VARSHA BONDS & OPTIONS

Capital Market Solutions For Crop Insurance Problems

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Abstract

The crop insurance scheme in India has been a failure in all dimensions of the performance vector; financial, economic, administrative, etc. excepting in the number of farmers it covers. This paper offers an alternative design in terms of loans, bonds and options whose interest rates and payoffs are linked to the adverse deviation in the level of rainfall, the dominant direct cause of loss in case of *kharif* crops and an exacerbating indirect cause of loss of a portion of *rabi* crops. These rainfall – related financial instruments entirely eliminate the problems of moral hazard and adverse selection because India possesses an independent rainfall reporting system. Valuation methods for the proposed 'Varsha' instruments and financial engineering possibilities to create an active secondary market for them have been elaborated.

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[1] I would like to dedicate this paper to my teacher, the late Professor V.M. Dandekar whose work on crop insurance in the 70's has culminated in the present National Agricultural Insurance Scheme in India.

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1. Background

The Comprehensive Crop Insurance Scheme (CCIS) has recently been replaced with modifications, and enlargements by the National Agricultural Insurance Scheme (NAIS). All that was in CCIS is to be found in NAIS but the NAIS menu is more elaborate as the following table shows.

Table 1

MAJOR DIFFERENCES OF NATIONAL AGRICULTURAL INSURANCE SCHEME (NAIS) WITH CCIS

S.No.	Parameters	CCIS	NAIS
1	Farmers Covered	Loanee farmers	All Farmers
2	Crop covered	Food Crop & Oilseeds	All CCIS crops 3 annual commercial / Hort. Crops. *Viz.* Cotton, potato & sugarcane in the 1st year and all other annual comm.. / hort. Crops by 3rd years.
3	Premium	2% for Cereals & Millets and 1% for Pulses & Oilseeds	(a) Food crops & Oilseeds *Kharif* : Bajra & Oilseeds : 3.5% or actuarial rate which ever is lower. Other crops : 2.5% or actuarial rate, whichever is lower. *Rabi* : Wheat : 1.5% or actuarial rate whichever is lower Other Crops : 2.0% or actuarial rate whichever is lower. (b) annual commercial / hort. Crops : actuarial rates.
4	Premium subsidy	50% subsidy for Small & Marginal farmers	50% in the first year, but to be phased out in five years.
5	Limit of sum Insured	Rs. 10,000 per farmer	Upto the value of 150% of average yield. However, sum insured exceeding value of thresh old yield shall attract premium at actuarial rate.

S.No.	Parameters	CCIS	NAIS
6	Sharing of risk	2:1 by Central and State Government	Food crops & Oilseeds : Until complete transition is made to actuarial regime in a period of five years, all claims beyond 100% of premium shall be borne by the GOI and States on 50:50 basis. Thereafter, all claims upto 150% of premium for a period of three years and 200% of premium for an extended period of additional three years, thereafter shall be met by IA. Claims beyond the limits of IA shall be paid out of Corpus fund for a period of three years. Annual commercial / hort. Crops : IA shall bear claims upto 150% of premium in the first three years and 200% of premium thereafter subject to satisfactory claims experience. The claims beyond the limits of IA shall be paid out of Corpus Fund.
7	Participation by Farmers	Compulsory for Loanee Farmers	Compulsory for Loanee farmers & Optional for non-loanee
8	Participation by States	Voluntary	Available to all States / U.T.s
9	Approach by the Scheme	Area approach	Area approach. However in case of localized calamities, individual assessment will be experimented in limited areas.
10	Administrative Expenses	The Government of India reimburses 50% of Expenses to GIC	The GOI / States reimburses 100% expenses in the 1st year which will be reduced on sun-set basis. From 6th year onwards, all expenses shall be borne by the implementing Agency.

Nevertheless, to get to the point quickly, whether it was CCIS or NAIS, the performance of the crop insurance scheme in India can only be judged as disappointing on all counts; financial, economic and administrative. Financially, the scheme has been incurring continuous losses. Over the CCIS period from 1985-6 through 1999 the total premiums collected were Rs. 402.83 crores and the total claims paid Rs. 2305.0 crores with a sum insured of Rs. 24921.87 crores [See Mishra (1996)]. The loss ratio excluding huge management expenses stands at 5.72. The NAIS has not been auspicious either. In the first year of operations, 2000, the NAIS collected Rs. 211 crores in premiums and paid Rs. 1100 crores in claims. Thereafter, the available figures for 2001 – 2002 indicate total premium collections of Rs. 284.35 crores and claims of Rs. 555.27 crores [see Tables 3a, 3b below]. [It may be pointed out that crop insurance schemes world over suffer losses and are supported by the government].

On the economic front too the performance has been pitiable both in terms of the size of the impact of the scheme and equitability of premium collections and claim payments. For instance average per annum claims paid were Rs. 233 crores which if compared to the sum-at-risk *i.e.* the agricultural output of the country worth Rs. 6,50,000 crores is hardly 0.035% and when compared to the total farm loans of Rs. 58,000 crores is only 0.40%. It does not compare well even with the interest on the loans which would be in the region of Rs. 3,800 crores per annum. Even though the sum insured of Rs. 24,922 seems to compare well with farm loans outstanding the actual claims payout nowhere close to loss estimates of output. For example the standard deviation in the growth rate of agricultural output at an all-India level is 13.75% and the average annual growth rate is 3.5%. So that annual crop losses in normal circumstance could be placed in the region of 0.1375 x 0.035 x 6,50,000 crores = Rs. 3128 crores. On the equitability side too one can witness arbitrary cross subsidisation as tables 2a and 2b show. Some crops and regions pay the premiums, others make the claims.

Table 2a
Cropwise Premiums and Claims : Origin & Destination (1985-6-1999)

	Premium		**Claims**		**Loss Ratio**
	Rs. Cr.	%	Rs. Cr.	%	
Paddy	217.52	54	576.26	25	2.65
Wheat	52.36	13	46.10	2	0.88
Groundnut	60.42	15	1221.68	53	20.22
Jowar	36.25	9	184.40	8	5.08
Bajra	24.16	6	184.40	8	7.63
Pulses	4.02	1	23.05	1	5.73
Others	8.04	2	69.15	3	8.60

Table 2b
Statewise Premium & Claims : Origin & destination (1985-6-1999)

	Premium		**Claims**		**Loss Ratio**
	Rs. Cr.	**%**	**Rs. Cr.**	**%**	
Gujarat	64.45	16	1336.93	58	20.74
Maharashtra	60.42	15	253.55	11	4.19
Andhra Pradesh	100.70	25	322.70	14	3.20
Others*	177.24	44	391.86	17	2.21

*include 22 states & UT's excluding Punjab, Haryana & North-Eastern states.

Source : Mishra (1996)

Finally the administrative front. A more complex administrative mechanism for a scheme of so small a financial dimensionality might not have existed in economic history, even in the former Soviet Union. The scheme is operated by (a) the ministries of agriculture at the Central and State levels (b) the ministries of finance at the Central and State Levels (c) NABARD (d) apex / state co-operative banks (e) district co-operative banks (f) primary agricultural credit societies and banks (g) registrars of co-operatives (h) officials of the state agriculture departments (i) agricultural production commissioners (j) officials of the state revenue departments (k) the bureaus / directorates of economic and statistics at the state level (l) national sample survey officials (m) officers of the General Insurance Corporation of India in the state level crop insurance cells and those at central office level. In accordance with academic customs I shall refrain from mentioning the high degree of political involvement at the stage of claims assessment at the village level and going upto the level of Centre-State fiscal relations whose result is the injection of large doses of moral hazard and mutual suspicion into the crop insurance system. The costs of this entire machinery are difficult to quantify because they are hidden in the Central and State budgets. [On the flip side it may be claimed that the Indian crop insurance scheme utilizes the existing administrative machinery which requires no *additional* expenditure. Only the government can decide whether directing the existing machinery for the cause of crop insurance leads to deterioration in the quality of public services in those areas in which that machinery was supposed to deliver].

2. Scheme Operation

The CCIS used to be administered exclusively through the credit mechanism. The NAIS too does so but it also gives non-loanee farmers the option to buy insurance. Under the credit mechanism premiums are added to the crop loans of the farmer. The sum insured is usually equal to the loan amount. Threshold yields are calculated on a 3-year moving average basis for rice and wheat and 5-year moving average for other crops. The indemnity is

$$\left(\frac{T-A}{T}\right) \text{ (Sum Insured)}$$

where T is the threshold yield ascertained from crop cutting experiments and A is the actual or realized yield ascertained from crop loss sample surveys in various homogenous areas. The indemnity so arrived at is credited to the crop loan account of the farmer. Small and medium sized farmers are eligible for a subsidy in premium to the extent of 50%, which is paid on 50:50 basis by the Central and State governments.

The NAIS, besides extending coverage to non-loanee farmers, has recognized heterogeneous risk classes for the computation of actuarially fair premium rates, which has resulted in very complex procedures for indemnity calculation(1). [See Annexure 1a to 1c]. Moreover the NAIS has given choice to the farmer to choose indemnity limits of 60%, 80% or 90% of the threshold yields as indemnity limits. The value of the thresold yield upto 150% of average yield or the amount of crop availed, this last being the compulsory minimum, are options for the choice of the sum insured. In case of the former the valuation of yield is made at the minimum support price (MSP) for the crop for calculating indemnity (2).

The performance of the NAIS is summarized in Tables 3a and 3b below.

