. Production was most stable in the state of Punjab followed by Kerala. Haryana, Uttar Pradesh and West Bengal were able to bring down instability in food grain production sharply in the second period. Instability in production remained very high in Maharashtra and Tamil Nadu despite reduction over time. Apart from these two states instability exceeded scale of 20 in Orissa, Madhya Pradesh, Rajasthan and Gujarat. Though Orissa is located in high rainfall eastern region but its agriculture shows high instability like states in the dry-land arid region. Changes in instability and changes in area, production and yield of foodgrains in different states (Annexure 2) show mixed pattern.

The main factor for inter state variations in instability in area, production and yield seems to be the variation in access to irrigation. Instability in foodgrain production during 1989 to 2006 was less than 9 per cent in Uttar Pradesh, Punjab and Haryana, where more than 70 per cent area under foodgrains is irrigated. In contrast, instability in foodgrain production exceeded 23 per cent in Maharashtra, Orissa, Madhya Pradesh, Rajasthan and Gujarat where less than 40 per cent area under foodgrains has access to irrigation.

## V

## CONCLUSIONS AND POLICY IMPLICATIONS

The role of technology in increasing agricultural and food production in the country is well known. However, adequate, clear and convincing evidence on the impact of new crop technologies and policies followed during different periods since 1951 in reducing variation in production and resulting risk has been lacking. The issue of instability attracted lot of attention of researchers in the early phase of adoption of green revolution technology and most of them concluded that adoption of new technology had increased instability in food grain and agricultural production in India. This conclusion was based on the period when improved technology had reached very small area. This study shows that when a longer period is taken into consideration, which witnessed spread of improved technology to large area, the inference on increase in instability due to adoption of new technology gets totally refuted at country level. Yield variability in food grain crops as well as in non-food grain crops was much lower in the first phase of green revolution extending up to 1988 as compared to pre-green revolution period. Deviation in yield, away from trend, witnessed further decline during 1989-2007. Beside larger spread of high yielding varieties, expansion of irrigation, development of crop varieties resistant to insects and pests and technologies to mitigate effect of weather on yield appears to be the other major factors in reducing yield variability.

Production of non-food grains shows increase in instability during the last two decades but production of food grains and total crop sector was much more stable in the recent period compared to pre green revolution and the first two decades of green revolution in the country. This indicates that Indian agriculture has developed resilience to absorb various shocks in supply caused by climatic and other factors. Food grain production remained more unstable as compared to production of group of non food grain crops. Instability in yield of cereal and pulses declined over time. However, the opposite holds true for oilseeds. Oilseed production is also found more risky as compared to cereals and pulses. The pattern in area, yield and production instability of food grain differs widely across states. Yield instability was the major source of instability in food grain production in most of the states. Production was most stable in the state of Punjab followed by Kerala. Haryana, Uttar Pradesh and West Bengal have brought down instability in food grain production sharply. Food grain production is highly unstable in the states of Maharashtra, Tamil Nadu, Orissa, Madhya Pradesh, Rajasthan and Gujarat. The foodgrain area under irrigation in all these states except Tamil Nadu is less than 40 per cent as against national average of 44 per cent.

As the spread of improved technology is found to be associated with decline in variability in production there is a need to pay special attention to production and distribution of seed of improved varieties to bring stability in production. Expansion of area under irrigation, development of watershed, and development of varieties resistant to insects, pests and climate stress are the other major factors for reducing variability in area, yield and production. There is also a need for large scale promotion of stabilisation measures like crop insurance to face the consequences of production fluctuations.

*Received July 2008.* *Revision accepted May 2009.*

NOTES

1. This measure is same as variance of residuals divided by mean of the dependent variable ($Y_t$). Mehra did not divide standard deviation (S.D.) in the detrended variable by mean of the detrended variable (as it was zero) to arrive at CV as per the standarised definition of CV; she rather divided the S.D. in detrended variable by mean of the variable ($Y_t$) and termed this expression as CV.

2. Hazell also used residuals derived from the deviation between actual and trend values to estimate instability but he did not use mean of dependent variable in place of mean of residuals (which is zero) to get estimate of CV as done by Mehra (1981). Hazell constructed a detrended variable ($Z_t$) by centring the residuals ($e_t$) on mean area and yield ( $\bar{Z}$) as follows: $Z_t = e_t + \bar{Z}$ . The detrended data on production was obtained by multiplying the detreded area and detrended yield. CV in the detrensded data ($Z_t$) was used as a measure of instability.

3.This raised our suspicion about the accuracy of the results relating to instability reported by Larson *et al.* Estimation of C.V. of detrended data series by us shows that the instability estimate for foodgrains reported by Larson *et al.* are totally wrong. The correct figure for Period II comes to be 5.5 and not 15.48 as reported by Larson *et al.*. Based on the figure estimated by us there is a decline in instability of foodgrain production in the period 1967-68 to 2001-02 compared to the period 1950-51 to 1964-65. It is very surprising that the authors did not care to check why instability in foodgrains was showing totally different pattern as compared to the pattern observed for total cereals and total pulses, that comprise foodgrains. Had Larson *et al.* checked the accuracy of their estimate, their inference on effect of green revolution technology on instability in foodgrain production would have been entirely opposite of what they had concluded in their paper. Similarly, the CV for yield in period II comes out to be 5.30 instead of 15.54 reported by the authors.

