



A Multi-Criteria GIS Framework for Socio-Economic Drought Risk Assessment across India

SUPPLEMENTARY MATERAIL



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AHP WEIGHT DETERMINATION

Saaty AHP scale (qualitative + symbolic)

Use the 1–9 scale for pairwise comparisons:

- 1: equal importance
- 3: moderate importance
- 5: strong importance
- 7: very strong importance
- 9: extreme importance
- 2, 4, 6, 8: intermediate values

• If criterion i is judged more important than j with value a_{ij} , then

$$a_{ji} = \frac{1}{a_{ij}}, a_{ii} = 1$$

AHP steps and formulas (no numericals)

1. Construct pairwise comparison matrix

For n criteria, build an $n \times n$ matrix A

= $[a_{ij}]$ with:

a_{ij} = importance of criterion i over j

2. Normalize the matrix

Column sums:

$$c_j = \sum_{i=1}^n a_{ij}$$

Normalized entries:

$$N_{ij} = \frac{a_{ij}}{c_j}$$

3. Compute priority vector (weights)

For each row i :

$$w_i = \frac{1}{n} \sum_{j=1}^n N_{ij}$$

Weight vector:

$$\mathbf{w} = (w_1, w_2, \dots, w_n)^T \quad \sum_{i=1}^n w_i = 1$$

4. Consistency check – eigenvalue and CI

Weighted sum vector:

$$WS_i = \sum_{j=1}^n a_{ij} w_j$$

Consistency measures per criterion:

$$\lambda_i = \frac{WS_i}{w_i}$$

Principal eigenvalue:

$$\lambda_{\max} = \frac{1}{n} \sum_{i=1}^n \lambda_i$$

Consistency Index:

$$CI = \frac{\lambda_{\max} - n}{n - 1}$$

5. Consistency Ratio (CR)

Let RI = Random Index for size n (e.g., $RI_3 = 0.58, RI_4 = 0.90, RI_5 = 1.12, \dots$)

Consistency Ratio:

$$CR = \frac{CI}{RI}$$

Decision rule (put in words on slide):

1. If $CR \leq 0.10$: acceptable consistency.
2. If $CR > 0.10$: revise pairwise matrix

RESULTS

AHP Table for Hazard Parameters:

Hazard parameters	Available Soil Water	Global Surface Water
Available Soil Water	1	1/3
Global Surface Water	3	1

Assigned weights:

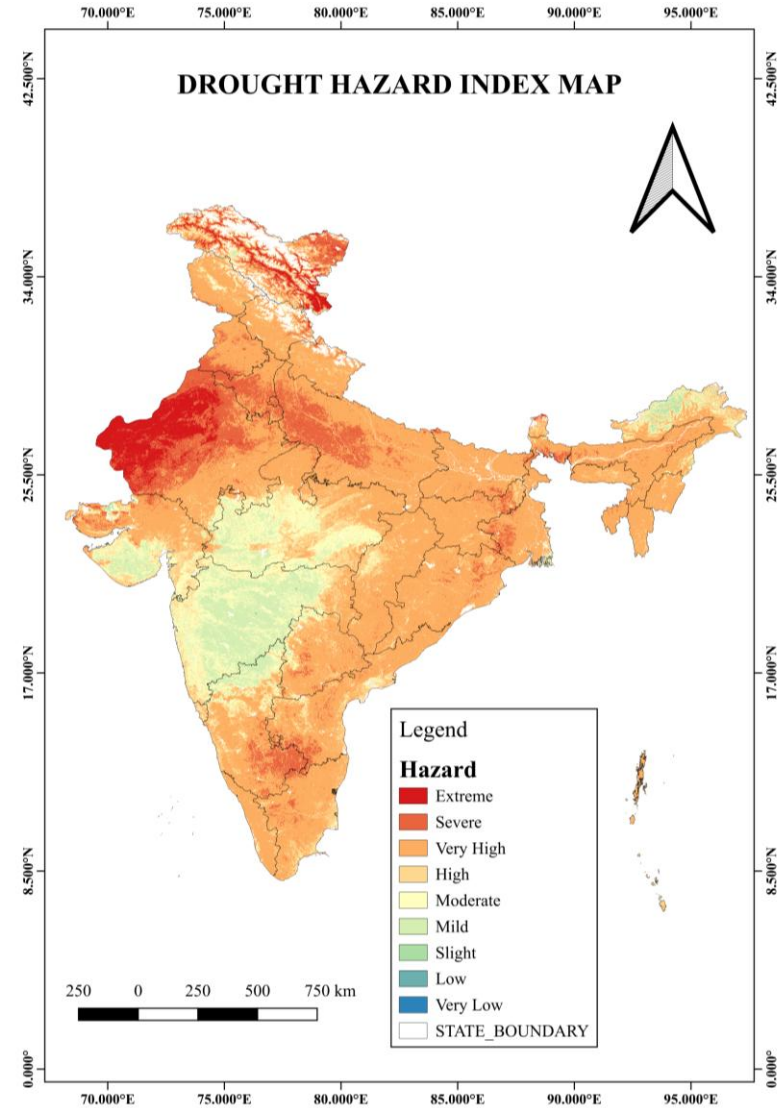
Available Soil Water - 0.75

Global Surface Water - 0.25

$\lambda_{\max} = 2$

Consistency index = 0

Consistency ratio = 0



RESULTS

AHP Table for Exposure Parameters:

Exposure parameters	Population density	Livestock
Population density	1	1/5
Livestock	5	1

Assigned weights:

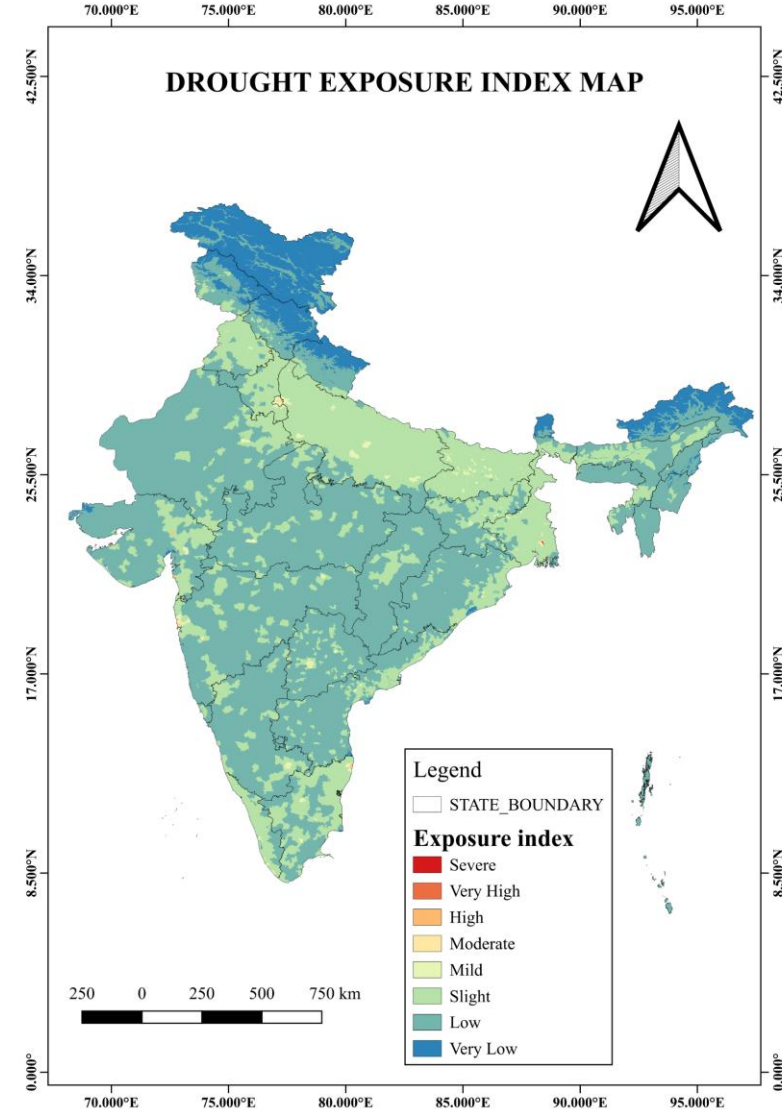
Population density- 0.83

Livestock - 0.17

$\lambda_{\max} = 2$

Consistency index = 0

Consistency ratio = 0



RESULTS

AHP Table for Economic vulnerability Parameters:

Economic vulnerability parameters	Agricultural yield	Electricity consumption	GDP
Agricultural yield	1	3	5
Electricity consumption	1/3	1	2
GDP	1/5	1/2	1

Assigned weights:

Agricultural yield- 0.65

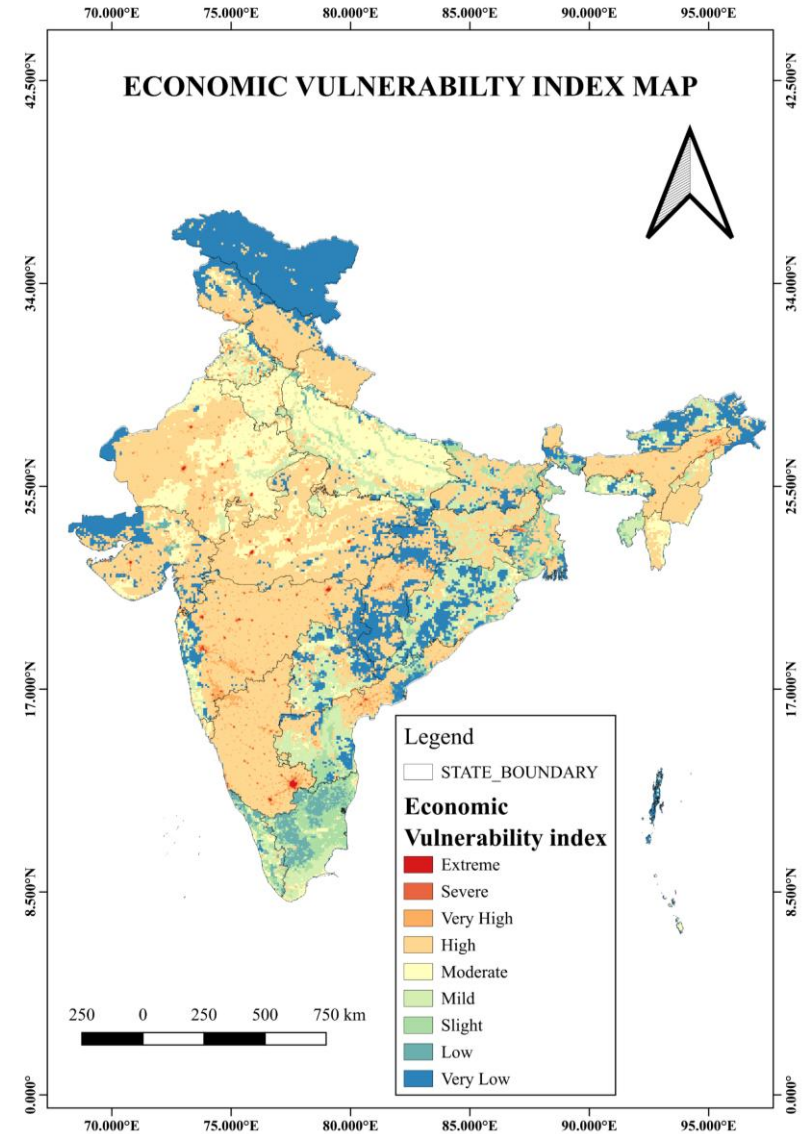
Electricity consumption - 0.23

GDP- 0.12

$\lambda_{max} = 3$

Consistency index = 0.0025

Consistency ratio = 0.0043



RESULTS

AHP Table for Infrastructure vulnerability Parameters:

Infrastructure vulnerability parameters	Road density	LULC	Biomass	Ground Water	DEM
Road density	1	1/3	3	1/5	3
LULC	3	1	5	1/3	5
Biomass	1/3	1/5	1	1/7	3
Groundwater	5	3	7	1	7
DEM	1/3	1/5	1/3	1/7	1

Assigned weights:

Road density- 0.50

LULC - 0.235

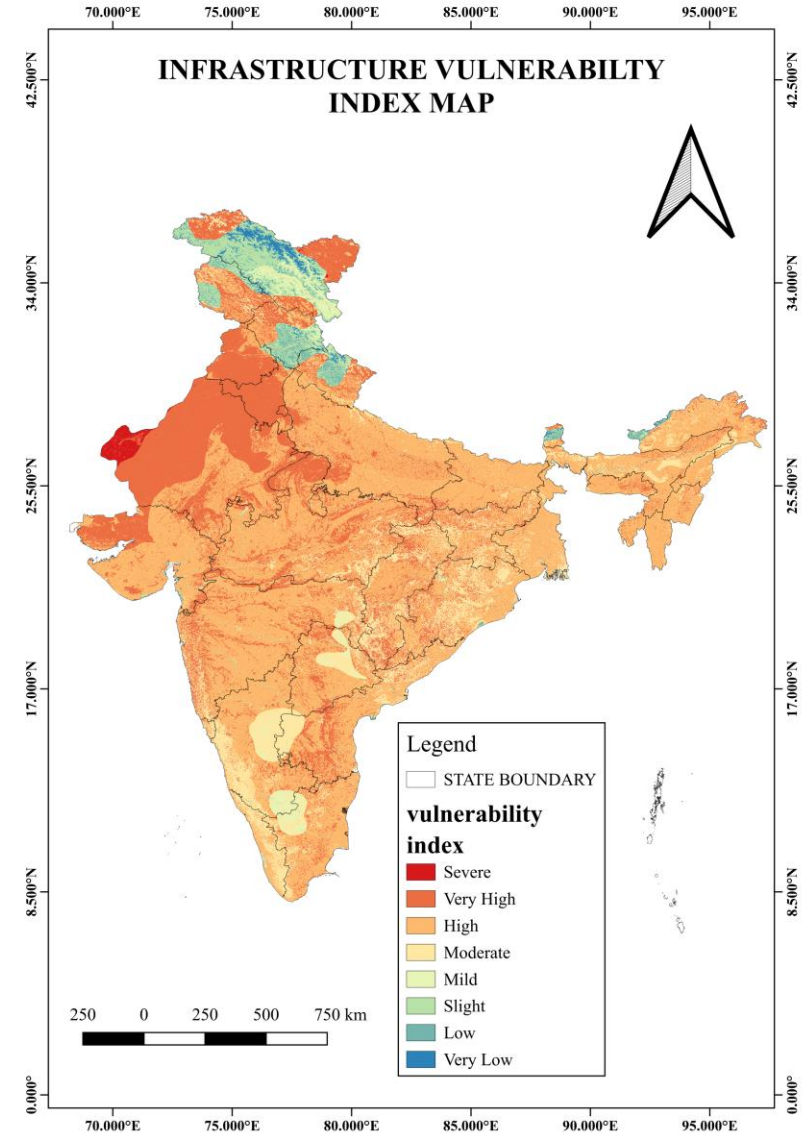
Biomass- 0.13

Groundwater-0.07

DEM-0.05

$\lambda_{max} = 5.27$, Consistency index = 0.0675,

Consistency ratio = 0.060



HISTORIC DROUGHT IMPACT

Table 1.7: Drought years with percentage area of the country affected by drought

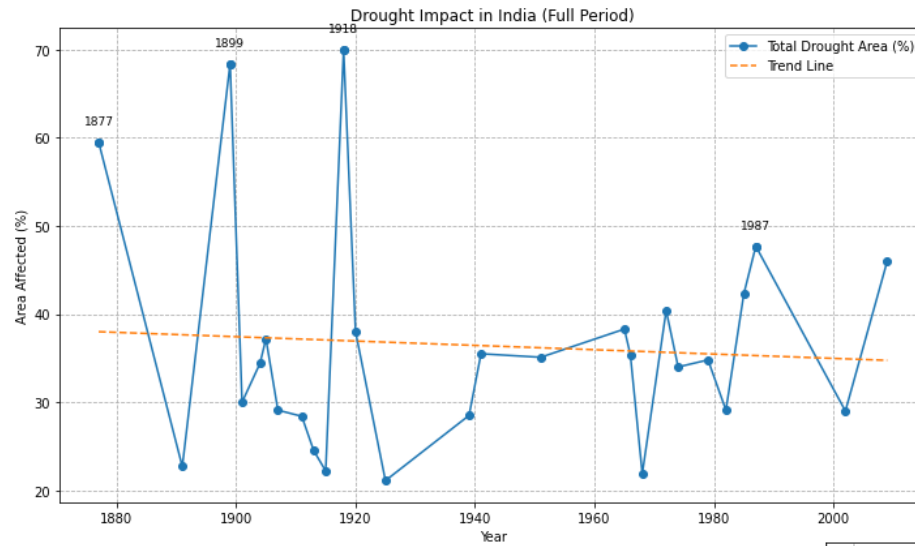
S. No.	Year	Moderate drought (%)	Severe drought (%)	Total (%)
1	1877	30.6	28.9	59.5
2	1891	22.4	0.3	22.7
3	1899	44.1	24.3	68.4
4	1901	19.3	10.7	30.0
5	1904	17.5	16.9	34.4
6	1905	25.2	12.0	37.2
7	1907	27.9	1.2	29.1
8	1911	13.0	15.4	28.4
9	1913	24.5	0.0	24.5
10	1915	18.8	3.4	22.2
11	1918	44.3	25.7	70.0
12	1920	35.7	2.3	38.0
13	1925	21.1	0.0	21.1
14	1939	17.8	10.7	28.5
15	1941	35.5	0.0	35.5
16	1951	35.1	0.0	35.1
17	1965	38.3	0.0	38.3
18	1966	35.4	0.0	35.4
19	1968	21.9	0.0	21.9
20	1972	36.6	3.8	40.4
21	1974	27.1	6.9	34.0
22	1979	33.0	1.8	34.8
23	1982	29.1	0.0	29.1
24	1985	25.6	16.7	42.3
25	1987	29.8	17.9	47.7
26	2002	19.0	10.0	29.0
27	2009	32.5	13.5	46.0

Source: IMD

Source :NIDM(page no:17)

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TEMPORAL TREND OF DROUGHT AFFECTED AREA



Major peak years :

1899 (70%)

1918 (68.4%)

1987(47.7%)

2009 (46%)

Gradual increasing trend along with higher fluctuations, suggesting increased frequency and intensity of drought