Table 3a

NAIS Experience

	States	**Coverage (lakh farmers)**	**Premium (Rs. Crs.)**	**Claims (Rs. Crs.)**
Rabi 99 – 00	9	5.79	5.42	7.69
Kharif 00	17	8.40	206.74	1184.68
Rabi 00 – 01	18	20.79	27.45	47.17
Kharif 01	20	85.68	256.90	508.10
Rabi 02	18	20.16	32.07	In process
Kharif 02	20	100.00	300.00	In process

Table 3b

NAIS Experience Non-loanee farmers

	Coverage	**Premium**	**Claims**
Rabi 99 – 00	0.19	0.15	0.59
Kharif 00	1.92	3.10	36.50
Rabi 00 – 01	1.69	9.33	14.96
Kharif – 01	7.21	9.79	84.71
Kharif 02	10	In progress	In progress

Source : Data compiled by GIC's Crop Insurance Cell.

The figures speak for themselves. The fact that the claim ratios for non-loanee farmers are greater than loanee farmers shows a substantial tendency for adverse selection. (The loss cost measured as the ratio of claims to sum insured is 3 times for non-loanee as compared to loanee farmers).

The NAIS envisages phasing out GIC and creating a separate specialized Agricultural Insurance Company of India Limited [to be incorporated in January 2003 with GIC owning 35%, NABARD 30% and four general insurance subsidiaries owning 8.75% each] which will charge actuarial premium rates so that financial support can be withdrawn in a phased manner(3), and the scheme can be made self-supporting in 5 years ! Indeed !

Before going on to raise the issues it may be worthwhile to look at the causal analysis of losses conducted by GIC's Crop Cell in respect of all losses during the period 1985-6 to 2001-2002,

Table 4

Cause	Proportion of Losses
Drought / Low Rainfall	70 %
Floods / Excess Rainfall	20 %
Others*	10 %
* includes storms, earthquakes, disease, pests, negligence etc.	

Source : Data compiled by GIC's Crop Insurance Cell.

Obviously, losses due to droughts are more severe in case of unirrigated as compared to irrigated areas where other causes dominate.

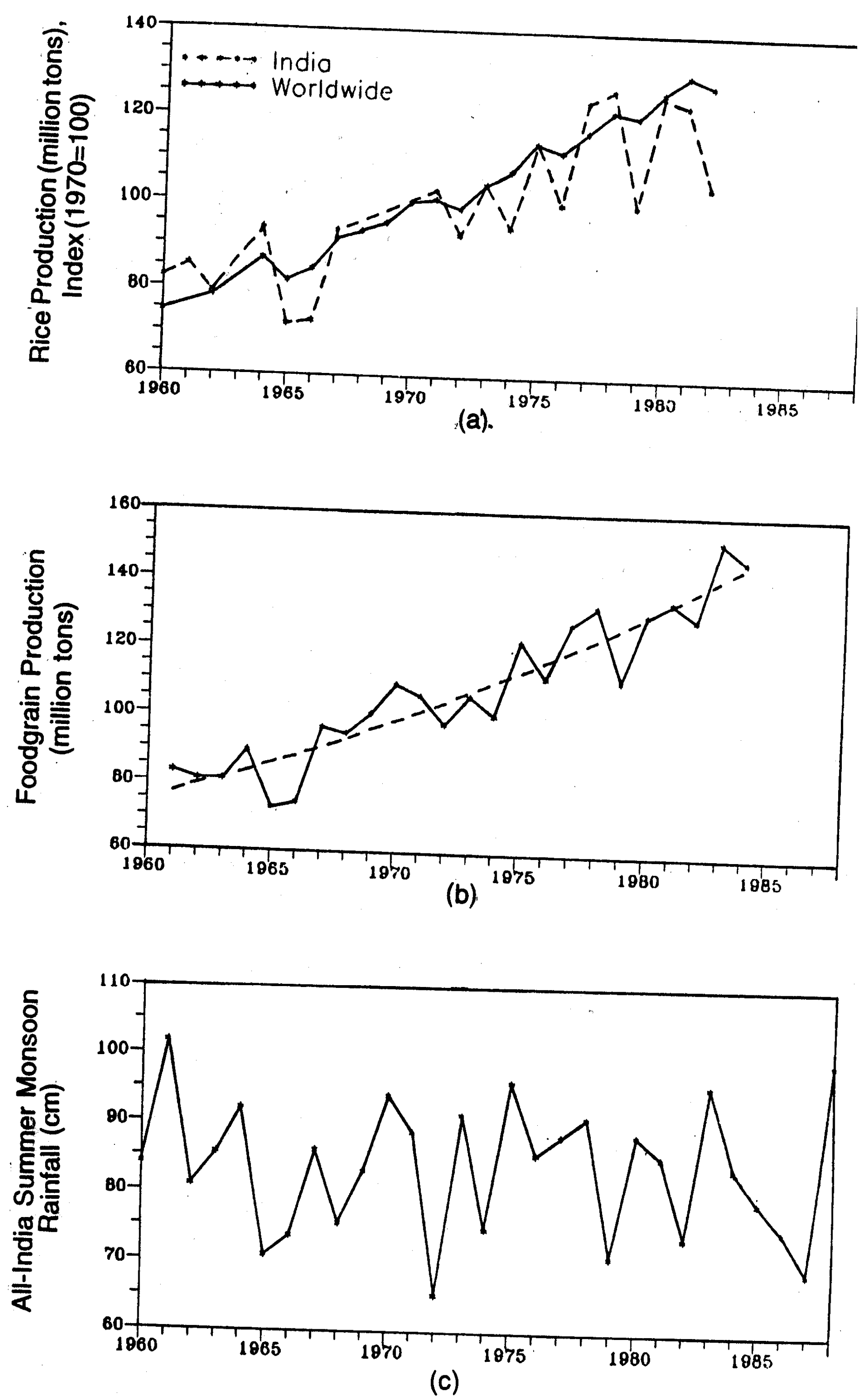
That agriculture in India is extremely sensitive to rainfall is well-known. A recent study by Gadgil (1996) shows just how much. Observe the close alignment of the turning points in the graphs of rice production, total foodgrains production and monsoon rainfall in the graphs below.

As early as in 1976 the National Commission on Agriculture (1976) had estimated that rainfall variations accounted for 50% of the variability in agricultural yields, being as high as 90% for cotton and groundnut, 47% for wheat and 45% for barley and jowar.

This causal analysis of crop yield losses will necessarily have a direct bearing on any scheme of insurance whose main purpose is to protect insureds against acts of God.

3. Issues

The foregoing discussion suffices to raise some critical issues towards reforming the crop insurance scheme.



Source : Gadgil (1996)

1. The crop insurance scheme is low - impact – the size of genuine protection that it gives is small. Can this be enlarged ?
2. The administrative design is enormously complex – calculations are tedious and too many functionaries are made to co-ordinate at different levels. Can this be trimmed down and simplified ?
3. The system is financially non-viable even after the introduction of actuarial rates. Can financial viability be ensured ?
4. The system is replete with moral hazard – farmers of some crops and/or some regions seem to have specialized in claims manipulation. Can this be eliminated ?
5. The scheme is perhaps too 'comprehensive' – it ignores the preponderance of a specific peril that accounts for a majority of the crop losses in India *viz.* rainfall, whether deficient or excess. Can this be given explicit and special recognition ?

Now this is quite a mouthful of issues. But nothing short of a simultaneous solution of all the issues would do. Even at the cost of sounding clichéd what seems to be required is a complete business process reengineering.

Nevertheless despite its many drawbacks if the crop insurance scheme's performance is to be evaluated on a 360^0 basis it would have to be accorded high marks for one and only one reason, *viz.* it has resulted in nationwide insurance awareness amongst the farming community and has resulted in the systematic development of databases on agricultural production and crop losses in several areas of the country. The success of any alternative crucially depends on the strength achieved by the crop insurance scheme.

4. Alternative Approach

The simple device that this paper suggests is to explicitly recognize rainfall as the dominant peril and design an insurance system to immunize farm incomes against adverse deviations in rainfall to reduce volatility of farm income. The primary insurance mechanism can be strengthened by means of a reinsurance system in which financial institutions and capital markets can accept the risk-return of farm incomes in order to improve their own risk-return tradeoffs.

Any system of insurance must necessarily ensure that

(i) the farmers, as insureds, should have no control over the loss event and its reporting
(ii) the size of the loss should be quantifiable in financial terms
(iii) moral hazard and adverse selection should be minimized, ideally eliminated
(iv) the insurance provider should find the risk-return package attractive.
(v) the system should minimize transaction / administrative costs.

Of the above, (i), (ii) and (iii) are preconditions for insu*rabi*lity and (iv) and (v) are preconditions of economic efficiency.
It should be clear from the very outset that *kharif* and *rabi* foodgrains should be considered separately in view of the data in tables 5(a), 5(b) which readily show that *rabi* foodgrains belong to a lower risk category both in terms of the standard deviations in output growth rates as well as in their sensitivity to changes in rainfall.

Step I – Finesurance

Let us first tackle the issue of administrative costs. The NAIS is administered through the agricultural banking system in case of both loanee and non-loanee farmers. The huge administrative paraphernalia detailed in section 1 basically performs three jobs, (a) the determination of threshold yields on moving average basis (b) the determination of actual yields through surveys and (c) arranging the center-state funds and reaching them to the widely dispersed nodal points. Of these job (a) is completely mechanical and can be performed by the financier itself. Job (c) is what the NAIS wants to eliminate. Job (b) although tedious can in principle be performed by the bank officials themselves. (but as we shall see this can be dispensed with under the alternative scheme proposed) If so, where is the need for a separate agricultural insurance corporation if crop insurance premiums are to be actuarially determined and all state support is to be withdrawn? The insurance scheme can be wholly administered by the agricultural credit system, represented say by NABARD as the apex refinancer, without the need for involving anyone else !

