



APPROACH NOTE

District Vulnerability Index Framework for Haryana

Submitted by



SDGCAC

SUSTAINABLE DEVELOPMENT GOALS
COORDINATION AND ACCELERATION CENTRE

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March, 2026

Reference No: 0008/2026

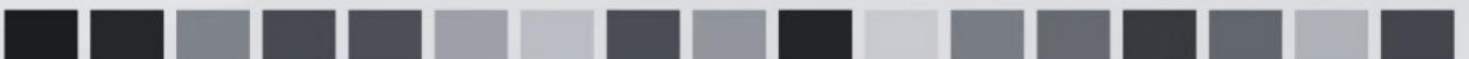


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APPROACH NOTE

District Vulnerability Index Framework for Haryana

A Composite, Multi-Indicator Scoring System for Proactive Resilience Planning

1. Executive Summary

The State of Haryana faces climate variability related challenges from recurrent flash floods in the Yamuna and Ghaggar belts^{1,2}, to severe groundwater depletion across the semi-arid south-west where extraction rates in some blocks exceed 130%^{3,4}, and escalating urban heat islands in the National Capital Region (NCR) corridor, characterized by a consistent increasing trend in annual mean minimum temperatures^{5,6}. This Approach Note presents a comprehensive, scientifically grounded, and cost-effective framework for constructing a District Vulnerability Index (DVI) for Haryana's 23 districts. The DVI is envisioned as a composite, multi-indicator scoring system that enables the State Government to shift from reactive disaster management (post-event relief) to proactive resilience planning (pre-event risk reduction).

The framework is rooted in the IPCC AR6 Risk Framework, which defines Risk as the dynamic intersection of Hazard, Exposure, and Vulnerability. The DVI isolates and operationalises the Vulnerability component — defined as the sum of Sensitivity (susceptibility to harm) and Adaptive Capacity Deficit (lack of coping/recovery ability)^{7,8}. It employs the Iyengar–Sudarshan (1982) inverse-variance weighting method for transparent, committee-defensible index construction⁹. Crucially, the approach is designed to be cost-effective and fast, relying entirely on existing secondary administrative data — requiring no new large-scale household survey — and proposes a lean single-district pilot to validate the methodology before state-wide application.

How the DVI Differs from UNDP's Multidimensional Poverty Index (MPI)

The UNDP/NITI Aayog MPI measures deprivations across health, education, and living standards to identify multidimensionally poor households. The DVI, by contrast, is a climate-risk-oriented tool that measures susceptibility to climate hazards (sensitivity) and the deficit in coping/recovery ability (adaptive capacity). While MPI indicators such as nutrition and housing overlap, the DVI integrates environmental stressors (groundwater depletion, flood exposure, heat vulnerability) and disaster-specific mechanisms (crop insurance, early warning systems, emergency shelter infrastructure) that MPI does not capture. The

¹ Central Water Commission (CWC). *Flood Forecasting Sites under Yamuna Basin Organisation*. Government of India.

<https://cwc.gov.in/en/ybo/ff-sites>

² National Remote Sensing Centre (NRSC), ISRO. (2023). *Flood Affected Area Atlas of India - Satellite based Study*.

<https://ndem.nrsc.gov.in/documents/downloads/Flood%20Affected%20Area%20%20Atlas%20of%20India%20-Satellite%20based%20study.pdf>

³ Central Ground Water Board (CGWB). (2023). *National Compilation of Dynamic Ground Water Resources of India*. Ministry of Jal Shakti, Government of India. <https://cgwb.gov.in/cgwbpnm/public/uploads/documents/17014272111704550895file.pdf>

⁴ ResearchGate. (2024). *Status of ground water development in Western Haryana, India*.

https://www.researchgate.net/publication/384628400_Status_of_ground_water_development_in_Western_Haryana_India

⁵ ResearchGate/SCIRP. (2011/2025). *Urban Heat Island Effect over National Capital Region of India: A Study using the Temperature Trends*. https://www.scirp.org/pdf/JEP20110400013_81916120.pdf

⁶ PMC (PubMed Central). (2019). *Urban Heat Island and Future Climate Change—Implications for Delhi's Heat*.

<https://pmc.ncbi.nlm.nih.gov/articles/PMC6458210/>

⁷ IPCC. (2022). *Climate Change 2022: Impacts, Adaptation and Vulnerability. Working Group II Contribution to the Sixth Assessment Report (AR6)*. Cambridge University Press. <https://www.ipcc.ch/report/ar6/wg2/>

⁸ Adaptation Community. *Conceptual Framework: Climate Risk Sourcebook (based on IPCC AR6)*.

<https://www.adaptationcommunity.net/climate-risk-assessment-management/climate-risk-sourcebook/conceptual-framework/>

⁹ Iyengar, N. S., & Sudarshan, P. (1982). *A Method of Classifying Regions from Multivariate Data*. *Economic and Political Weekly*, Vol. 17, No. 51. <https://www.epw.in/journal/1982/51>

DVI is designed to overlay hazard data to produce a full district risk profile — a functionality beyond MPI's scope.

2. Conceptual Foundation

2.1 The Global Risk Equation

The internationally accepted framing, consolidated in IPCC AR5/AR6 and adopted by the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015–2030, expresses disaster risk as the product of hazard, exposure, and vulnerability^{7,10}.

$$\text{Risk} = f(\text{Hazard} \times \text{Exposure} \times \text{Vulnerability})$$

Component	Definition	Haryana Example
Hazard	Physical climate event (frequency, intensity)	Heatwaves, floods, droughts, groundwater stress
Exposure	People, assets, and livelihoods in harm's path	Population density, built-up area in floodplains, net sown area
Vulnerability	Propensity to be adversely affected	Poverty, fragile housing, weak health systems, low insurance coverage

