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Analysing rainfall impact on farm output

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Data over the years show that although the effects of rainfall are significant, factors such as fertiliser use cannot be discounted

How important is rainfall in affecting agricultural output? In spite of various developments that have taken place in the field of agriculture, dependence on monsoon continues. Over the long run, agricultural production is influenced by a variety of factors which include technological changes, extension of irrigation, availability of credit and land reforms.

However, in a short period, year-to-year variations in agricultural production can be influenced by rainfall. This article explores the relationship between rainfall and agricultural production in the period 1993-94 to 2013-14. We also look at the behaviour of food prices in normal, below and above normal rainfall years.

Behaviour of rainfall

Table 1

Agricultural production and rainfall –All India (1993-2014)

Year	Fertiliser consumption	Agricultural production (All crops)	Agricultural production (Vegetables)	Rainfal (mm)	% Change in agricultural production -All Crops (Y-o-Y)	% Change in vegetable production (Y-o-Y)	% Change in rainfall (Y-o-Y)	Rainfal category
1993-94	100	100.0	100.0	1,200.5	3.8	3.1	6.2	N
1994-95	109	105.8	102.3	1,306.2	5.8	2.3	8.8	AN
1995-96	112	103.1	108.8	1,231.7	-2.6	6.4	-5.7	AN
1996-97	115	112.0	114.1	1,159.7	8.6	4.9	-5.8	N
1997-98	131	106.3	110.5	1,211.8	-5.1	-3.2	4.5	AN
1998-99	135	112.0	133.1	1,158.8	5.4	20.5	-4.4	N
1999-00	145	114.4	138.1	1,147.4	2.1	3.8	-1.0	N
2000-01	135	109.0	142.7	1,005.8	-4.7	3.3	-12.3	BN
2001-02	140	115.5	134.7	1,127.9	6	-5.6	12.1	N
2002-03	129	100.7	128.9	1,010.9	-12.8	-4.3	-10.4	BN
2003-04	135	108.1	141.6	1,203.0	7.3	9.9	19.0	N
2004-05	148	106.4	154.2	1,147.0	-1.6	8.9	-4.7	N
2005-06	164	119.3	167.6	1,161.0	12.1	8.7	1.2	N
2006-07	174	136.4	174.8	1,170.1	14.3	4.3	0.8	N
2007-08	181	140.6	191.4	1,184.5	3.1	9.5	1.2	N
2008-09	201	140.6	196.2	1,077.4	0	2.5	-9.0	BN
2009-10	213	134.9	203.3	954.1	-4.1	3.6	-11.4	BN
2010-11	227	159.0	222.8	1,232.1	17.9	9.6	29.1	AN
2011-12	224	164.5	237.6	1,111.8	3.5	6.6	-9.8	N
2012-13	206	163.2	246.5	1,071.3	-0.8	3.7	-3.6	BN
2013-14	198	170.3	247.6	1,258.2	4.4	0.4	17.4	AN

Source: 1. Rainfall Data, India Meteorological Department, Ministry of Earth Sciences
2.Overall Production Index, Handbook of Statistics, RBI (Base: 1993-94=100)
3.Vegetable Production Index, Ministry of Agriculture and Farmers Welfare
4.N- Normal , AN- Above Normal, BN- Below Normal

Chart A and Table-1 provide a picture of rainfall in India between 1993-94 and 2013-14.

Rainfall data are made available by the India Meteorological Department.

