INSTITUTE OF ACTUARIES OF INDIA

EXAMINATIONS

November 2026

CP2 - Actuarial Modelling (Paper A)

Time allowed: 3 Hours 15 Minutes

Total Marks: 100

Q.1) Read the background document, which describes the scenario that needs to be modelled and documented for this project. Technical assistance for the modelling work, should you require it, can be found in the Additional Guidance contained in this booklet. No marks will be deducted for the use of this guidance.

Construct a spreadsheet model that produces the following calculations. You should ensure that your spreadsheet contains appropriate self-checks and that you have performed (and documented in the audit trail) reasonableness checks at each stage of your calculations.

i) Carry out checks on the trails data provided, making any adjustments wherever necessary to confirm that the trails data is complete, reasonable, and fit to use. **[5]**

Construct a calculation engine covering all 18 active Region-Crop combinations, as follows:

ii) For each active Region-Crop combination,

a) determine whether each applicable peril (Drought, Flood) occurs, **[2]**

b) simulate its severity where it occurs (see Additional Guidance A). **[3]**

c) calculate the resulting actual yield after applying the combined-loss cap. **[4]**

d) calculated the shortfall against the Guaranteed Yield and the resulting indemnity. **[2]**

e) Aggregate total indemnity across all Region-Crop combinations. **[1]**

iii) Using a lookup-based technique, or any other suitable method, calculate total indemnity for each of the 10 trials provided, **[2]**

iv) Calculate summary statistics (mean, minimum, maximum, and the 90th and 95th percentiles) of total indemnity for each year, across all 10 trials. **[3]**

v) Using Goal Seek, estimate the Guaranteed Yield percentage such that the mean total indemnity (across all 10 trials) equals the Ministry of Finance's fiscal budget target. **[4]**

vi) Construct suitable charts showing:

a) a comparison of total indemnity by Region, under the original Guaranteed Yield proposal versus the Goal Seek-solved Guaranteed Yield **[1]**

b) a comparison of total indemnity by Crop, under the original Guaranteed Yield proposal versus the Goal Seek-solved Guaranteed Yield **[1]**

c) a suitable chart showing the proportion of total indemnity attributable to each Region, under the Goal Seek-solved Guaranteed Yield **[1]**

d) a suitable chart showing the proportion of total indemnity attributable to each Crop, under the Goal Seek-solved Guaranteed Yield **[1]**

[Note: all scenarios outlined above should be modelled separately in your spreadsheet. The user should not need to change the parameters to see the results.]

[30 Marks]

Q.2) Modelling technique and practice

i) Auto checks or reasonableness checks on the modelling completed in (Q.1). **[4]**

ii) Demonstration of good modelling techniques and practice. **[6]**

[10 Marks]

Q.3) Audit trail

Produce an audit trail for your spreadsheet model that includes the following aspects:

- Purpose of the model
- Data and assumptions used
- Methodology, i.e., description of how each calculation stage in the model has been produced
- Explanation of checks performed

You should ensure that your audit trail is suitable for both a senior actuary, who has been asked to approve your work, and a fellow student, who has been asked to peer review and correct your model, to continue work on it or to use it again for a similar purpose in the future.

Marks available for audit trail:

Audit approach

i) Communication skills (the audit trail provides enough detail to be read as a stand-alone document). **[7]**

ii) Fellow students can review and check methods used in the model. **[7]**

iii) Senior actuary can scrutinize and understand what has been done. **[7]**

iv) Written in clear English. **[4]**

v) Written in a logical order. **[3]**

Audit content

vi) All steps clearly explained. **[8]**

vii) Clear signposting included throughout. **[4]**

viii) Statement of assumptions made. **[5]**

ix) All model steps accurately covered. **[15]**

[60 Marks]

Background

The Ministry of Agriculture of the Republic of Meridia operates a national crop support scheme intended to protect farmer incomes against yield losses arising from adverse weather conditions, while ensuring the scheme remains fiscally sustainable within a budget allocation set by the Ministry of Finance.

The Ministry has engaged your firm, KLP Actuarial Associates, to build a forecasting model that projects the scheme's expected indemnity (payout), and to calibrate the scheme's Guaranteed Yield level so that expected indemnity matches the fiscal budget allocated to the scheme.

Geography and crops

Meridia is divided into four agricultural regions - Region A, Region B, Region C and Region D - each with a distinct climate profile. Five crops are cultivated across these regions: Wheat, Rice, Cotton, Maize and Sugarcane. Not every crop

is grown in every region; the 18 Region-Crop combinations covered by the scheme, together with their baseline yield and cultivated area (in hectares), are set out below.

Region	Crop	Baseline Yield (tonnes/ha)	Cultivated Area (ha)
A	Wheat	3.20	45,000
A	Cotton	0.55	30,000
A	Maize	4.80	25,000
A	Rice	3.80	8,000
B	Rice	4.50	50,000
B	Wheat	3.00	20,000
B	Maize	5.00	35,000
B	Sugarcane	65.00	15,000
C	Wheat	3.40	40,000
C	Rice	4.20	38,000
C	Cotton	0.60	22,000
C	Maize	5.20	30,000
C	Sugarcane	70.00	20,000
D	Rice	4.00	42,000
D	Cotton	0.50	18,000
D	Maize	4.60	28,000
D	Sugarcane	68.00	25,000
D	Wheat	2.50	10,000

The Minimum Support Price (MSP) for each crop is shown below.