The fact that this simple institutional rearrangement has not been thought / sought to be implemented means that bankers are not enthusiastic about providing insurance. Lack of enthusiasm on the part of bankers must be either because the premium rates are not adequate or because they fear being pressurized into settling unfairly large claims at the local level, a fear which GIC officials who operate at the national level are expected to be immune to. Otherwise a merging of the financial function and insurance function into a single institution will by itself substantially eliminate administrative / transactions costs [8]. But this will require eliminating moral hazard.

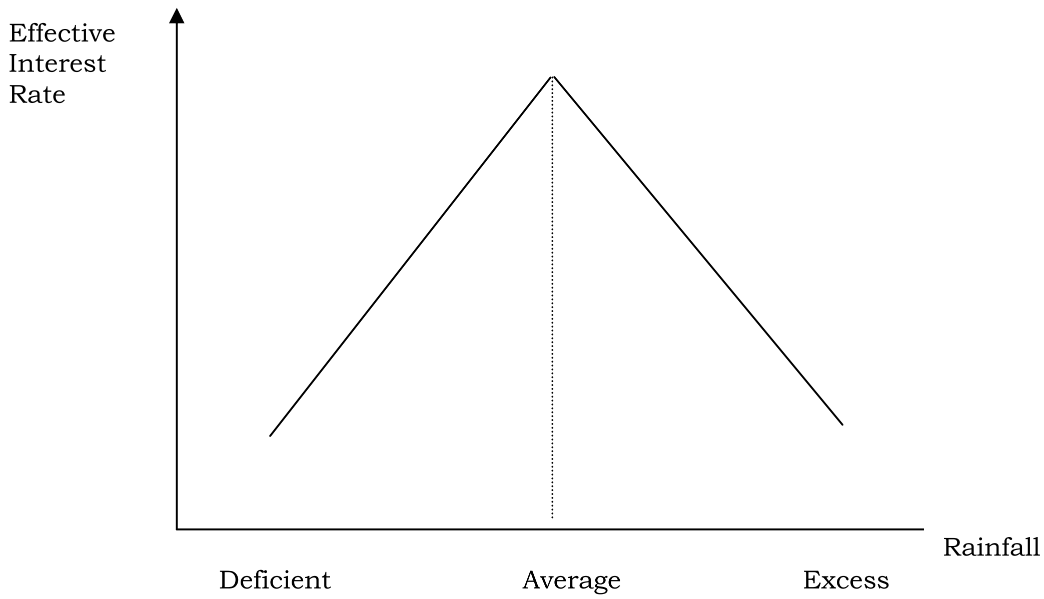
Step II – Link Crop Loss to Rainfall

To eliminate moral hazard we shall now invoke the fact that 90% of the crop losses in India are due either to inadequate rainfall (70%) or due to excess rainfall (20%) (Refer Table 4 above). Thus, if the loss event could be stated directly in terms of the level of rainfall (instead of the realized crop yield) preconditions (i) (ii) and (iii) of insurance would be automatically satisfied, moral hazard would be eliminated[5]. India fortunately has an independent daily rainfall reporting system administered by the Indian Meteorology Department which has installed rain guages upto village levels in many cases. This data can be shared with the finesurer.

The only problem would be to fix premium rates in terms of rainfall and then to translate it into a premium in terms of the interest rate on crop loans by means of a multiplier. The rate of interest charged on the crop loan will now be a gross rate, *viz.* the regular loan rate plus the crop insurance premium rate. Any adverse deviation in the rainfall which causes farm output / income to decline will result in a lower interest rate. For example if 1% adverse deviation in the rainfall is translated into ε percentage points of the interest rate,

Effective Interest Rate = Gross Interest Rate – (ε) times % points of adverse deviation in rainfall.

The result of applying this principle would be a straddle as shown in the diagram below:



The above represents an economical institutional structure that will work viably provided the multiplier linking deviations in rainfall to the interest rate is properly determined, "proper" in the sense of being acceptable to the insured and the insurer. We now turn to these questions.

Step III – Rainfall – Interest Multiplier

To determine the size of the multiplier linking rainfall to the interest rate $(\in)$ consideration must necessarily be given to the impact of rainfall on the income of the farmer because that is what must ultimately be protected. Now the rainfall affects the output of agricultural crops and only through that the farm income. And in a regime where minimum support prices (MSP) of agricultural crops are declared in advance of sowing operations, which is the system prevailing in India, the price risk stands mitigated so that representing the crop's income elasticity with respect to rainfall by the crop's output elasticity with respect to rainfall is quite in order. The output elasticity with respect to rainfall is estimated by an established methodology. Estimates by Rao, Ray and Rao (1988) are given below,

Table 4a

Output Elasticity With Respect To Rainfall (1980's)

(% deviation in output due to 1% deviation in rainfall from normal level)

Crops	Elasticity Estimate	
	Range	**Mean**
Rice	0.75 – 0.85	0.8
Wheat	0.10 – 0.20	0.15
Coarse Cereal	0.55 – 0.70	0.58
Total Cereals	0.50 – 0.60	0.55
Pulses	0.60 – 0.70	0.65
Kharif Foodgrains	0.70 – 0.80	0.75
Rabi Foodgrains	0.15 – 0.25	0.20
Total Foodgrains	0.55 – 0.65	0.60
Oilseeds	0.20 – 0.32	0.28
All Crops	0.35 – 0.45	0.40

TABLE 4b
Sensitivity of Output to Rainfall Variations

Crop and Crop Groups	Percent deviation in output due to 1 per cent deviation in rainfall from its normal level		
	1950 – 65	**1966 – 85**	**1968 - 85**
Rice	0.4657	0.6650	0.6437
Wheat	0.0980	0.1643	0.0279
Coarse Cereals	0.0407	0.5746	0.5907
Cereals	0.1747	0.526	0.4431
Pulses	0.2350	0.572	0.6093
Kharif Foodgrains	-	-	0.7613
Rabi Foodgrains	-	-	0.1130
Total Foodgrains	0.1939	0.3240	0.4643
Oilseeds	0.1912	0.3910	0.3539
All Crops	0.1651	0.4052	0.3794

Source : Rao, Ray and Rao (1988)

Given the figure for income loss (*i.e.,* output loss at the MSP) the multiplier can be worked out once the level of maximum protection is determined. Suppose the maximum protection that we wish to provide is equal to the crop loan interest and consider a rice farmer who has taken a loan of Rs. 2,000/- at a 10% rate of interest. His interest liability during a season at 3.33% (assuming a crop cycle of 4 months) would be Rs. 66.60. The income elasticity is 0.8 with respect to rainfall as reported in Table 4a which means that an adverse deviation of 1% in rainfall results in an output and income loss of 0.8%. In other words an adverse deviation of (1/0.8) x 3.33% = 4.1625% in the rainfall would reduce his income by Rs. 66.60, his interest-paying capacity, which is what we have decided to protect. Thus, the value equivalents will be

4.1625% adverse deviation in rainfall = Rs. 66.60 = 3.33% interest rate

or

1% rainfall = Rs. 16 = 0.8% interest rate

which will become the value of rainfall - interest multiplier.

For every adverse deviation in rainfall by 1% the rate of interest charged on the crop loan will reduce by 80 basis points. Of course this is an all-India figure. Output elasticities will vary according to regions but even these estimates are available and/or can be made available by an independent research institute and monitored by a finesurer like NABARD. In effect the output elasticity with respect to rainfall itself serves as the required multiplier. Thus for wheat which is not as sensitive to rainfall as rice the multiplier would be, 1% in rainfall = 15 basis points of interest rate.

Of course the indemnity level need not be restricted to the interest liability. Suppose it is set x% of the amount of loan principal P,

$$I = xP$$

then an adverse deviation of x / ε_i in rainfall would reduce the income by an amount equal to the indemnity. Thus

$$(x\% / \varepsilon_i) \text{ adverse deviation in rainfall} = xP$$

so that

$$1\% \text{ adverse rainfall} = (\varepsilon_i \%)P$$

These aspects are illustrated in the following sections.

Step IV – Pricing

The next task is to determine the crop insurance premium rate which should be loaded on to the normal lending rate to obtain the gross interest rate.

To determine the premium rate we note that the observed rainfall data in India between 1870 to 2000 has shown a normal distribution with a mean of 85.2 cms and a standard deviation of 8.4 cms *i.e.,* R ~ N (85.2, 8.4). Let *r* renote the deviation from the mean rainfall.

$$r = R - \mu$$

so that r ~ N (0, 8.4). Then the premium measured in terms of centimeters of deficient rainfall should be

$$\int_{-\mu}^{o} rf(r)dr$$

to which may be added the premium due to excess rainfall,

$$-\int_{o}^{\infty} rf(r)dr$$

where the negative sign denotes that excess rainfall is an *adversity.* Of course the adversity in rainfall will not actually stretch from 0 rainfall to ∞ rainfall as the above integrals suggest.

Over the period 1870 – 2000 adverse deviation in rainfall has never fallen below – 29% (in year 1877) at an all India level and the adverse deviation above the mean has never exceeded + 20% (in year 1961). This sets the limits of the integrals and the crop insurance premium in terms of rainfall under extreme conditions would be,

$$\int_{-24.70}^{o} rf(r)dr - \int_{o}^{17.04} rf(r)dr \qquad (1)$$

where –24.70 = -0.29 x 85.2 and 17.04 = +0.20 x 85.2.