The annual all-India rainfall data are area weighted rainfall. It is seen that rainfall has varied from a maximum of 1,306 mm in 1994-95 to a minimum of 954 mm in 2009-10. Looked at as the deviation from the average, it is highest in 1993-94 at 13.7 per cent and lowest in 2008-09 at (-) 16.9 per cent.
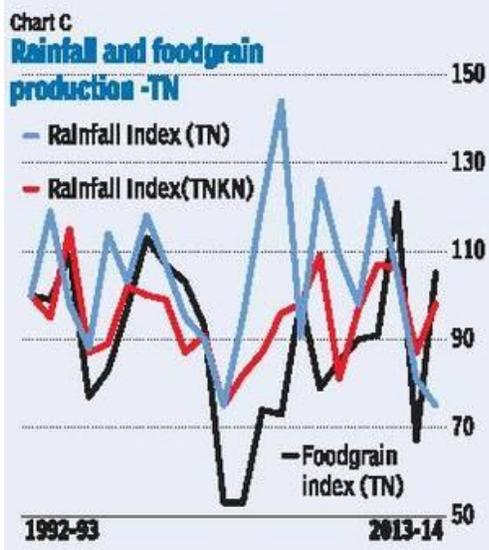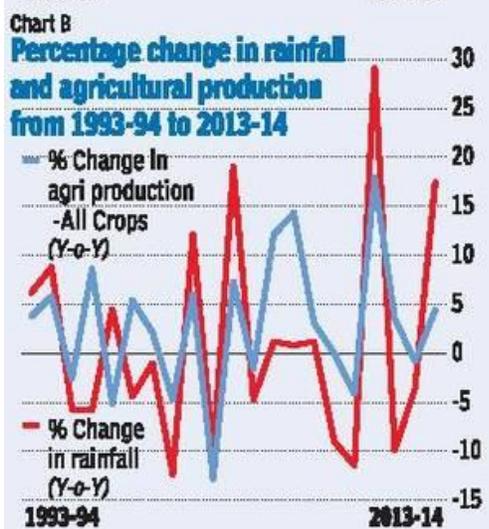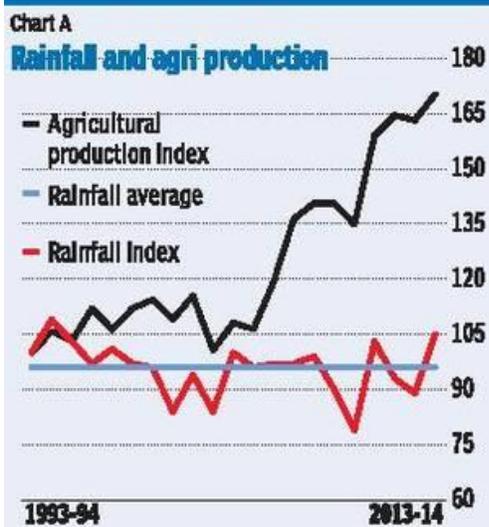
Table 2

Rainfall and agricultural production in India

Category	Total no.of years	Average increase in Production (Y-o-Y)	Number of years when % increase in Agricultural production is	
			-ve	+ve
Above Normal (AN)	5	4.10	2	3
Normal (N) Below	11	5.90	1	10
Normal (BN)	5	-4.50	5	0

Notes: The Average Rainfall is 1149 mm.
The categories have the following representation:
AN, when rainfall is 5% or above than average; N, when rainfall is within +/- 5% of average; BN, when rainfall is 5% or lower than average

If the normal year is defined as one which falls in the range of (+) or (-) 5 per cent of average, of the 21 years, 11 years were normal, 5 years were above normal and 5 below normal. (Table-2).

The coefficient of variation of agricultural production is 18.62 per cent as compared with 7.59 per cent for rainfall for the same period. This indicates higher degree of variability in agricultural production than that of rainfall.

Chart A

Rainfall and agri production

- Agricultural production Index
- Rainfall average
- Rainfall Index

180
165
150
135
120
105
90
75
60

1993-94   2013-14

Chart B

Percentage change in rainfall and agricultural production from 1993-94 to 2013-14

- % Change in agri production -All Crops (Y-o-Y)

30
25
20
15
10
5
0
-5
-10
-15

- % Change in rainfall (Y-o-Y)

1993-94   2013-14

Chart C

Rainfall and foodgrain production -TN

- Rainfall Index (TN)
- Rainfall Index(TNKN)

150
130
110
90
70
50

-Foodgrain index (TN)

1992-93   2013-14

In order to bring out the relationship between rainfall and agricultural production, Chart B gives the percentage change in each of the two variables. The co-movement was

somewhat blurred during the period 1993-94 to 2002-03. But in the later period this is very clearly visible.