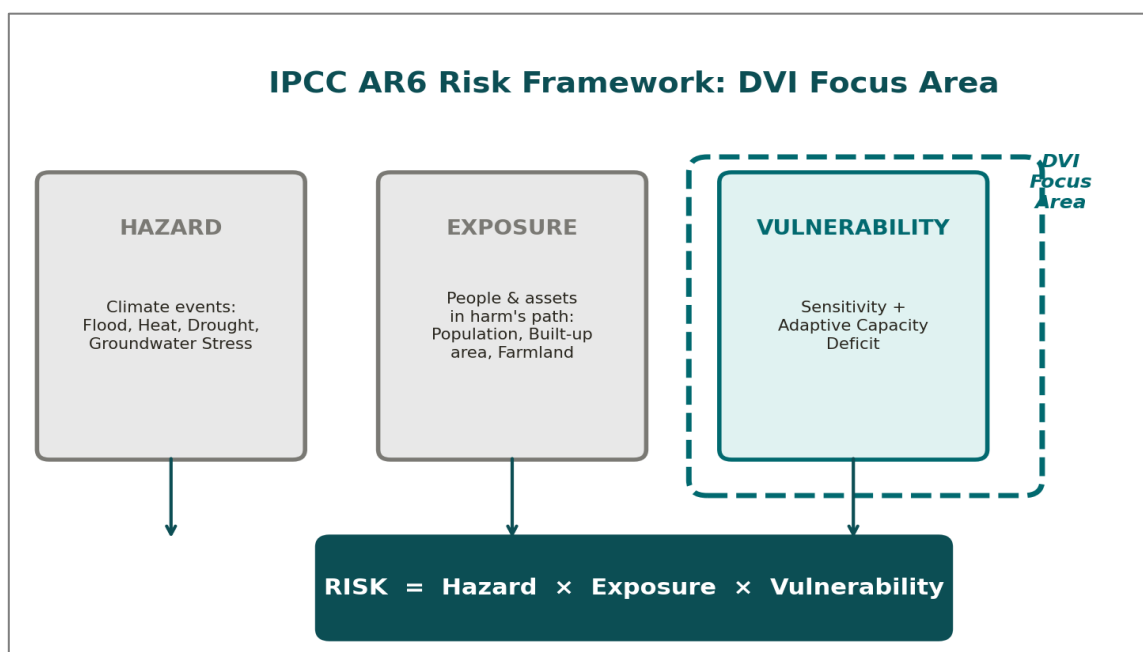


Figure 1: IPCC AR6 Risk Framework — the DVI focuses exclusively on the Vulnerability component

2.2 What the DVI Measures — And What It Does Not

The DVI focuses exclusively on the Vulnerability component:

$$\text{Vulnerability} = \text{Sensitivity (S)} + \text{Adaptive Capacity Deficit (ACD)}$$

¹⁰ UNDRR. (2015). *Sendai Framework for Disaster Risk Reduction 2015–2030*. United Nations Office for Disaster Risk Reduction. <https://www.undrr.org/implementing-sendai-framework/what-sendai-framework>

This separation is critical. Unlike older frameworks that conflated exposure within vulnerability, the AR5/AR6 approach separates them, making it possible to plug the DVI into hazard-specific risk computations (heat risk, flood risk, drought risk) once ready⁷.

Key Characteristics of the DVI

- A vulnerability-only composite score — not the full district risk score.
- Primarily comparative — useful for ranking, categorising, and tracking change across districts/blocks.
- Policy-actionable — identifies who is at risk and why, enabling targeted resource allocation.
- Designed to capture gender and social dimensions (social norms, informal livelihoods) often missed by standard databases.
- Includes critical infrastructure beyond housing — emergency shelters, health facilities, and public service infrastructure.

2.3 Alignment with Global and National Frameworks

Framework	Relevance to DVI
IPCC AR6 (2021–23)	Provides the foundational Hazard–Exposure–Vulnerability risk conceptualisation adopted by the DVI ⁷
Sendai Framework for DRR (2015–2030)	Mandates understanding and acting on risk dimensions (vulnerability, capacity, exposure, hazard) and investing in risk reduction ¹⁰ . 38 indicators and 7 global targets guide measurement ¹¹
SDG Targets 1.5, 11.5, 13.1	Directly linked to reducing exposure and vulnerability of poor populations to climate shocks ¹² ; Sendai indicators are co-designated as SDG indicators
Paris Agreement (2015)	National Adaptation Plans (NAPs) require vulnerability assessments as the basis for adaptation planning ¹³
PM's 10-Point Agenda for DRR	India's domestic roadmap for Sendai implementation — emphasises risk-informed development and vulnerability mapping ¹⁴
National DM Act, 2005	Mandates HRVCA (Hazard, Risk, Vulnerability & Capacity Analysis) in every District Disaster Management Plan (DDMP) ¹⁵
DST Climate Vulnerability Assessment (2021)	National-level district vulnerability mapping using IPCC AR5 common framework; Haryana classified as "low vulnerability" state overall, but intra-state disparities remain invisible ¹⁶
Haryana SDG District Index	Existing state-level SDG benchmarking framework that provides a ready institutional and data ecosystem for DVI docking

¹¹ United Nations Statistics Division. *Tier Classification for Global SDG Indicators (Sendai Framework Linkages)*.

<https://unstats.un.org/sdgs/iaeg-sdgs/tier-classification/>

¹² United Nations. *Sustainable Development Goal 13: Climate Action*. <https://sdgs.un.org/goals/goal13>

¹³ UNFCCC. (2015). *The Paris Agreement*. <https://unfccc.int/process-and-meetings/the-paris-agreement>

¹⁴ National Disaster Management Authority (NDMA). *PM's 10-Point Agenda on DRR*. <https://ndma.gov.in/Governance/PM-10-Point-Agenda>

¹⁵ Ministry of Law and Justice, India. (2005). *The Disaster Management Act, 2005*. Section 31 (District Plan).