To solve (1) note that the two integrals must be solved separately, they cannot be combined because both represent expected losses due to adverse deviations below or above normal levels. Consider the standard normal variate of r ~ N (0, 8.4)

$$z = \frac{r-0}{\sigma} = \frac{r}{8.4} \qquad (2)$$

The expected value of the truncated normal variate z is

$$E(z) = \int_L^U zf(z)dz$$

$$= \frac{f(L) - f(U)}{F(U) - F(L)}$$

where *f(.)* and *F(.)* represent the probability densities and cumulative probabilities respectively and L and U are

$$L_1 = \frac{r_L - \mu}{\sigma} = \frac{24.7}{8.4} = -2.94 \qquad L_2 = \frac{r_L - \mu}{\sigma} = \frac{0}{8.4} = 0$$

$$U_1 = \frac{r_U - \mu}{\sigma} = \frac{0}{8.4} = 0 \qquad U_2 = \frac{r_U - \mu}{\sigma} = \frac{17.04}{8.4} = 2.03$$

Thus in units of the standard normal variate

$$\int_{-2.94}^{0} zf(z)dz - \int_{0}^{2.03} zf(z)dz = \frac{f(-2.94) - f(0)}{F(0) - F(-2.94)} - \frac{f(0) - f(2.03)}{F(2.03) - F(0)}$$

Considering that f(-x) = f(x) and F(-x) = 1- F(x) and referring to the normal distribution table gives

$$E(z) = -0.7898 - 0.7262 = -1.516 \qquad (4)$$

Clearly in view of equation (2)

$$E(r) = \sigma E(z) = -12.73 cms \qquad (5)$$

is the expected adverse deviation in the rainfall on either side. The premium for the straddle which is the crop insurance premium measured in rainfall would be

$$\left(\frac{12.73}{85.2}\right)(100) = 14.94\%$$

This premium however is unduly large in normal times. Since the rainfall distribution is normal, variations within 8.4 cms *i.e.* 8% from the normal occur 68% of the times and variations within 16.8 cms *i.e.* 16% from the normal occur 97% of the times. Thus if we set the limits of the integral at say 15% above and below the average, the limits of the integrals in z values would be

$$L_1 = -1.521 \quad U_1 = 0$$
$$L_2 = 0 \qquad U_2 = 1.521$$

giving a premium in rainfall terms via equation (3) and (5) and the normal distribution table of 10.53 cms which in percentage terms is 12.35%. And if we were to consider 1 standard deviation fluctuation, *i.e.* 8.4 cms $L_1 = -1\, U_1 = 0\, U_2 = +1$ gives (E(z) = 0.919 and E(r) = 7.72 cms *i.e.* a crop insurance premium rate of 9.06% in rainfall terms about 68% of the times.

The crop insurance premium in rainfall terms would tend to vary between 9.06% per annum in normal times to 14.94% in crisis situations at the overall national level.

The premium in rainfall terms multiplied by the output elasticity of the crops with respect to rainfall will give the premium rate in interest rate terms (more generally financial terms). This premium rate when added to the crop loan rate gives the gross crop loan rate.

But before we explicitly consider its determination there is one small difficulty. Almost all the rainfall in India is received during monsoons so that the average annual rainfall is nearly equal to the total rainfall. [Excepting the south-eastern region and Kashmir the rest of India receives about 85% of the rainfall in four months stretching from June to September]. The *kharif* crop output directly depends on monsoons. The *rabi* crop depends on rainfall as well but a little indirectly through its dependence on water availability in reservoirs. Thus, for an unirrigated farmer who grows a single *kharif* crop during the year the crop insurance premium rate is both the annual rate as also the rate for the season. For a farmer who grows the *kharif* and the *rabi* crop the premium rate would be considered as an annual rate but the difficulty is that he will not repeat the crop so that output elasticities of different crops must be considered for each part of the year.

Consider the single *kharif* crop case and suppose the premium rate in rainfall is 9.06%. For the sake of illustration if we consider 'all crops' and its elasticity of 0.4 with respect to rainfall the crop insurance premium rate in interest rate terms would be 3.62% which would also apply to the season, say of 4 months duration. Then gross crop loan rate would be

	Crop Loan Rate + Crop Insurance Premium Rate					
i.e.,	3.33 %	+	3.624 %	=	6.95 %	

And suppose the farmer has sought an indemnity of 3.33% equal to his interest liability. We must then determine the multiplier by which the *gross loan rate* should decline due to adverse deviations in rainfall. This multiplier would be,

$$\frac{\text{Gross Crop Loan Rate}}{\text{Adverse Deviation Corresponding To Indemnity}}$$

The denominator we have already ascertained as $(x\% / \varepsilon_i)$. For a crop loan of Rs. 2,000 and an indemnity of 3.33% with an output elasticity of 0.4 this is 8.325%. Thus the multiplier would be

$$\frac{6.95}{8.325} = 0.8357$$

The schedule of the effective loan rate with respect to realized adverse deviations from mean rainfall can then be worked out

Indemnity 3.3%

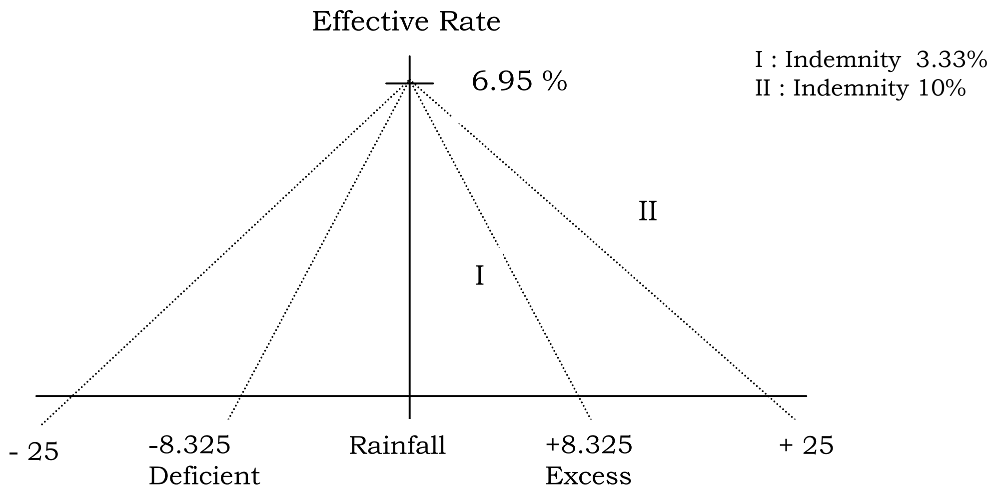
	Adverse Deviation	**Effective Rate**
	+ 10 %	0
Excess	+ 8.325 %	0
	+ 5 %	2.77 %
	+2 %	5.28 %
Normal	0	6.95 %
	- 2 %	5.28 %
	- 5 %	2.77 %
Deficient	- 8.325 %	0
	- 10 %	0

If a higher indemnity is sought, say 10%, then adverse deviation in rainfall corresponding to the indemnity would be (10% / 0.4) = 25% and the multiplier would be 6.95 / 25 = 0.2783 and the effective rate schedule would be as follows

Indemnity 10%

Adverse Deviation	**Effective Rate**
> +25 %	0
+ 25 %	0
+ 15 %	2.78 %
+ 5 %	5.56 %
0	6.95 %
- 5 %	5.56 %
- 15 %	2.78 %
- 25 %	0
< - 25 %	0

Observe that in comparison with the previous case the straddle has become wider, more spread out as the diagram below shows



If it is a double crop and once again speaking macroscopically in terms of 'all crops' the gross loan rate would be 10% + 6.95% = 16.95 % on an annual basis. For an indemnity of 10% for a loan of Rs. 2000, the adverse deviation corresponding to the indemnity would be 25% and the multiplier would be (16.95 / 25 = 0.678] giving the following effective rate schedule;

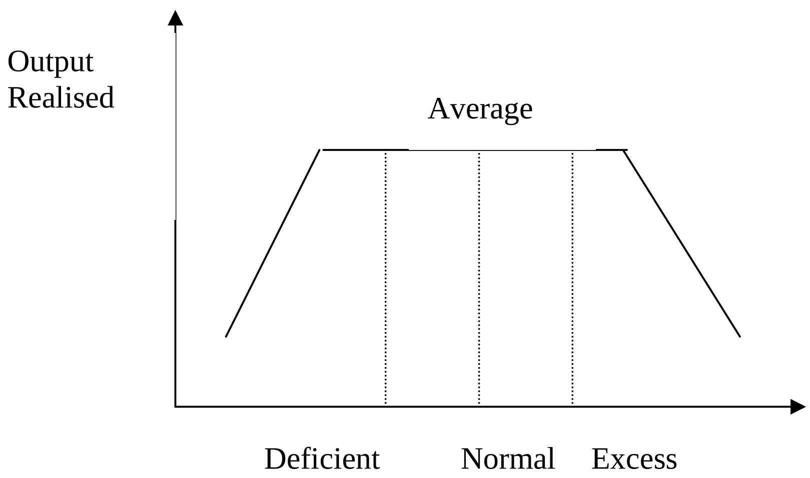
Indemnity 10%

Adverse Deviation	Effective Rate
+ 25	0
+ 15	6.78
+ 5	13.56
0	16.95
- 5	13.56
- 15	6.78
- 25	0

Step V – More Realistic Pricing

In practice there will be three considerations that will enter the actual premium determination. The most obvious is that different regions of the country experience different rainfall distributions and output elasticities with respect to rainfall may differ regionwise. But this does not present any difficulty. Once the rainfall distributions and the output elasticities are ascertained the method illustrated above can simply be applied *ad nauseum* to all the diverse region-crop combinations to obtain the different premium rates.