4. Also see footnote 1.

5. Also see footnote 2.

6. For instance, manipulation of residuals $e_t$ by adding mean $\bar{Y}$ implies that detrending is done around sum of estimated/trend value $\hat{Y}$ and $\bar{Y}$ instead of doing it around $\hat{Y}$ alone. The variable Z constructed by adding $\bar{Y}$ to $e_t$ do not satisfy statistical criteria of best fit.

REFERENCES

Acharya, S.S. (2001), "Domestic Agricultural Marketing Policies, Incentives and Integration", in S.S. Acharya and D.P. Chaudhri (Eds.) (2001), *Indian Agricultural Policy at the Crossroads*, Rawat Publications, Jaipur and New Delhi.

Chand, Ramesh (2008), "The State of Indian Agriculture and Prospects for the Future", in Kanchan Chopra and C.H. Hanumantha Rao (Eds.) (2008), *Growth Equity, Environment and Population*, Sage Publications India Pvt. Ltd., New Delhi.

Dandekar, V.M. (1994), *The Indian Economy 1947 - 92*, Volume 1, *Agriculture*, Ch.6, Sage Publications India Pvt. Ltd., New Delhi.

Hazell, Peter B.R. (1982), *Instability in Indian Food grain Production*, Research Report No. 30, International Food Policy Research Institute, Washington, D.C., U.S.A.

Larson, D.W, E. Jones, R.S. Pannu and R.S. Sheokand (2004), "Instability in Indian Agriculture – A Challenge to the Green Revolution Technology", *Food Policy*, Vol.29, No.3, pp. 257-273.

Mahendra Dev S. (1987), "Growth and Instability in Foodgrains Production : An Interstate Analysis", *Economic and Political Weekly*, Vol. 22, No. 39, September 26, pp. A82-A92.

Mehra, Shakuntala (1981), *Instability in Indian Agriculture in the Context of the New Technology*, Research Report No. 25, International Food Policy Research Institute, Washington, D.C., U.S.A.

Rao, C.H. Hanumantha, Susanta K. Ray and K. Subbarao (1988), *Unstable Agriculture and Droughts: Implications for Policy*, Vikas Publishing House Pvt. Ltd, New Delhi.

Rao, V.M. (1996), "Agricultural Development with a Human Face: Experience and Prospects", *Economic and Political Weekly*, Vol..31, No.15 April 16-23.

Ray, S.K. (1983a), "An Empirical Investigation of the Nature and Causes for Growth and Instability in Indian Agriculture : 1950-80", *Indian Journal of Agricultural Economics*, Vol. 38 , No.4, October-December, pp. 459-474.

Ray, S.K. (1983b), "Growth and Instability in Indian Agriculture" , Institute of Economic Growth, Delhi (mimeo).

Saha, Anamitra and Madhura Swaminathan (1994), "Agricultural Growth in West Bengal in 1980s: A Dis-Aggregation by Districts and Crops", *Economic and Political Weekly*, Vol. 29, No. 13, March 26, pp. A2-A11.

Sharma, H.R., Kamlesh Singh and Shanta Kumari (2006), "Extent and Source of Instability in Food grains Production in India", *Indian Journal of Agricultural Economics*, Vol . 61, No.4, October-December, pp. 648-666.

ANNEXURE 1

ALL INDIA AREA, PRODUCTION AND YIELD OF SELECTED CROPS IN DIFFERENT PERIODS (TRIENNIUM ENDING)