<https://ndmindia.mha.gov.in/ndmi/images/The%20Disaster%20Management%20Act,%202005.pdf>

¹⁶ Department of Science & Technology (DST). (2021). *Climate Vulnerability Assessment for Adaptation Planning in India Using a Common Framework*. <https://dst.gov.in/sites/default/files/Climate%20Vulnerability%20Assessment%20Report.pdf>

3. Historical and Comparative Audit

3.1 Global Benchmarks

Index / Tool	Developer	Key Features	Lessons for Haryana
Social Vulnerability Index (SoVI)	Cutter et al., 2003	PCA-based; county-level socio-economic data; maps social drivers of vulnerability ¹⁷	Emphasises that vulnerability is socially created — factors like caste, land ownership, and gender determine exposure risks
CDC/ATSDR Social Vulnerability Index (SVI)	US CDC	Freely available; used by FEMA for National Risk Index; 4 themes (socioeconomic, housing, minority status, transportation) ¹⁸	Demonstrates institutional adoption pathway — from academic tool to federal policy instrument
UNDP Digital Social Vulnerability Index (DSVI)	UNDP SDG AI Lab	Automated data pipeline using freely available data (DHS, UN, satellite); GIS + ML for high-resolution mapping ¹⁹	Demonstrates feasibility of cost-effective, secondary-data-only mapping without primary surveys
INFORM Risk Index	EU JRC / OCHA	Global, multi-hazard risk index; 3 dimensions (Hazard & Exposure, Vulnerability, Lack of Coping Capacity) ²⁰	Validates the Sensitivity + Capacity Deficit structure adopted for DVI

3.2 Indian State and National Exercises

Several Indian states and national agencies have conducted DVI-like exercises, providing directly relevant precedent:

Exercise	Agency / State	Year	Methodology	Key Findings
National Climate Vulnerability Assessment	DST, GoI	2021	IPCC AR5 common framework; 612 districts; indicators for sensitivity & adaptive capacity ¹⁷	8 eastern states highly vulnerable; Haryana classified "low vulnerability" at state level — masking intra-state disparities
DST District-Level Climate Risk Assessment	DST (IIT Mandi, CSTEP)	2024	IPCC AR5/AR6; district-level maps integrating hazard, exposure, vulnerability ²¹	51 districts in "Very High" flood risk; Haryana districts appear in "High" drought risk category

¹⁷ Cutter, S. L., Boruff, B. J., & Shirley, W. L. (2003). *Social Vulnerability to Environmental Hazards*. *Social Science Quarterly*, 84(2), 242-261. <https://onlinelibrary.wiley.com/doi/10.1111/1540-6237.8402002>

¹⁸ CDC/ATSDR. *Social Vulnerability Index (SVI) Methods and Documentation*. <https://www.atsdr.cdc.gov/placeandhealth/svi/index.html>

¹⁹ UNDP SDG AI Lab. *Digital Social Vulnerability Index (DSVI) Methodology*. <https://sdgailab.org/>

²⁰ European Commission. *INFORM Risk Index - Technical Release*. <https://drmkc.jrc.ec.europa.eu/inform-index>

²¹ DST & CSTEP. (2024). *District-Level Climate Risk Assessment for India: Mapping Flood and Drought*.

https://dst.gov.in/sites/default/files/User%20Manual_District-Level%20Climate%20Risk%20Assessment%20for%20India_Mapping%20Flood%20and%20Drought%20Risks%20Using%20IPCC%20Framework.pdf

IHR Vulnerability Assessment	DST-SDC	2018	Common framework; indicators include irrigation, PMFBY, road density, female literacy, BPL, MGNREGA ²²	Demonstrates workable indicator library directly reusable for Haryana
CEEW Climate Vulnerability Index (CVI)	Council on Energy, Environment & Water	2021	Composite CVI for 640 districts; exposure, sensitivity, adaptive capacity ²³	463 districts vulnerable to extreme events; Assam, AP, Maharashtra most vulnerable states
CEEW Heat Risk Index	CEEW	2025	35 indicators; 734 districts; IPCC AR5 framework ²⁴	First comprehensive district-level heat risk mapping for India
Bundelkhand Climate Vulnerability Index	NIDM	2023	IPCC method (exposure, sensitivity, adaptability) ²⁵	Lalitpur most vulnerable; 12 districts extremely vulnerable to drought
Tamil Nadu Composite Drought Vulnerability Index	Balaganesh et al.	2020	IPCC method; 30 districts; agricultural and dairy data ²⁶	12 districts extremely vulnerable to drought
Meghalaya District-Level Vulnerability Assessment	DST	2025	Tier 1, IPCC AR5-aligned; 8 indicators; secondary data + expert judgment ²⁷	Demonstrates replicability using secondary data under conditions of limited primary data
Odisha Cyclone/Flood Vulnerability	OSDMA	Ongoing	Multi-hazard; housing vulnerability (kutch/pucca); EWS coverage ²⁸	Pioneer in DRR operationalisation; DVI can dock into DDMP cycles

Multiple Indian states and national agencies have successfully conducted DVI-like exercises using secondary data and IPCC-aligned frameworks. No state has, however, attempted a PPP-linked (*Parivar Pehchan Patra*), family-level aggregated vulnerability index of the kind proposed for Haryana — this would be a national first.

²² DST-SDC. (2018). *Climate Vulnerability Assessment for the Indian Himalayan Region (IHR)*.

https://dst.gov.in/sites/default/files/IHCAP_Climate%20Vulnerability%20Assessment_30Nov2018_Final_aw.pdf

²³ CEEW. (2021). *Mapping India's Climate Vulnerability: A District-level Assessment*. <https://www.ceew.in/publications/mapping-indias-climate-vulnerability-district-level-assessment>

²⁴ Council on Energy, Environment and Water (CEEW). (2025). *India Heat Risk Index 2025: A District-level Analysis*. <https://www.ceew.in/sites/default/files/mapping-climate-risks-and-impacts-of-extreme-heatwave-disaster-in-indian-districts.pdf>

²⁵ NIDM. (2023). *Climate Change Vulnerability Assessment of Bundelkhand Region*. https://nidm.gov.in/PDF/pubs/CCVAB_2023.pdf