Crop	Year 1 MSP ($ per tonne)
Wheat	280
Rice	320
Cotton	1,850
Maize	240
Sugarcane	45

Climate and perils

Two perils are covered under the scheme: Drought and Flood.

- Drought affects Region A and Region C only (semi-arid and mixed climates respectively).
- Flood affects Region B, Region C and Region D only (monsoon/riverine, mixed, and coastal/humid climates respectively).

Where a peril occurs, it reduces yield for every crop grown in the affected region, by an amount depending on:

1. the severity of the peril, and
2. the crop's susceptibility to that peril.

Yield loss for a given peril = Severity x Susceptibility Factor

For severity, refer additional guidance A.

Susceptibility factors (representing the fractional yield loss at a peril severity of 1.0) are estimated as follows:

Crop	Drought	Flood
Wheat	50%	50%
Rice	45%	20%
Cotton	25%	40%
Maize	30%	25%
Sugarcane	35%	15%

Note:

- Both perils can affect the same Region-Crop combination.
- Where this happens, the resulting yield losses are added together, but the total yield loss in any Region-Crop-combination is capped at 90% (i.e., a minimum of 10% of baseline yield is always assumed to be harvested, reflecting that some portion of any crop typically survives even a severe compound event).
- A worked example is provided in Additional Guidance B.

Simulation of peril occurrence and severity

Historical climate records do not repeat in a predictable pattern, so the Ministry has asked that the model be built using a simulation approach. The data template provides 10 independent trials, each representing one plausible outcome path for the scheme. For each trial, a set of random numbers (each uniformly distributed between 0 and 1) is provided for every applicable Region-Crop-Peril combination, representing (i) whether the peril occurs that year, and (ii) if it occurs, how severe it is. These random numbers should be translated into **occurrence flags and severity levels**, **and then into yield losses**, following the methodology set out in Additional Guidance A.

The probability that each peril occurs, and the parameters of the Lognormal severity distribution that applies where a peril does occur, are given below.

Peril	Probability of Occurrence (per year)
Drought	30%
Flood	40%

Peril	Lognormal mu	Lognormal sigma
Drought	-1.20	0.75
Flood	-1.35	0.50

Scheme design

- Guaranteed Yield: Guaranteed Yield is the yield threshold below which the scheme compensates the farmer for the shortfall, expressed as a percentage of baseline yield. This guarantee is currently proposed at 75% of baseline yield, for each Region-Crop combination. The Ministry has asked that this parameter be calibrated - see Q.1(v).
- Indemnity = MAX(0, Guaranteed Yield - Actual Yield) x Cultivated Area x MSP, where Actual Yield reflects the combined-loss cap described above.

Fiscal budget target

The Ministry of Finance has earmarked $10,000,000 for scheme payouts. The Ministry has asked that the Guaranteed Yield be calibrated so that the mean (expected) total indemnity, taken across the 10 simulated trials, equals this fiscal budget target.

Additional Guidance

Additional Guidance A: Simulating Peril Occurrence and Severity

For each applicable Region-Crop-Peril combination and each year, the data template provides two random numbers, each uniformly distributed between 0 and 1: an Occurrence Draw and a Severity Draw.

Step 1: Determine occurrence

If the Occurrence Draw is strictly less than the peril's Probability of Occurrence (given in the Background), the peril occurs in that Region-Crop combination. Otherwise, the peril does not occur, and both its severity and its contribution to yield loss are zero for that Region-Crop combination.

Step 2: Simulate severity

Severity = EXP(NORM.S.INV(Severity Draw) x sigma + mu), using the mu and sigma given for that peril.

This is a standard inverse-transform method for simulating a draw from a Lognormal distribution using a uniform random number.

Suggested technique: a lookup key

Since the data template records each draw against a Trial, Region, Crop and Peril, candidates may find it convenient to build a single concatenated key (for example, Trial & "_" & Region & "_" & Crop & "_" & Peril) and use VLOOKUP against a matching key column, rather than a multi-criteria lookup function. This is a suggestion only; any correct technique is acceptable.

Additional Guidance B: Combined-Loss Cap - Worked Example

Suppose that in a given Region-Crop combination, Drought is simulated to occur with a severity that produces a yield loss of 20%, and Flood is also simulated to occur in the same Region-Crop combination with a yield loss contribution of 15%. The combined yield loss before capping is 20% + 15% = 35%. Since 35% is below the 90% cap, the capped combined loss remains 35%, and Actual Yield = Baseline Yield x (1 - 35%) = 65% of Baseline Yield.

Now suppose instead that Drought contributes a 55% yield loss and Flood contributes a 45% yield loss in the same Region-Crop combination (an extreme joint event). The combined yield loss before capping is 55% + 45% = 100%, which exceeds the 90% cap. The capped combined loss is therefore 90%, and Actual Yield = Baseline Yield x (1 - 90%) = 10% of Baseline Yield.

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