Less obvious are two agronomic considerations. The first is that the output response of crops to adverse deviations rainfall may not actually follow a straddle, it may follow a strangle as shown in the diagram below, ie. there may be a range of rainfall values around the average, small for some crops like cotton, large for others like bajra, in which the output of the crop is not much affected. Only deviations beyond this range may then be considered adverse. The second agronomic consideration is that the



output elasticities of crops may not be symmetric for upward and downward deviations in rainfall eg. In the case of rice downward deviations may have far more serious consequences as compared to upward deviations under the present Indian cultivation practices. In which case the strangle in the diagram above will be skewed to the right.

The effect of both these agronomic phenomena would be to reduce the crop insurance premium. Not having in my possession any estimates of what constitutes 'normal' deviation in rainfall the best I can do is to illustrate with a purely subjective example, its effect on crop insurance 'premium rate'. Let me suppose that 5% below the mean (4.26 cms) and 7.5% above the mean (6.39 cms) is a range of normal deviations that will not have an adverse impact on the output of agricultural crops. And suppose we are considering the usual case of 10% ie, 8.52 cms, standard deviation. The limits of the integrals in Z values will now be :

$$L_1 = \frac{-8.52}{8.4} = -1.014 \qquad L_2 = \frac{6.39}{8.4} = +0.760$$

$$U_1 = \frac{-4.26}{8.4} = -0.507 \qquad U_2 = \frac{8.52}{8.4} = +1.014$$

Now the integrals,

$$\int_{-1.014}^{-0.507} zf(z)dz \quad - \int_{+0.760}^{+1.014} zf(z)dz$$

respectively have the values of –0.748 and –0.8811

If we use the normal distribution tables showing the normal ordinates and areas (i.e. from $-\infty$ to z) we must subtract

$$\int_{-0.507}^{0} zf(z)dz \quad = \quad -0.243$$

from the first and

$$\int_{0}^{+0.076} zf(z)dz \quad = \quad -0.362$$

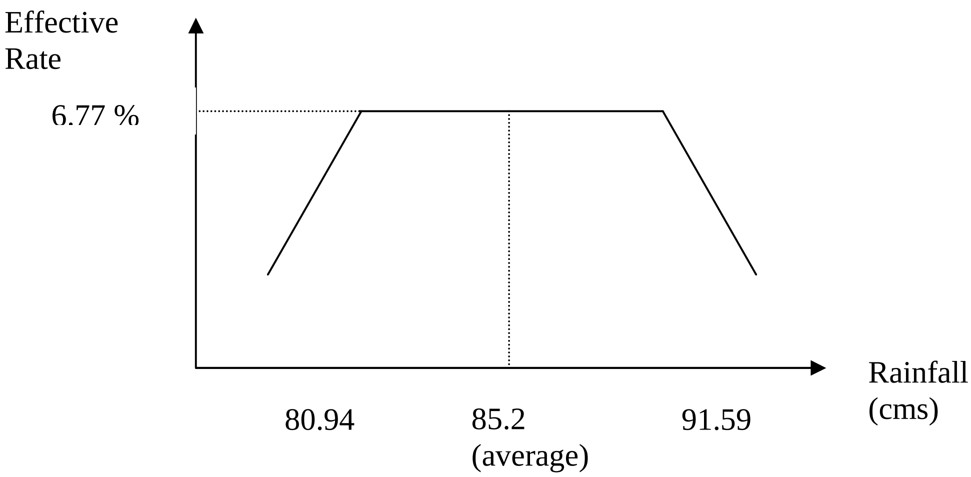
from the second integral in the expression above to avoid the error of double counting so that the sum of the netted amounts will be

[-0.748 – (-0.243)] + [-0.8811 – (-0.362)]
= -0.5057 - 0.5190 = -1.0247 = E(z)

Thus the crop insurance premium in terms of rainfall will

8.4 x 1.0247 = 8.707 %

which is lower than 9.06% that was obtained from the straddle. When multiplied by output elasticity of the crop it would translate to the crop insurance premium in interest rate terms. In case of all crops it would be 0.4 x 8.607% = 3.44%. The gross interest rate may then be 6.77% and the effective interest rate schedule will be as shown in the diagram below.



As has already been stated earlier the range of normal deviations of rainfall postulated for the above example viz. –5% to +7.5% is hypothetical whose only purpose is to illustrate that economies in crop insurance premium rates are possible.

It may also be emphasized that it is by no means necessary to package both deficient and excess rainfall always. A farmer / financier who is worried only about deficient rainfall may pay the premium corresponding to deficient rainfall alone [about half the premium for the straddle]. Likewise for the farmer who is chiefly worried about excess rainfall. In that case we may designate the Varsha loan as a Varsha put loan and Varsha call loan respectively. But more on Varsha options later.

Clearly the methodology linking crop loss to rainfall will not apply to *rabi* crops and those commercial / horticultural crops that do not depend on rainfall – related sources of water. It would seem that that the existing crop insurance scheme should continue to be administered for this class with the justification that *rabi* claims are only a fraction of *kharif* claims. However the institutional arrangement should necessarily be finesurance where the lender himself makes the crop loss assessment and crop insurance premiums are charged by the formula.

$$\int_{-T}^{0} y\, f(y) dy$$

where T is the threshold yield in the homogenous area and y is the deviation of the actual yield from the threshold. [Rustagi (1988) shows that for cross-section data from homogenous agroclimatic regions y exhibits a normal distribution].

It remains now to compare in formal terms the scheme of linking crop loan interest to rainfall, Varsha loans, to the existing credit administered crop insurance scheme.

The output elasticity with respect to adverse deviation in rainfall

$$\in = \frac{dT}{dR} \frac{\bar{R}}{T}$$

where T is the threshold yield that corresponds naturally to conditions of normal rainfall $\bar{R}$. From the above we get

$$dT = (\in T) \frac{dR}{\bar{R}}$$

The actual output realised will therefore be,

$$X = T - dT = T - (\in T)\frac{dR}{R}$$

So that the farm income (given the minimum support price P) which is exposed to risk of adverse rainfall is,

$$F = pX - C - (1+i)L$$

where C is the cost of production met from the farmer's own funds and (1+i)L the liability due to the crop loan with interest.

The indemnity under the present crop insurance system is

$$\frac{(T-X)}{T}L = \frac{(dT)}{T}L = \frac{(dR)}{\bar{R}} \in L$$

So that the farm income after receiving indemnity is,

$$F_I = pX - C - (1+i)L + \frac{(dR)}{\bar{R}} \in L$$

$$= pT(1 - \frac{dR}{\bar{R}} \in) - C - (1+i)L + \left(\frac{dR}{\bar{R}}\right) \in L - M$$

where M is the crop insurance premium

Under the Varsha Loan scheme the effective interest rate on the farm loan would be

$$i_G - \left(\frac{dR}{\bar{R}}\right) \in = i + \left(\frac{M}{L}\right) - \left(\frac{dR}{\bar{R}}\right) \in$$

where M/L is the crop insurance premium rate. Thus the farm income would be,

$$F_v = pX - C - (1 + i + \frac{M}{L} - \frac{dR}{\bar{R}} \in)L$$

$$= pT(1 - \frac{dR}{\bar{R}} \in) - C - (1+i)L + \left(\frac{dR}{\bar{R}}\right) \in L - M$$

Observe that $F_I = F_V$ leading to the following simple but remarkable theorem :

The Varsha loan scheme is identical with the existing credit administered crop insurance system provided that rainfall is the only peril and the insurance premium rates for both are actuarially determined.

The simple inference is that the present crop insurance scheme, although it appears to indemnify, and does in fact indemnify, the entire farm loan at the individual farmer's level, it actually indemnifies only the interest on the farm loan at the macroeconomic level in a situation in which 90% or more of the farm losses are attributable to adverse deviations in rainfall !

The Varsha Loan Scheme represents in itself a complete solution to that portion of the crop insurance problem which is administered through the credit mechanism and where the dominant peril is rainfall *viz. kharif* crops. It dispenses with all problems associated with determination of threshold and actual yields, conducting crop loss surveys, collection of claim amounts from Centre / State governments and their distribution to the nodal points etc. as also those of subsidization of crop insurance. It only has the additional problem of monitoring the output elasticities of crops with respect to rainfall for which though a standard methodology exists or can easily be put into place.

It would now be interesting to probe ways in which the efficacy of the Varsha loan scheme can be enhanced. Are there possibilities for efficient risk packaging and risk transfer by the primary insurer (rather finesurer) i.e. possibilities for financial engineering that could result in finer spreads and lower transaction costs ?

Step VI – Risk Packaging

It is a fundamental theorem of investment management that the risk of a portfolio is not a simple summation of the individual risks that make up the portfolio. Thus the multiplier for a rainfall sensitive crop may be large and the actuarial premium too would be large and so would the loadings for adverse deviations from expected outgoes. What is more these could differ regionwise [See Annexure 2]. Also rainfall deficiencies in some regions may depart from the normal levels by 30 – 40% even though at the national level the departure is no more than 15% [See Annexure 3]. All this suggests that correlation coefficients between rainfall in different regions are less than unity and so are the correlation coefficients between outputs of a commodity between regions and the output sensitivities of different commodities. As Table 5 shows, groups of commodities show lower fluctuations in output growth than individual crops. In other words there are definite possibilities for diversifying across crops and regions and working towards greater portfolio efficiency.