²⁶ Balaganesh, G., et al. (2020). *Development of composite vulnerability index and district level mapping of climate change induced drought in Tamil Nadu, India*. <https://www.sciencedirect.com/science/article/abs/pii/S1470160X20301345>

²⁷ DST & NMSHE. *Climate Vulnerability Assessment for Meghalaya*. <https://meghalayacc.org/static/578d2370900c4c8f504a316d1937b739/Vulnerability-Assessment-of-Meghalaya-using-Common-Framework-at-District-Level-2018-2019.pdf>

²⁸ OSDMA. *Odisha State Disaster Management Authority – Vulnerability Mapping Initiatives*. <https://www.osdma.org/>

4. The Developmental Paradox of Haryana: Why a Custom DVI Is Needed

Standard national indices fail to capture Haryana's unique characteristics:

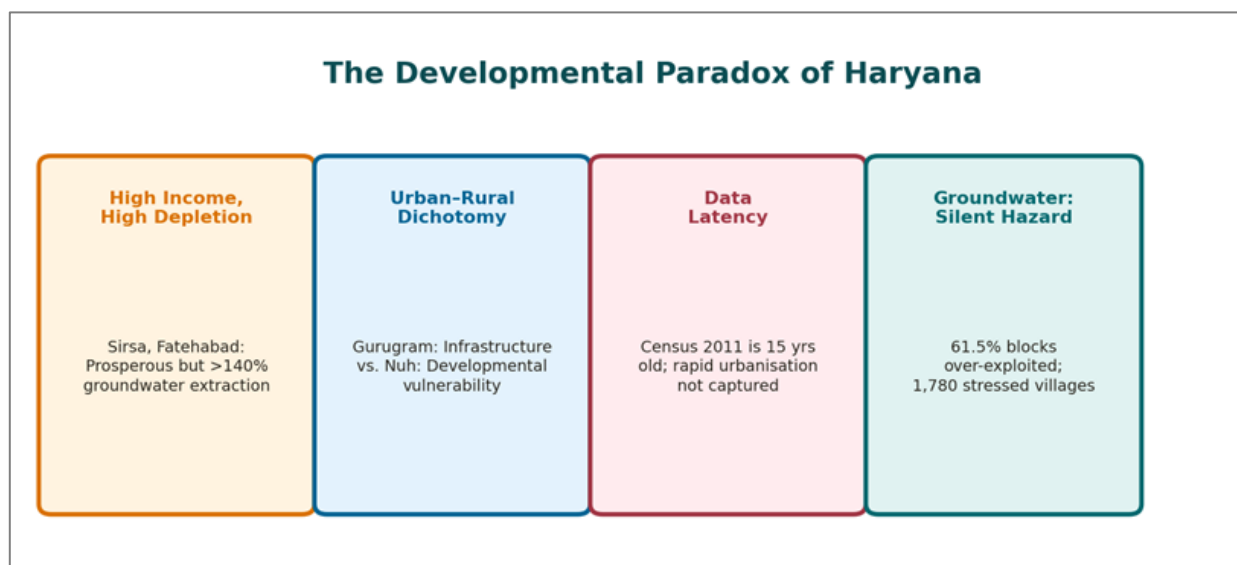


Figure 2: The four paradoxes that make a Haryana-specific DVI essential

1. **High Income, High Depletion:** Districts like Sirsa and Fatehabad are agriculturally prosperous with relatively high incomes, yet face ecological bankruptcy from severe groundwater depletion. While standard economic indices often rank these regions as "resilient" due to high per-capita income, they mask a high biophysical vulnerability; for instance, the stage of groundwater extraction in Fatehabad and Sirsa has historically exceeded 140%, placing them in the "Over-exploited" category^{29,30}.
2. **Urban–Rural Dichotomy:** Gurugram's vulnerability is primarily infrastructural, characterized by significant drainage failure during monsoon events and intensifying urban heat islands^{5,31}. Conversely, Nuh's vulnerability is developmental; as per the NITI Aayog Multidimensional Poverty Index and NFHS-5, Nuh remains a significant outlier in the state with a female literacy rate of approximately 36.6%—far below the state average—and high levels of childhood stunting^{32,33}. A single set of standard indicators often fails to capture these diverging risk profiles.
3. **Data Latency:** Most national vulnerability indices rely on Census 2011 data, which is now 15 years old. For a rapidly urbanising state like Haryana—where the urban population share is projected to have increased significantly from the 34.8% recorded in 2011—this data is obsolete for real-time planning³⁴. The DVI must leverage dynamic administrative data sources.
4. **Groundwater: The Silent Hazard:** The Haryana Water Resources Authority (HWRA) reports indicate that a vast majority of the state's blocks are "Over-exploited," with nearly 1,780 villages

²⁹ Central Ground Water Board (CGWB). (2023). *National Compilation on Dynamic Ground Water Resources of India, 2023*. Ministry of Jal Shakti. <https://cgwb.gov.in/sites/default/files/2024-01/National-Compilation-2023.pdf>

³⁰ Haryana Water Resources Authority (HWRA). <https://hwra.org.in/Atlas2025/HWRAAtlas2025.pdf>

³¹ India State-Level Disease Burden Initiative. (2020). *Health and economic impact of air pollution in the states of India: the Global Burden of Disease Study 2019*. https://www.researchgate.net/publication/350432185_Health_and_economic_impact_of_air_pollution_in_the_states_of_India_the_Global_Burden_of_Disease_Study_2019

³² NITI Aayog. (2023). *National Multidimensional Poverty Index: A Progress Review 2023*.