Table 3

Rainfall and foodgrain production in Tamil Nadu

Category	Total number of years	Average food inflation (WPI) (%)	Number of year when food inflation < 4%	Number of year when food inflation between 4 and 9%	Number of year when food inflation > 9%
Above Normal (AN)	5	10.50	1	1	3
Normal (N)	11	6.40	4	4	3
Below Normal (BN)	5	7.80	2	0	3

Note: The Average Rainfall is 1149 mm. The categories have the following representation: AN, when rainfall is 5% or above than average; N, when rainfall is within +/- 5% of average; BN, when rainfall is 5% or lower than average

Table 3 looks at the behaviour of food inflation in conjunction with rainfall. In the five years which had a rainfall above normal, food inflation (WPI) on an average was the highest. Rainfall at best affects food production and thus the supply side. Equally important is demand, monetary demand. For example in a year in which production rose substantially if there was an extraordinary increase in money supply, prices may rise despite an expanded supply.

We first examine the impact of rainfall on overall agricultural production. One thing that stands out is that in all the five years when the rainfall was below normal, agricultural output had declined from the previous year. The average annual decline for the five years was 4.5 per cent. Among the 16 years, when the annual rainfall was either normal or above normal, in 13 years, the year-to-year change in output was positive and during this period the annual average increase in production was 5.3 per cent.

Table 4

Rainfall and vegetable production in India

Category	Total number of years	Average increase in Production (Y-o-Y) (%)	Number of years when % increase in agricultural production is < 4%	Number of years when % increase in agricultural production is > 4%
Above Normal (AN)	5	3.10	3	2
Normal (N)	11	6.80	4	7
Below Normal (BN)	5	2.20	5	0

Notes: The Average Rainfall is 1149 mm. The categories have the following representation: AN, when rainfall is 5% or above than average; N, when rainfall is within +/- 5% of average; BN, when rainfall is 5% or lower than average

In the five years, when the annual rainfall was above normal, the average annual increase in production was not higher than in the normal years. Similar findings are found when we analyse the impact on vegetable production (Table 4). In the case of vegetables, even in years when rainfall is below normal, the annual increase in production is positive. However, the average increase is much lower than in normal years. In fact, out of the 16 years when the rainfall was either normal or above normal, in nine years the increase in output has been above 4 per cent.

Regression analysis

In order to establish a more rigorous relationship between rainfall and production, we analysed the problem with the help of regression equations.

An old study done in 1988 by Parathasarathy *et al*, estimates the effect of rainfall over the production of foodgrains. Their sample included a 25-year period from 1961 to 1985 and finds a significant positive relationship between percentage departure of all-India summer monsoon rainfall from average level, and total annual foodgrain production index.

Table 5

Estimated Equations - impact of rainfall on foodgrain

Variable	Equation 1	Equation 2	Equation 3
Dependent variable	Percentage change in agricultural production	Ln of agricultural production	Ln of agricultural production
Constant	+2.5644* (2.04)	1.05 (-0.66)	-2.33 (-1.57)
Percentage change in rainfall	+0.0.04* (3.43)		
Time trend		+0.03** (9.56)	
Ln of rainfall		+0.49* (2.17)	+0.52* (2.68)
Ln of fertilizer consumption			0.687** (11.4)
R bar square	0.35	0.82	0.87

Using the data for the period 1993-94 to 2013-14, we regressed annual percentage change in agricultural production on annual percentage change in rainfall and we noticed a significant relationship (Equation 1 of Table 5).

When we also estimated this equation with an additional variable viz., time trend, in order to capture the impact of all other measures taken to enhance agricultural production, we find that the time trend variable is also significant. Both the time and rainfall explain about 82 per cent of the variation in agricultural production (Equation 2).

We replaced the time trend variable by fertiliser consumption, which is also an indicator of recent developments in agriculture, we find both the coefficients are significant and explain about 87 per cent of the variation in agricultural production (Equation 3). Thus the broad conclusion is that rainfall has a significant impact on agricultural production even though for a full explanation of the variations in agricultural production, other variables are relevant.