Table 5a
Instability of Crop Production All India (Standard Deviation In Annual Output Growth Rates)

Crop	1968 – 1995
Rice	14.27
Wheat	11.44
Coarse cereals	13.35
Cereals	11.10
Pulses	16.07
Kharif Food grains	13.88
Rabi Food grains	9.83
Total Food grains	11.43
Oilseeds	17.36
All crops	9.40

TABLE 5b
Trends in Productivity Instability, All India (Standard Deviation in Annual Output Growth Rates)

Ten year period ending in	Rice	Wheat	Coarse Cereals	Total Cereals	Pulses	*Kharif* Food grains	*Rabi* Food Grains	Total Food Grains	Oil seeds	All Crops
1977	11.37	10.36	14.92	8.80	12.91	11.83	4.23	9.54	17.31	7.84
1978	13.42	10.36	14.02	9.69	11.66	12.60	4.29	10.24	16.51	8.43
1979	13.42	10.18	13.80	9.67	10.92	12.60	4.30	10.19	16.17	8.38
1980	15.88	10.95	10.74	11.52	15.33	14.22	4.58	12.47	15.92	10.50
1981	17.99	11.20	11.75	12.69	17.26	15.35	4.54	13.75	15.85	11.44
1982	17.49	10.50	11.43	12.20	16.96	14.98	4.16	13.11	16.28	10.68
1983	17.94	8.24	9.70	12.23	16.96	15.17	4.09	13.24	16.57	10.77
1984	18.84	8.25	10.76	12.68	17.08	15.95	3.91	13.60	18.00	10.99
1985	18.01	7.98	10.26	11.87	15.11	14.86	3.22	12.72	17.62	10.46

Source : Rao, Ray and Rao (1988)

To be sure, in considerations of pricing the argument also works the other way – the risk groups made must be homogeneous to prevent cross-subsidisation across the groups and the largest numbers must be sought within homogeneous groups (a principle, however, that is rarely followed in insurance practice). On the other handthe portfolio principle also has considerable force of its own because it results in a reduction of premium rates for all classes of business even though that reduction is not proportionate to the individual class experience which in usual insurance practice is sought to be attained by no claim discounts, deductibles and the like.

The greatest advantage of applying the portfolio principle is that it results in a viable market, *i.e.,* a market in which both buyers and sellers can gain. This is because the asking price of crop insurance would be lower on account of the lower volatility of across-crop across-region portfolios as compared to individual crops in individual regions, than the demand prices for crop insurance, these being based on greater volatilities. This creates a spread and therefore opportunity to make profits. Of course since the aim of a crop insurance scheme is not to make profits, profits can be used either to give indemnities covering principal repayments and/or the funds of the finesurer can be directed towards investments in agricultural infrastructure.

Step VII – Risk Transfer

An insurer retains a portion of the risk and passes on what he cannot to reinsurers. In the case under consideration the route to reinsurance would be in the form of securitisation of Varsha loan receivables and their placement among other financial institutions via a special purpose vehicle. Indeed the securities, called *Varsha Bonds*, can also be placed among individual investors and can also be listed and traded. It is in the securitisation loan receivables across crops and regions that the portfolio principle has the greatest force. Even if the finesurer prices individual crops and regions in accordance with their individual risk characteristics, when he places the risks in the secondary market it is best to package them and moderate the overall portfolio risk for the secondary investor.

The reinsurance capacity of the non-agricultural financial system is large indeed considering that the total assets of the financial system in India is Rs. 15,00,000 crores compared to which the crop insurance indemnity even if it is not limited to the short-term crop loan interest (about Rs. 3800 crores) will be a negligible fraction, of the order of 0.25 %. Be that as it may, Varsha Bonds must possess investment merits intrinsic to them if they are to be acceptable to investors.

Indeed Varsha Bonds do in fact possess some attractive features. Firstly, one component of their return will be directly related to changes in the rainfall which is completely uncorrelated with changes in the general level of interest rates. Investment in Varsha Bonds will therefore efficiently reduce the total risk of bond portfolios. Secondly, the agricultural credit system in India will continue to run on semi-administered lines in the foreseeable future so that changes in crop loan interest rates themselves will change somewhat slowly as compared to general market rates which have now become volatile. This is an additional reason for correlation coefficients between crop loan rates and general market rates to be weak which further enhances the portfolio risk reduction effect of Varsha Bonds. [Indeed in India's own experience of the last 7 years the correlation coefficient has been zero. Prior to 96 the 10% crop loan rate seemed to be subsidized. Today with prime lending rates down to 11% and 10 year government security rates down to 7.10% the same 10% looks attractive].

Thirdly, insurance companies and banks are subject to priority sector investment norms. These institutions themselves possess no machinery whatsoever or at any rate inadequate machinery to appraise creditworthiness in rural areas, disburse the amounts, monitor the beneficiaries and recover the amounts. It would be foolish to expect them to build that infrastructure when one is already in place. Instead Varsha bonds can be made eligible investments for rural / social sector investment norms.

Insurance regulations applicable to life and general insurance companies stipulate that 5% of the premiums collected must come from rural areas. At the present levels these are in the region of Rs. 30,000 crores p.a. (Rs. 10,000 crores for general insurance and Rs. 20,000 crores for life insurance) giving a rural business target of Rs. 1500 crores This represents 40% of the annual interest liability on short term crop loans. If investments in Varsha Bonds are made eligible then in effect insurance companies would be writing rural insurance premiums without having to sit in bullock carts, a prospect especially daunting to the large number of new insurance companies who have no rural network. Besides premium targets there are the investment regulations which stipulate that not less 10% of the total funds of insurance companies, which are about Rs. 2,40,000 crores presently, should be invested in infrastructure and social sector including the rural sector, which is a target amount of Rs. 24,000 crores ! And on top of it are priority sector lending norms for commercial banks which total upto about Rs.

42,000 crores (about 5% of total deposits) a substantial part of which are non-performing assets. This by itself is a large financial base for absorbing agricultural risks that will enable the primary finesurer to obtain favourable terms from the secondary market.

In addition two features may be added to make Varsha bonds more attractive

(a) a government guarantee that the rate of interest will not fall below some minimum, a rate which must be changed from time to time depending on the general market rates and may be reset every year. Of course the rate should be low enough that the guarantee never actually takes effect except in a national calamity.

(b) tax-advantaging for institutions as well as individuals to raise the post-tax return on the bonds.

5 Varsha Options

All of the foregoing discussion applies to loanee farmers seeking an indemnity for the interest on their crop loans and the Varsha loan / bond scheme is designed to substitute the credit administered portion of the NAIS. Of course it can be extended on identical lines to cover non-loanee farmers as well (these constitute about 75% of India's farmers) at the same crop insurance premium rates.

But the straddle / strangle technology which underlies the scheme may prove to be somewhat inflexible and restrictive in a wide variety of situations in which individual farmers or groups find themselves in. For instance, what about farmers who seek to indemnify the entire output value against rainfall risk? What about farmers who are more worried about the prospect of deficient rainfall as opposed to excess rainfall or vice versa? What about farmers who are more worried about the distribution of rainfall over the crop cycle rather than its quantum eg. July rainfall which is crucial for the kharif crop ?

Step I – Disentangle the Straddle

To help meet contingencies of this kind and to make the technology of farm income protection more versatile, it would be better to disentangle the straddle into its constituents viz. a Varsha put option and a Varsha call option and transact them separately. The purchase of a Varsha Put option will protect the farmer only against deficient rainfall, the purchase of a Varsha call option only against excess rainfall. The primary underwriter of these options will of course be the finesurer. But observe that this need not be so. Farmers themselves may also like to write options !

For example a farmer who is not at all worried about excess rainfall may choose to buy a Varsha put option but may choose to reduce the net cost of insurance by selling a Varsha call option to another farmer who is worried about excess rainfall, something which does not worry the first farmer. This opens the possibility for the finesurer to perform the role of a market – maker, giving two-way quotes for Varsha calls and puts[6]

Step II – Contract Designs

In designing the options contracts care must be taken to ensure simplicity, variety and versatility. First, with respect to the value equivalent that is to be fixed for every point of deviation of rainfall. This value equivalent may be either or both of,

(a) the output elasticity of the crop w.r.t. rainfall, $\in_i$

(b) an externally fixed value for deviation in rainfall e.g. Rs. 5, Rs. 10, Rs. 20 or indeed all of them, E_i.

The maturities of the options contracts will be for the cropping season, *kharif* – June to September on the season's quantum of rainfall i.e. a period of 4 months.

A variety of striking rainfalls can also be introduced, say 6 strikes below and 6 strikes above the average rainfall and of course the average rainfall in the region itself.

The payoffs and premiums under type (a) and (b) options would be as follows :

$$\left(\frac{\text{Strike - Actual Rainfall}}{\text{Strike rainfall}}\right)(\in_i)\ (100) \qquad \text{for type (a)}$$

$$(\text{Strike - Actual Rainfall})\ E_i \qquad \text{for type (b)}$$

where Strike > Actual will denote put and Strike < Actual will denote call options, $\in_i$ is the output elasticity with respect to rainfall and E_i is the externally determined value per tick of deviation in rainfall. The premiums will be determined by the formula,

$$\frac{f(L)-f(U)}{F(L)-F(A)}\left(\frac{\sigma}{\mu}\right)\in_i \quad \text{for type (a)}$$

and

$$\frac{f(L)-f(U)}{F(U)-F(L)}\left(\frac{\sigma}{\mu}\right) E_i \qquad \text{for type (b)}$$

where L and U are Z-values in which one would correspond to strike depending on whether it is a call or a put option.