<https://niti.gov.in/sites/default/files/2023-07/National-Multidimensional-Poverty-Index-2023.pdf>

³³ International Institute for Population Sciences (IIPS). (2021). *National Family Health Survey (NFHS-5) 2019-21: India - State Report: Haryana*. https://rchiips.org/nfhs/NFHS-5_FCTS/Haryana.pdf

³⁴ National Commission on Population, Ministry of Health & Family Welfare. (2019). *Population Projections for India and States 2011-2036*. https://nhm.gov.in/New_Updates_2018/Report_Population_Projection_2019.pdf

identified in "Severely Stressed" categories³⁵. In districts like Kurukshetra and Sirsa, water levels in many pockets have breached the 30-metre depth mark, creating a chronic, slow-onset hazard that is often invisible in standard rapid-onset disaster frameworks^{27,35}.

5. **Economic Vulnerability Beyond Agriculture:** Standard vulnerability frameworks tend to capture agricultural livelihood sensitivity but often miss other critical livelihood sectors. COVID-19 demonstrated that unregistered small vendors — vital to urban economies — were initially forgotten. Similarly, informal workers during heat waves suffer income loss without additional provisions. The DVI must capture vulnerability across agricultural, informal, and urban livelihood sectors.
6. **Critical Infrastructure Gaps:** Beyond housing stock, the DVI must also assess the vulnerability of infrastructure used as emergency shelters and health facilities. The condition and accessibility of schools, community halls, and primary health centres that serve as critical infrastructure during disasters is a vital dimension of adaptive capacity.

5. Mathematical Methodology

5.1 Step 1: Directional Normalization (Two-Case Logic)

All raw indicator data is normalised to a 0–1 scale using Min-Max normalisation, where 1 always represents higher vulnerability^{36,37}. The logic follows two distinct paths based on the indicator's relationship with risk:

Case A — Positive ("Bad") Indicators: Higher values signify higher vulnerability (e.g., poverty rate, groundwater depth)³⁶.

$$y_{ij} = \frac{x_{ij} - \min(x_j)}{\max(x_j) - \min(x_j)}$$

Case B — Negative ("Good") Indicators: Higher values signify lower vulnerability (e.g., literacy rate, road density)^{36,38}.

$$y_{ij} = \frac{\max(x_j) - x_{ij}}{\max(x_j) - \min(x_j)}$$

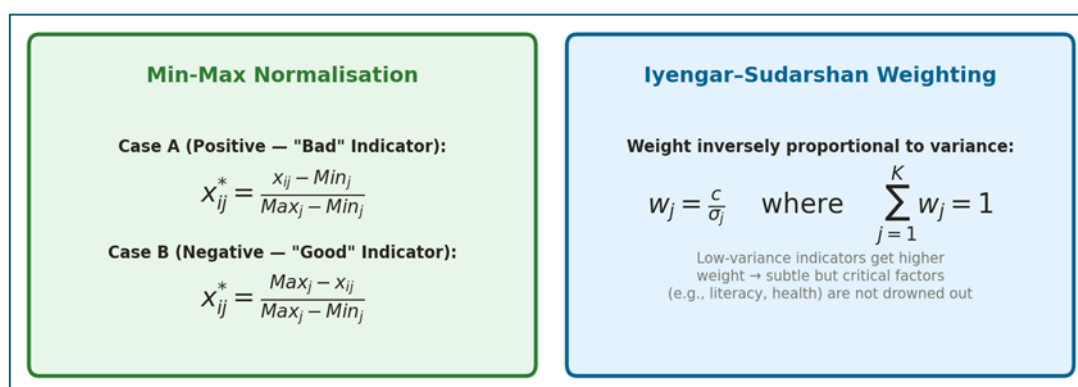


Figure 3: Normalisation (left) and Iyengar–Sudarshan weighting (right) formulae

³⁵ Haryana Water Resources Authority (HWRA). <https://hwra.org.in/Atlas2025/HWRAAtlas2025.pdf>

³⁶ OECD/European Union/JRC. (2008). *Handbook on Constructing Composite Indicators: Methodology and User Guide*. <https://www.oecd.org/sdd/42483945.pdf>

³⁷ UNDP. (2020). *Technical Notes: Human Development Indices*. https://hdr.undp.org/sites/default/files/hdr2020_technical_notes.pdf

³⁸ Ministry of Agriculture & Farmers Welfare. (2024). *Agriculture Census 2021-22: Provisional State Reports*. <https://agcensus.nic.in/>

⚠️ Outlier Treatment

For indicators with extreme values, such as groundwater depth which ranges from 3m to over 40m in Haryana³⁹, winsorization⁴⁰ at the 5th/95th percentile is recommended before normalisation to prevent a single outlying district from skewing the results for the entire state^{41,42}.

5.2 Step 2: Iyengar–Sudarshan Inverse-Variance Weighting

The Iyengar–Sudarshan (1982) method is employed to assign weights inversely proportional to the variance (standard deviation) of each normalised indicator across all 23 districts^{9,43}:

$$w_j = \frac{c}{\sigma_j} \text{ where } c = \left(\sum_{j=1}^K \frac{1}{\sigma_j} \right)^{-1}$$

such that $\sum w_j = 1$.

Weighting Method	Pros	Cons	Recommendation
Iyengar–Sudarshan	Data-driven and transparent; prevents high-variance indicators from dominating; deterministic	Does not account for theoretical importance	Primary method for Haryana pilot
Equal Weights	Simple and no statistical assumptions	Ignores variance differences; volatile indicators dominate	Use as robustness check
PCA Weights	Eliminates multicollinearity ⁴³	Statistically fragile with only 23 districts (low N)	Use as diagnostic at block level

Why Iyengar–Sudarshan fits Haryana: Infrastructure metrics like road density are relatively uniform across Haryana (low variance), while ecological metrics like groundwater depth and rainfall vary drastically—from 1,100mm in Ambala to 300mm in Sirsa. Iyengar–Sudarshan dampens the "loudest" variables, allowing subtle but critical factors like literacy or health access to influence the final score meaningfully⁴⁴.