Impact of rainfall in Tamil Nadu

We also studied the impact of rainfall on foodgrain production in Tamil Nadu (Chart C and Table-7). Tamil Nadu has experienced extreme variations in rainfall and foodgrain production.

Table 7

Rainfall and foodgrain production in Tamil Nadu

Year	Rainfall TN (mm)	Rainfall TNKN (mm)	Food grain production -TN (000 Tonnes)	% Change in rainfall -TN (Y-o-Y)	% Change in rainfall -TNKN (Y-o-Y)	% Change in food grain production -TN (Y-o-Y)
1992-93	932.5	4,821.4	8358.0	1.20	3.90	1.40
1993-94	1,105.4	4,589.7	8258.0	18.50	-4.80	-1.20
1994-95	909.6	5,540.4	9088.0	-17.70	20.70	10.10
1995-96	818.3	4,172.4	6,405.0	-10.00	-24.70	-29.50
1996-97	1,063.3	4,257.0	6,930.0	29.90	2.30	8.20
1997-98	957	4,896.3	8,103.7	-10.00	14.70	16.90
1998-99	1,099.4	4,806.8	9,418.7	14.90	-1.80	16.20
1999-00	1,000.5	4,794.5	8,968.8	-9.00	-0.20	-4.80
2000-01	881.6	4,218.3	8,616.8	-11.90	-12.00	-3.90
2001-02	839.8	4,381.5	7,731.9	-4.70	3.90	-10.30
2002-03	700	3,614.7	4,442.1	-16.60	-17.50	-42.50
2003-04	890.3	3,973.4	4,406.1	27.20	9.90	-0.80
2004-05	1,128.4	4,186.1	6,175.8	26.70	5.40	40.20
2005-06	1,342.5	4,622.5	6,127.2	19.00	10.40	-0.80
2006-07	851.7	4,712.2	8,263.0	-36.60	1.90	34.90
2007-08	1,178.6	5,277.0	6,582.3	38.40	12.00	-20.30
2008-09	1,011.8	3,896.4	7,102.3	-14.20	-26.20	7.90
2009-10	910.1	4,693.4	7,511.4	-10.10	20.50	5.80
2010-11	1,152.6	5,147.6	7,594.9	26.60	9.70	1.10
2011-12	983.4	5,129.0	10,151.8	-14.70	-0.40	33.70
2012-13	759.2	4,183.0	5,592.8	-22.80	-18.40	-44.90
2013-14	698.8	4,716.9	8,783.2	-8.00	12.80	57.00

Source 1. Rainfall Data, Ministry of Earth Sciences, India Meteorological Department
2.Food Grains Production, Handbook of Statistics, RBI
3.TN represent rainfall in Tamil Nadu, TNKN represents rainfall in Tamil Nadu and Coastal Karnataka

The coefficient of variation in foodgrains production is 20.48 per cent and in rainfall 16.85 per cent. The interesting finding that comes out of the regression analysis is that rainfall in Tamil Nadu by itself has no significant impact on output of foodgrains.

Table 6

Estimated equations Impact of rainfall on foodgrain output in TN

Dependent variable - ln (food grain production) in Tamil Nadu	[1]	[2]	[3]	[4]
Intercept	4.91 (1.1)	7.49** (3.79)	-3.46 (-1.22)	-3.32 (-1.17)
ln (Rainfall - India)	0.57 (0.89)			
ln (Rainfall - Tamil Nadu)		0.21 (0.72)		
ln (Rainfall - KNTN)			1.47** (4.39)	1.45** (4.35)
Time Trend – t				-0.01 (-0.94)
R-Squared	0.04	0.02	0.45	0.45

**Significant at 1 %   *Significant at 5 %

However, if we add Tamil Nadu's rainfall with the rainfall in coastal Karnataka, it turns out to be significant (Table-6).

Karnataka rainfall in coastal areas has an impact on the flow of water in Cauvery as well as other rivers which originate in Western Ghats and flow into Tamil Nadu. It is also seen that there is no trend increase in foodgrain production and the trend coefficient is insignificant.

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