Of course it should be mentioned that in any actual situation the premium rates above would serve only as benchmarks, the market will evolve its own premium rates based on diversities of opinions in respect of $\sigma, \mu, \in_i$ and one of L or U. Varsha options can be used to indemnify any amount the farmer may choose. The number of Varsha put options that the farmer must buy should equal,

$$\frac{\text{Amount of Exposure}}{\text{Pay off of Varsha Put}}$$

Step III – Month Options

It is well known in agriculture that contingencies with respect to distribution of rainfall over the cropping season are at least as serious if not more as the contingency with respect of the quantum of the rainfall. Agricultural output fructifies over stages; pre-sowing, sowing, flowering, grain formation, maturation, harvesting etc. and requires the right conditions of sunlight, temperature, humidity and rainfall over each of these stages for an optimal result. These contingencies too can be adequately met by Varsha options for shorter lengths of time eg. Varsha June, Varsha July options etc. pertaining to rainfall realisations during those months or even fortnights of those months. These can even be offered for sale after the planting operations. Of course the options will expire in the months that they pertain to. The pricing of these options will obviously depend on the probability distributions of rainfall over the specific months / fortnights to which they pertain, not on aggregate distributions.

Step IV – Secondary Markets

What are the possibilities of developing a non-agricultural secondary market interest in Varsha Options ? Can the primary underwriter offload some parts of his short positions to other market participants ? These are difficult questions to answer definitively. Nevertheless it is possible to call attention to some desirable aspects of Varsha Options for financial institutions and capital markets.

Firstly, the regulatory aspects that were pointed out in case of Varsha bonds would apply here as well. If Varsha options can be made eligible for rural / priority sector business norms and investment stipulations for insurance companies, both life and general, and banks they could effectively meet the regulatory requirements by secondary purchases (or even primary) of Varsha options.

On their own too investment institutions may like to write Varsha options (a) to obtain cash and (b) for diversification in view of the fact that the level of rainfall and market interest rates are uncorrelated with one another. Regulations can indeed be put into place, say for mutual funds, permitting the sale of Varsha options because of their hedging abilities.

Stock market traders may want to buy and sell Varsha options to make cross-hedges, eg. this year consistent bad news about rainfall caused an unprecedented bearish wave on the stock market, and when the agriculture minister announced that India is experiencing the worst drought in the last 12 years there was a bloodbath in the stock market, which a trader could have hedged by purchasing Varsha puts and perhaps selling Varsha calls to protect his stock portfolio! Varsha options may even be bought by municipal corporations whose water supply to citizens depends on the rainfall in the region. If Varsha calls and puts could be listed and traded on options exchanges that may boost liquidity.

The portfolio principle will work here as well. The writer of Varsha options on an all-India level would charge an asking price that is lower than the bid prices of Varsha option buyers because the asking price would be based on the lower volatility of all-India rainfall and the lower volatility of all crops' responses whereas the bid price would depend on greater volatility of rainfall in individual regions and the greater sensitivity of individual crops. Thus it may be possible for the primary writer to sell not individual crop / region options in the secondary market which are risky, but instead sell portfolios of options and obtain reinsurance.

For these reasons as well as those mentioned earlier, viz., the large capacity of the financial system, priority sector regulations and the like, the business of Varsha bonds and options is likely to be profitable. But of course the idea of a crop insurance scheme is not to make profits and if these were to arise they can be used to make modest contributions to say the National Water Grid project whose objective is to mitigate rainfall risks.

There is however one proviso to all this viz. news reports on aggregate rainfall at an all-India level may create one-way expectations of rainfall, either pessimistic or optimistic, and the market for options may dry up on the buying or selling sides in the secondary market. To induce diversity of opinion it may be necessary to trade portfolios of Varsha options containing varieties with respect to striking rainfall levels, months of expiry, crops and regions.

Step V – General Weather Insurance

Studies of the crop-weather relationships have brought about the importance of factors other than rainfall, temperature, humidity, sunlight and so on, that have an important bearing on realised output. [See for example Tiwari (1991) for a study of apple production and further references]. If Varsha bonds and options prove to be successful (with or without secondary market interest it may be noted) options on these other factors taken individually or on composite weather indices can be researched and experimented with to make the crop insurance schemes more comprehensive.

5. Concluding Remarks

The alternative approach to crop insurance based on Varsha bonds and options that has been advocated in this paper is founded on the following grounds :

1. Merging of the financial and insurance functions at an apex level institution, most naturally NABARD, will economise administrative and transaction costs substantially without the need for creating and running a separate institution and machinery. Premiums can continue to remain subsidised with Central and State government paying their shares but claims cannot be subsidised these bring linked to rainfall. The only modification in

administration would be that of the data sharing mechanism – rainfall data must go from the Indian Meterology Department to NABARD on regular basis.

2. Linking crop insurance claims to the rainfall, for which there exists an independent and scientific reporting system run by the Indian Meteorological Department, has the twin advantage of meeting 90% of crop insurance claims and eliminating moral hazard and claims manipulation, in respect of *kharif* crops. [Of course an insurance system that runs on the accuracy of rain gauges creates its own moral hazard – an incentive to tamper with rain gauges is automatically created so that manipulation – free electronic rain gauges may have to be innovated]. The existing crop insurance system may be continued for *rabi* crops with the financer himself performing the job of loss assessment. Contingencies of deficient rainfall and excess rainfall can also be separated from one another and embedded into the crop loans giving more flexibility in desired payoffs and premium paying abilities. Varsha month options (or even fortnight options) can be introduced to cover contingencies associated with the frequency distribution of rainfall during the cropping season.

3. Securitisation of crop loans that are insured into Varsha bonds and developing a secondary market in Varsha bonds and options will result in passing on agricultural risks and returns due to rainfall fluctuations to the national financial system which has the largest risk bearing capacity. Application of the portfolio principle across groups of crops and regions will help moderate risk of Varsha bonds and options and lead to a viable market. It will, besides, bring about greater economic integration between "India" and "Bharat".

NOTES

1. The risk classes for calculation of actuarial rates are as follows :

Risk Category	**Coeff. Of Variation**	**Indemnity**
Low	$\leq 15\%$	90 %
Medium	$16\% \leq CV \leq 30\%$	80 %
High	$\geq 30\%$	60 %

Where CV measures the coefficients of variations of crop output in the region.

2. This and the risk classes has considerably complicated the claim calculations. Consider a farmer in Maharashtra who owns 1 hectare and has availed a loan of Rs. 500 to grow Jowar in the *rabi* season of 2002 – 2003. The average and threshold yields are,

Average Yield	**Threshold Yield**		
	@ 60 %	**@ 80 %**	**@ 90 %**
489 Kg.	293 Kg.	391 Kg.	440 Kg

Suppose the MSP of Jowar is Rs. 390 per quintal. The farmer may choose 3 sum insured options at the applicable threshold yield of 60% of average yield, *i.e.,* 293 Kgs.

a) Amount of loan availed Rs. 500 compulsory minimum

b) Value of threshold yield Rs. 1149 = Rs. 3.90 x 293 Kg.

c) Value of 150% of Avg. yield Rs. 2861 = Rs. 3.90 x 1.5 x 489 Kg.

The premium rate is 2% or actuarial rate 2.10% whichever is less. Thus the premium worked out is,

	Farmer	
	Regular	**Marginal**
a) Compulsory portions Rs. 500 @ 2%	10.00	5.00
b) Option (b) Rs. 649 @ 2%	12.98	6.49
c) Option (c) Rs. 1712 @ 2.10 %	35.95	17.97
	58.93	24.46

If he chooses indemnity of Rs. 2000 the option (c) premiums will be @ 2.10% of Rs. 851 = (2000 – 500 – 649) for the regular farmer and half of that for the marginal farmer. The claim too will be settled in slabs.

3. The net losses will be shared equally by Central and State Government on a sunset basis; 100% in the first year, 80% in the 2^{nd} year, 60% in the 3^{rd} year, 40% in the 4^{th} year, 20% in the fifth year and zero thereafter. Exceptions will be made in case of calamities. The fact is that the governments have *not* withdrawn as per the above schedule – state support continues as before.

4. The merger of the financial function with the insurance function we have termed as 'finesurance'. The more obvious 'bancassurance' might have been better but it has already been employed to connote selling of insurance products by banks. Finesurance has been preferred over finsurance for its rhyme and also to strengthen the point that a merger of functions will truly be fine.

5. This system would take care of 90% of the crop insurance needs. For the remaining 10% either local level insurance schemes may need to initiated or these could be made a part of the state's disaster management programmes.

6. Just to prove that there is nothing new under the sun reference may be made to Chakravarty (1920) who had proposed a scheme very similar to this for the erstwhile Mysore State more than 80 years ago! Careful reading of his scheme will reveal that what he had in mind was *binary* options, not the vanilla-type proposed in this paper. I have no references on the history of weather derivatives but Chakravarty's scheme might easily be the pioneering effort.