🔗 Consideration: Alternative Weighting for Structurally Critical Indicators

While the Iyengar–Sudarshan approach assigns lower weights to high-variance indicators (preventing any single volatile variable from disproportionately influencing the composite score), an alternative weighting scenario may also be explored. In such a scenario, structurally critical indicators such as groundwater stress, poverty, and health could be assigned calibrated weights based on policy relevance, so that key

³⁹ Central Ground Water Board (CGWB). (2023). *National Compilation on Dynamic Ground Water Resources of India, 2023*. Ministry of Jal Shakti. <https://cgwb.gov.in/sites/default/files/2024-01/National-Compilation-2023.pdf>

⁴⁰ Winsorization is a data preprocessing technique that reduces the impact of extreme outliers by replacing them with specific percentile values (e.g., capping values below the 5th percentile and above the 95th percentile) rather than removing them. It creates robust, stable, and less skewed data, improving the accuracy of statistical analysis and machine learning models.

⁴¹ Kwak, S. K., & Kim, J. H. (2017). *Statistical data preparation: management of missing values and outliers*. Korean Journal of Anesthesiology, 70(4), 407–411. <https://doi.org/10.4097/kjae.2017.70.4.407>

⁴² Ministry of Statistics and Programme Implementation (MoSPI). *Statistical Manual on Theory of Attributes and Multivariate Analysis (Data Normalization)*. <https://www.mospi.gov.in/statistical-manual>

⁴³ Abdi, H., & Williams, L. J. (2010). *Principal Component Analysis*. Wiley Interdisciplinary Reviews: Computational Statistics. <https://doi.org/10.1002/wics.101>

⁴⁴ Ministry of Statistics and Programme Implementation (MoSPI). *Statistical Manual on Theory of Attributes and Multivariate Analysis (Data Normalization)*. <https://www.mospi.gov.in/statistical-manual>

long-term drivers of vulnerability are not underrepresented due to purely statistical properties. This can be tested as a sensitivity analysis alongside the primary method.

5.3 Step 3: Weighted Aggregation and Scaling

Vulnerability sub-indices are computed as weighted linear sums within each dimension.

$$\text{Sensitivity Index (SI)} = \sum_{j=1}^{K_S} w_j \cdot y_{ij}$$

$$\text{Adaptive Capacity Deficit (ACD)} = \sum_{j=1}^{K_A} w_j \cdot y_{ij}$$

The composite DVI is then:

$$\text{DVI}_i = \alpha \cdot \text{SI}_i + (1 - \alpha) \cdot \text{ACD}_i$$

where $\alpha = 0.5$ (default balanced weight), unless policy rationale dictates otherwise (e.g., stronger emphasis on capacity-building for Aspirational Districts).

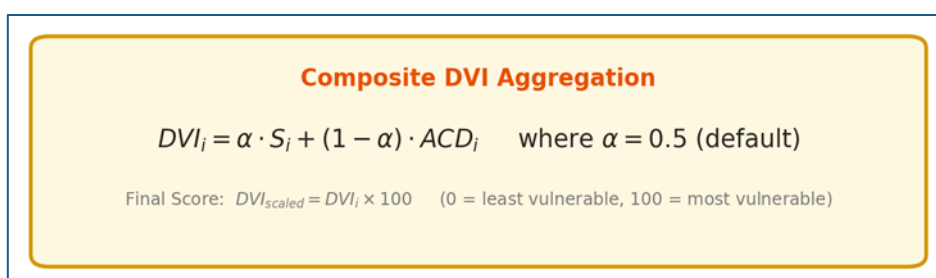


Figure 4: Composite DVI aggregation formula

Final Scaling for communication: $DVI_{100} = DVI_i \times 100$, producing a 0–100 score where 100 = maximum vulnerability.

5.4 Robustness and Validation

Validation Method	Description
Multi-method robustness	Compute DVI ranks under different weighting schemes and measure rank agreement via Spearman correlation
External validation	Correlate DVI with historical disaster losses—SDRF payouts, crop loss reports, and PMFBY claims ⁴⁵
Ground-truthing	Overlay high-DVI blocks with satellite-based flood inundation maps (e.g., NRSC 2023 reports) and PMFBY claim data ^{46,47}

⁴⁵ Ministry of Home Affairs (MHA). *Revised Guidelines on Constitution and Administration of the State Disaster Response Fund (SDRF)*. https://www.ndmarep.nic.in/SDRF_Guidelines.pdf

⁴⁶ NRSC (ISRO). (2023). *Flood Inundation Study of Haryana State using Satellite Data*. Bhuvan-Geoportal. https://bhuvan-app1.nrsc.gov.in/flood_haryana/

⁴⁷ Ministry of Agriculture. *PMFBY Dashboard: Haryana District Performance 2023-24*. <https://pmfby.gov.in/>

6. Proposed Indicator Matrix

The indicator library below is designed for measurability in Haryana using existing secondary data — Census 2011 tables, Statistical Abstract 2023-24, programme MIS (MGNREGA/PMFBY), national agency products (IMD, CGWB), and the Haryana SDG District Index framework^{16,18}.

6.1 Dimension 1: Sensitivity (Susceptibility to Harm)

Indicator Code	Indicator	Rationale for Haryana	Directionality	Primary Data Source
S01	% BPL households	Direct poverty proxy; financial incapacity to cope ⁷	Positive (+)	PPP aggregates / SECC / Statistical Abstract
S02	% SC/ST population	Social vulnerability proxy — marginalised groups often occupy hazardous lands ⁴⁸	Positive (+)	Census 2011 / PPP
S03	% Workers in agriculture	Livelihood sensitivity to heat/rain shocks ⁷	Positive (+)	Census 2011 / Statistical Abstract
S04	% Marginal & small farmers	Lack capital buffers against crop loss; less independent irrigation ⁴⁹	Positive (+)	Agriculture Census / Revenue Records
S05	% Kutchha/semi-pucca housing	Structural damage sensitivity to flood, wind, extreme heat ⁷	Positive (+)	Census 2011 (Housing) / PMAY
S06	Dependency ratio	Higher dependents reduce recovery capacity ⁵⁰	Positive (+)	Census 2011 / PPP
S07	Child stunting (% under-5)	Baseline nutritional stress increases sensitivity to shocks ⁷	Positive (+)	NFHS-5 district factsheets
S08	% No improved sanitation	Increases disease vulnerability, especially post-flood ⁷	Positive (+)	Census 2011 / NFHS-5
S09	% Informal/non-farm workers	Informal workers lack safety nets during heat waves and disasters; income loss without provisions	Positive (+)	PLFS / Census 2011 worker classification
S10	Gender vulnerability score	Social norms and gender-specific barriers affect response and recovery; often not captured in standard databases	Positive (+)	NFHS-5 (women's autonomy indicators) / Census