| Crops (1) | Area (million hectare) | | | | Production (million tonne) | | | | Yield (Kg/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1953 (2) | 1966 (3) | 1988 (4) | 2007 (5) | 1953 (6) | 1966 (7) | 1988 (8) | 2007 (9) | 1953 (10) | 1966 (11) | 1988 (12) | 2007 (12) |
| Foodgrains | 98.79 | 116.88 | 124.97 | 121.77 | 54.00 | 80.78 | 144.74 | 208.08 | 547 | 691 | 1158.2 | 1708.8 |
| Cereals | 79.55 | 93.28 | 102.02 | 98.99 | 45.33 | 69.97 | 132.73 | 194.51 | 570 | 750 | 1301.0 | 1964.9 |
| Pulses | 19.24 | 23.59 | 22.95 | 22.78 | 8.67 | 10.81 | 12.01 | 13.57 | 451 | 458 | 523.3 | 595.8 |
| Oilseeds | 11.20 | 15.11 | 19.26 | 27.30 | 4.97 | 7.36 | 11.58 | 25.54 | 444 | 487 | 601.4 | 935.6 |
| Paddy | 30.20 | 35.91 | 40.37 | 43.09 | 21.59 | 35.63 | 60.42 | 88.66 | 715 | 991 | 1496 | 2057 |
| Wheat | 9.68 | 13.16 | 23.06 | 27.01 | 6.71 | 10.84 | 45.85 | 70.56 | 693 | 823 | 1988 | 2613 |
| Jowar | 16.35 | 18.04 | 16.02 | 8.76 | 6.31 | 8.82 | 10.53 | 7.37 | 385 | 489 | 657 | 858 |
| Bajra | 9.77 | 11.63 | 10.21 | 9.43 | 2.71 | 4.05 | 3.82 | 7.96 | 277 | 348 | 374 | 845 |
| Maize | 3.36 | 4.67 | 5.76 | 7.60 | 2.23 | 4.68 | 6.65 | 14.24 | 657 | 1003 | 1152 | 1876 |
| Gram | 7.22 | 8.75 | 6.85 | 7.09 | 3.75 | 4.83 | 4.65 | 5.68 | 519 | 553 | 673 | 802 |
| Arhar | 2.34 | 2.55 | 3.22 | 3.54 | 1.75 | 1.67 | 2.33 | 2.53 | 748 | 653 | 725 | 715 |
| Groundnut | 4.74 | 7.32 | 6.98 | 6.39 | 3.20 | 5.19 | 5.62 | 6.58 | 678 | 712 | 805 | 1022 |
| R and Mustard | 2.19 | 2.96 | 4.11 | 6.98 | 0.85 | 1.23 | 2.91 | 7.47 | 390 | 418 | 707 | 1071 |
| Coconut | 0.63 | 0.84 | 1.27 | 1.95 | 38.95 | 49.34 | 68.06 | 138.22 | 6131 | 5856 | 5368 | 7112 |
| Cotton | 6.27 | 8.18 | 6.98 | 8.87 | 3.22 | 5.54 | 7.34 | 18.66 | 87 | 115 | 178 | 357 |
| Sugarcane | 1.79 | 2.56 | 3.07 | 4.23 | 56.56 | 116.71 | 184.49 | 280.40 | 31568 | 45636 | 60113 | 66171 |
| Potato | 0.25 | 0.44 | 0.85 | 1.36 | 1.79 | 3.43 | 12.40 | 23.77 | 7192 | 7719 | 14518 | 17491 |
| Tobacco | 0.34 | 0.41 | 0.37 | 0.37 | 0.24 | 0.34 | 0.42 | 0.55 | 710 | 824 | 1151 | 1490 |

*Source*: Same as in Table 2.

*Note*: Coconut production in lakh nuts and yield in nuts/hectare; Cotton production in '000 bales of 170 kg.

ANNEXURE 2

STATE WISE AREA, PRODUCTION AND YIELD OF FOODGRAINS IN DIFFERENT PERIODS (TE)

| | Area ('000 ha) | | | Production ('000 tonne) | | | Yield (kg / ha) | | |
|---|---|---|---|---|---|---|---|---|---|
| State | 1968 | 1988 | 2007 | 1968 | 1988 | 2007 | 1968 | 1988 | 2007 |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Andhra Pradesh | 9284 | 7700 | 6901 | 7217 | 9812 | 15525 | 777 | 1274 | 2244 |
| Assam | 2268 | 2630 | 2520 | 2152 | 2839 | 3453 | 950 | 1079 | 1368 |
| Bihar | 9881 | 9386 | 8630 | 8099 | 10498 | 11820 | 820 | 1118 | 1363 |
| Gujarat | 4964 | 4410 | 4087 | 3324 | 2400 | 5969 | 666 | 534 | 1462 |
| Haryana | 3672 | 3785 | 4287 | 4108 | 7359 | 13623 | 1109 | 1949 | 3176 |
| Himachal Pradesh | 816 | 870 | 812 | 964 | 1082 | 1411 | 1183 | 1242 | 1737 |
| Jammu & Kashmir | 795 | 874 | 886 | 1065 | 1259 | 1475 | 1338 | 1442 | 1664 |
| Karnataka | 7477 | 7562 | 7580 | 5629 | 6613 | 11993 | 754 | 872 | 1582 |
| Kerala | 945 | 683 | 294 | 1330 | 1160 | 660 | 1407 | 1698 | 2249 |
| Madhya Pardesh | 16779 | 17892 | 17090 | 10050 | 14524 | 19197 | 599 | 811 | 1124 |
| Maharashtra | 13255 | 13970 | 12937 | 6553 | 9011 | 11760 | 494 | 647 | 908 |
| Orissa | 5672 | 6912 | 5380 | 5189 | 6049 | 7125 | 916 | 873 | 1324 |
| Punjab | 3799 | 5411 | 6323 | 6832 | 16858 | 25387 | 1797 | 3118 | 4015 |
| Rajasthan | 11787 | 11572 | 12400 | 5865 | 6510 | 12604 | 488 | 559 | 1016 |
| Tamil Nadu | 5056 | 4163 | 3302 | 7209 | 7313 | 6131 | 1419 | 1761 | 1857 |
| Uttar Pradesh | 19485 | 20450 | 20677 | 17809 | 30119 | 41517 | 914 | 1472 | 2007 |
| West Bengal | 6041 | 6152 | 6440 | 7339 | 9681 | 15922 | 1215 | 1573 | 2473 |

*Source*: Same as in Table 2.