ANNEXURE 1A
NAIS – STATE-WISE ACTUARIAL PREMIUM RATES FOR ANNL. COMM./HORT. CROPS – *RABI* 2000 – 01

(Premiums in %. Figures in brackets are indemnity levels)

S.No.	State	Potato	Onion	Sugarcane	Red Chilli	Ginger
1	Andhra Pradesh	-	7.40 (60%)	-	4.60 (80%)	-
2	Assam	6.80 (80%)	-	3.60 (80%)	-	-
3	Bihar	7.00 (80%)	5.20 (80%)	3.25 (80%)	-	-
4	Chattisgarh	6.60 (60%)	-	-	-	-
5	Goa	-	-	-	-	-
6	Gujarat	-	1.75 (90%)	-	-	-
7	Jharkhand	2.65 (90%)	-	7.15 (80%)	-	-
8	Karnataka	2.50 (80%)	-	-	-	-
9	Madhya Pradesh	5.60 (60%)	-	-	-	-
10	Maharashtra	-	-	-	-	-
11	Meghalaya	9.85 (60%)	-	-	-	-
12	Orissa	1.25 (90%)	-	2.30 (80%)	-	-
13	Tamilnadu	2.25 (80%)	-	-	6.00 (80%)	-
14	Tripura	1.00 (90%)	-	-	-	-
15	Uttar Pradesh	3.05 (80%)	-	-	-	-
16	West Bengal	3.20 (90%)	-	-	-	-
17	A & N Islands	-	-	-	-	1.00 (90%)
18	Sikkim	1.20 (90%)	-	-	-	1.00 (90%)

Source : National Agricultural Insurance Scheme

ANNEXURE 1B
NAIS – STATEWISE ACTUARIAL PREMIUM RATES FOR VARIOUS CROPS – *KHARIF* 2001

(Premiums in %. Figures in brackets are indemnity levels)

S.No.	State	Paddy (I)	Paddy (UI)	Jowar	Bajra	Maize	Groundnut	Sunflower	Soyabean	Red Gram
1	Andhra Pradesh	3.60 (80%)	-	-	-	-	-	-	-	-
2	Assam	Ahu Paddy 6.65 (80%)	Sali Paddy 2.15 (80%)	-	-	-	-	-	-	-
3	Bihar	3.40 (60%)	-	-	-	6.30 (80%)	-	-	-	-
4	Chattisgarh	5.40 ((60%)	4.20 (60%)	8.25 (60%)	-	9.55 (80%)	5.55 (80%)	-	5.60 (60%)	-
5	Goa	2.20 (90%)	-	-	-	-	3.60 (80%)	-	-	-
6	Gujarat	5.20 (60%)	-	3.75 (60%)	17.70 (60%)	5.15 (60%)	27.00 (60%)	Sesamum	13.40 (60%)	7.55 (80%)
7	Himachal Pradesh	1.95 (80%)	-	-	-	3.35 (80%)	-	-	-	-
8	Jharkhand	3.15 (60%)	-	-	-	5.65 (80%)	-	-	-	-
9	Karnataka	3.90 (90%)	3.90 (90%)	2.90 (60%)	4.05 (60%)	2.35 (80%)	3.60 (60%)	4.15 (60%)	7.30 (60%)	14.30 (60%)
10	Kerala	4.65 (90%)		-	-	-	-	-	-	-
11	Madhya Pradesh	3.05 (80%)	3.40 (60%)	6.30 (60%)	5.65 (80%)	6.45 (60%)	5.55 (80%)	-	7.40 (80%)	8.80 (60%)

S.No.	State	Paddy (I)	Paddy (UI)	Jowar	Bajra	Maize	Groundnut	Sunflower	Soyabean	Red Gram
12	Maharashtra	5.55 (80%)	-	4.00 (60%)	7.65 (60%)	-	4.85 (60%)	6.05 (60%)	7.40 (80%)	13.80 (60%)
13	Meghalaya	Ahu Paddy 2.30 (80%)	Sali Paddy 2.75 (80%)	-	-	-	-	-	-	-
14	Orissa	3.70 (60%)		-	-	5.85 (80%)	2.10 (90%)	-	-	3.95 (80%)
15	Tamilnadu	Paddy I 3.90 (90%)	Paddy II 6.65 (80%)	5.90 (60%)	7.50 (60%)	-	7.05 (80%)	-	-	-
16	Uttar Pradesh	3.65 (80%)	-	4.85 (80%)	4.45 (80%)	2.20 (60%)	5.15 (80%)	-	8.80 (80%)	4.40 (80%)
17	West Bengal	Aman Paddy 2.30 (80%)	Aus Paddy 3.50 (80%)	-	-	-	-	-	-	-
18	A & N Islands	3.05 (90%)	-	-	-	-	-	-	-	-
19	Pondicherry	1.50 (90%)	-	-	-	-	-	-	-	-
20	Sikkim	1.10 (90%)	-	-	-	1.00 (90%)	-	-	1.00 (90%)	-

NOTE : The Percentage in parenthesis indicates applicable Indemnity Limit.
Source : National Agricultural Insurance Scheme.

ANNEXURE 1C
NAIS – STATEWISE ACTUARIAL PREMIUM RATES FOR VARIOUS CROPS – *RABI* 2001

S.No.	State	Wheat	Paddy	Jowar	Mustard	Maize	Groundnut	Blackgram	Gram
1	Andhra Pradesh		1.50 (80%)	3.40 (60%)		3.50 (80%)	2.82 (80%)	1.55 (60%)	
2	Assam	3.70 (80%)	3.90 (80%)		6.00 (80%)				
3	Bihar	4.70 (80%)			6.70 (80%)				4.55 (80%)
4	Goa		1.15 (90%)				1.55 (60%)		
5	Gujarat	(I) 1.85 (80) (UI) 4.60 (80)			2.60 (80%)		2.70 (80%)		3.85 (80%)
6	Himachal Pradesh	4.40 (80%)							
7	Karnataka	(R) 5.60 (60%)	2.80 (90%)	4.90 (60%)			4.65 (80%)		6.40 (60%)
8	Kerala	Paddy II 4.40 (90%) Paddy III 5.60 (90%)							
9	Madhya Pradesh	(I) 3.55 (80%)			2.85 (60%)				3.95 (80%)
10	Maharashtra	(I) 1.35 (80%)	1.00 (80%)	1.90 (80%)			1.00 (60%)		2.20 (80%)
11	Meghalaya		6.25 (80%)		4.15 (80%)				

S.No.	State	Wheat	Paddy	Jowar	Mustard	Maize	Groundnut	Blackgram	Gram
12	Orissa		2.45 (80%)		3.10 (60%)		2.55 (80%)		
13	Tamilnadu		6.45 (80%)	7.10 (80%)				9.70 (80%)	2.15 (80%)
14	Uttar Pradesh	3.15 (90%)			3.45 (80%)				2.50 (90%)
15	West Bengal	2.55 (80%)	2.80 (90%)		6.60 (80%)			10.60 (60%)	
16	A & N Islands								
17	Pondicherry		2.95 (90%)						
18	Sikkim	2.00 (80%)			1.30 (80%)			1.00 (90%)	

NOTE : The Percentage in parenthesis indicates applicable Indemnity Limit.
Source : National Agricultural Insurance Scheme.

ANNEXURE 2
State-wise Sensitivity of Foodgrains Output to Rainfall Variations

State	Percent deviation in production due to 1 percent deviation in rainfall from its normal value	
	1961 – 70	1971 – 85
Andhra Pradesh	0.14	0.11
Assam	0.02	0.10
Bihar	0.84	0.31
Gujarat	0.35	0.35
Haryana	0.53	0.10
Himachal Pradesh	0.41	0.21
Jammu & Kashmir	0.02	Neg.
Karnataka	0.33	0.58
Kerala	0.19	0.06
Madhya Pradesh	0.30	0.53
Maharashtra	0.27	0.82
Orissa	0.31	0.80
Punjab	0.28	Neg.
Rajasthan	-0.13	0.13
Tamil Nadu	0.09	0.50
Uttar Pradesh	0.30	0.29
West Bengal	0.41	0.36
All India	0.51	0.50

Source : Rao, Ray and Rao (1988)

ANNEXURE 3
List of Districts with rainfall deficiency of more than 25% in the years 2000 as well as 2001

Met. Sub-division	District	% Dep. From normal	
		2000	2001
Arunachal Pradesh	Tirap	-26	-45
West Bengal & Sikkim	Sikkim	-28	-34
East Uttar Pradesh	Hardoi	-34	-44
	Rae Bareli	-43	-46
West Uttar Pradesh	Agra	-37	-40
	Aligarh	-26	-34
	Elah	-35	-29
	Etawah	-30	-30
Uttaranchal	Garhwal Tehri	-27	-54
Haryana, Chd. & Delhi	Mahendragarh	-58	-34
Punjab	Bhatinda	-28	-31
	Faridkot	-53	-35
	Sangrur	-67	-47
Himachal Pradesh	Chamba	-26	-43
	Lahaul & Spiti	-72	-40
	Solan	-27	-42
Jammu & Kashmir	Badgam	-51	-36
	Ladakh	-84	-83
West Rajasthan	Hanumangarh	-58	-54
East Rajasthan	Alwar	-34	-38
	Bharatpur	-30	-30
	Chittorgarh	-35	-39
	Karauli	-26	-28
	Sawai Madhopur	-38	-29
	Tonk	-44	-31
West Madhya Pradesh	Chhindwara	-38	-40
	Dewas	-49	-29
	Dhar	-41	-39
	Hoshangabad	-48	-40
	Indore	-49	-38
	Jhabua	-41	-38
	Khandwa	-48	-36
	Raisen	-50	-26
	Ratlam	-50	-32
	Seoni	-46	-36
	Ujjain	-51	-44
East MP & Chhattisgarh	Rewa	-54	-58
Gujarat Region	Broach	-60	-31
	Kaira	-48	-29
	Panchmahal	-53	-50
	Sabarkantha	-52	-28
Tamilnadu	South Arcot	-46	-27
Kerala	Kozhikode	-34	-35
	Wynad	-36	-52

Source : Mausam (Several issues)

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