Note on Indicator Overlap

Indicators S01, S03, S04, and S05 (relating to poverty and marginal farming) may exhibit some degree of overlap. Basic correlation checks (e.g., Pearson/Spearman) will be conducted during the pilot computation to minimise redundancy and avoid inflating the vulnerability score. The proposed indicators S09 (informal workers) and S10 (gender vulnerability) are included to ensure that non-agricultural livelihood

⁴⁸ UNDP. (2014). *Social Vulnerability and Climate Change*. <https://www.undp.org/publications/social-vulnerability-and-climate-change>

⁴⁹ ICAR-NIAP. (2020). *Vulnerability of Indian Agriculture to Climate Change*. <https://niap.icar.gov.in/>

⁵⁰ HelpAge International. (2015). *Disaster Resilience in an Ageing World*. <https://www.helpage.org/>

vulnerability and gender dimensions — which are often inadequately represented in existing databases — are captured.

6.2 Dimension 2: Adaptive Capacity (Ability to Cope/Recover)

Indicator Code	Indicator	Rationale for Haryana	Directionality	Primary Data Source
AC01	Irrigation coverage	Critical buffer against drought; Haryana average ~91.3% ⁵¹	Negative (-)	Agri Dept / Statistical Abstract
AC02	Crop insurance (PMFBY)	Financial buffer against weather shocks ⁵²	Negative (-)	PMFBY portal / Agriculture Dept
AC03	MGNREGA avg person-days	Shock-responsive income smoothing; only ~2,191 HHs reached 100 days in 2024-25 ⁵³	Negative (-)	MGNREGA MIS
AC04	Road density	Access to markets, healthcare; state average ~104.69 km/100 sq km	Negative (-)	PWD / Statistical Abstract
AC05	Health capacity (beds)	Coping capacity for outbreaks; state average ~0.52 beds per 1k (public) ⁵⁴	Negative (-)	HMIS / State Health Reports ⁵⁵
AC06	Female literacy rate	Correlates with household preparedness; Haryana female literacy 65.9% ⁵⁶	Negative (-)	Census 2011 / Education Dept
AC07	Safe drinking water	Direct resilience co-benefit; reduces disease	Negative (-)	Census 2011 / JJM MIS ⁵⁷
AC08	Early warning readiness	Institutional preparedness for multi-hazard alerts	Negative (-)	NDMA Sachet portal / Telecom
AC09	Emergency shelter & health facility coverage	Condition and accessibility of schools, community halls, and PHCs used as emergency shelters during disasters	Negative (-)	DDMA / District Administration records

6.3 Optional Extension: Hazard Modules (For Full Risk Assessment)

Once the DVI (vulnerability score) is established, hazard-specific district risk can be computed:

Hazard Module	Key Indicators	Data Source
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⁵¹ Department of Economic and Statistical Affairs, Haryana. (2024). *State Statistical Abstract of Haryana 2023-24*.

<https://esaharyana.gov.in/en/statistical-abstract-of-haryana/>

⁵² Gulati, A., et al. (2018). *Supporting Indian Farmers: Price Support or Direct Income/Insurance?* ICRIER.

https://icrier.org/pdf/Working_Paper_357.pdf

⁵³ Ministry of Rural Development. (2025). *MGNREGA Public Data Portal: State Wise Status (Haryana)*.

<https://nrega.nic.in/Netnrega/Home.aspx>

⁵⁴ National Health Mission (NHM). (2023). *7th Common Review Mission Report: Haryana*.

<https://nhm.gov.in/index1.php?lang=1&level=2&sublinkid=150&lid=226>

⁵⁵ NITI Aayog. (2021). *State Health Index: Healthy States, Progressive India*. <https://social.niti.gov.in/health-index>

⁵⁶ Office of the Registrar General (2011). *Census of India: Primary Census Abstract Data Highlights (Haryana)*

<https://censusindia.gov.in/census.website/>

⁵⁷ Ministry of Jal Shakti. *Jal Jeevan Mission (JJM) Dashboard*. <https://ejalshakti.gov.in/jjmreport/JJMIndia.aspx>

Heat Stress	Heatwave days/year (Tmax ≥45°C)	IMD gridded data ⁵⁸
Drought	Rainfall variability (CV of monsoon); SPI frequency	IMD gridded rainfall
Flood	% area in flood-prone zone; Rx1day intensity	CWC Flood Atlas / NRSC
Groundwater	Pre-monsoon depth (m bgl); % blocks over-exploited	CGWB / HWRA Atlas 2025
Seismic	Seismic zone (III/IV) — ordinal	BMTPC Vulnerability Atlas ⁵⁹

7. Data Strategy: PPP-Based vs. Secondary-Data Alternative

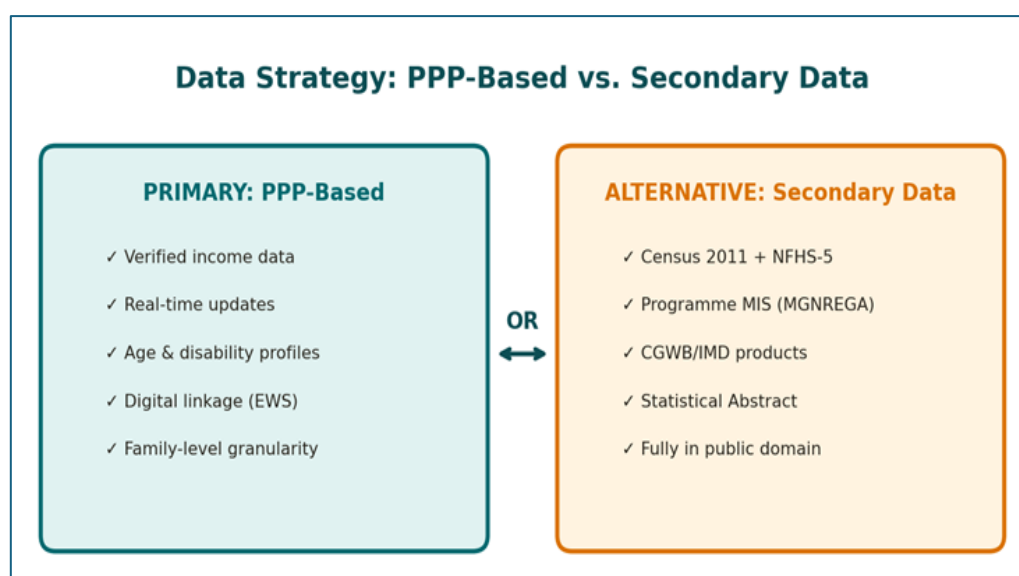


Figure 6: Two-track data strategy — PPP-based primary approach and secondary data alternative

7.1 The PPP Advantage (Primary Approach)

The Parivar Pehchan Patra (PPP) system — Haryana's unique family ID database managed by the Haryana Parivar Pehchan Authority — stores family structure, residential, and socio-economic details with a unique 8-digit Family ID. For DVI purposes, PPP offers transformative advantages:

- **Verified income** (replacing asset-based poverty proxies used by Census/SECC) — families earning <₹1.80 lakh/annum (Antyodaya threshold).
- **Age profiles** for dependency ratio computation.
- **Disability status** (Divyangjan).
- **Digital linkage** (mobile number seeding — proxy for EWS reach).
- **Near real-time updates** vs. decadal Census snapshots.

Data Access Protocol

Only block/GP-level aggregates are needed — no personally identifiable data. The PPP system's Family Information Data Repository (FIDR) can provide anonymised, aggregated extracts through the Citizen Resources Information Department (CRID).

⁵⁸ India Meteorological Department (IMD). *Gridded Climate Data (Rainfall and Temperature) for India*. <https://imdpune.gov.in/>

⁵⁹ BMTPC. (2019). *Vulnerability Atlas of India: Haryana State Summary (3rd Edition)*. Ministry of Housing and Urban Affairs. <https://bmtpc.org/>

7.2 The Alternative Approach: Secondary Data Without PPP

If the PPP database is not accessible or its use is not permitted, the DVI can still be computed using a robust alternative data stack that is entirely in the public domain or accessible through routine departmental requests:

DVI Indicator	PPP-Based Source	Alternative Secondary Source	Quality Trade-off
Poverty / BPL %	PPP verified income (<₹1.80L)	SECC 2011 deprivation data; NFHS-5 wealth quintiles; Antyodaya/BPL ration card data from Food & Supply Dept ⁶⁰	Older data (2011); proxy-based, not income-verified
Caste composition (SC/ST %)	PPP caste field	Census 2011 SC/ST tables	Reliable but dated
Dependency ratio	PPP age field	Census 2011 age cohort tables	Dated; projected estimates can be used
Housing quality (kutch/semi-pucca %)	PPP property ID link + PMAY	Census 2011 housing tables; PMAY-G beneficiary lists	Census 2011 data is old; PMAY data is recent but partial
Digital exclusion (% without mobile)	PPP mobile seeding data	NFHS-5 (% HHs with mobile phone); Telecom Regulatory Authority of India (TRAI) subscriber data ⁶¹	District-level estimates available from NFHS-5
Agriculture dependence	Computed from PPP livelihood fields	Census 2011 worker classification (cultivators + ag. labour)	Reliable for structural patterns
Health / nutrition sensitivity	PPP health field + Ayushman Bharat	NFHS-5 district factsheets (stunting, wasting, anaemia, ANC)	NFHS-5 is high-quality, 2019–21 data
MGNREGA days	Can be cross-linked via Family ID	MGNREGA MIS (nrega.nic.in) — block/GP level	Excellent; real-time MIS available
PMFBY coverage	Cross-linkable	PMFBY portal (pmfby.gov.in) — district level	Excellent; regularly updated
Health infrastructure	—	HMIS portal (hmis.mohfw.gov.in); State Statistical Abstract	Good; updated annually
Road density	—	PWD records; Basic Road Statistics (MoRTH) ⁶² ; Statistical Abstract	Reliable
Groundwater depth	—	CGWB bulletins ³ ; HWRA Atlas 2025 ^{Error! Bookmark not defined.}	Excellent; updated pre/post-monsoon

The DVI is fully computable without PPP using a combination of Census 2011 tables, NFHS-5 factsheets, programme MIS (MGNREGA, PMFBY, HMIS, Jal Jeevan Mission), Haryana Statistical Abstract 2023-24,

⁶⁰ Department of Food, Civil Supplies and Consumer Affairs, Haryana. *AePDS - Public Distribution System*.

<http://haryanafood.gov.in/>

⁶¹ Telecom Regulatory Authority of India (TRAI). (2024). *The Indian Telecom Services Performance Indicators*.

<https://www.trai.gov.in/>

⁶² Ministry of Road Transport and Highways (MoRTH). (2023). *Basic Road Statistics of India*. <https://morth.nic.in/>

and national agency products (IMD, CGWB, NRSC). The PPP enhances accuracy and timeliness (especially for poverty and demographic indicators) but is not a prerequisite.

8. Pilot Strategy: Cost-Effective, Fast, No Primary Survey

8.1 Is a Primary Household Survey Needed?

Answer: No.

The DVI methodology is explicitly designed to work with secondary administrative data that already exists in departmental MIS systems. This is consistent with:

- **DST National Climate Vulnerability Assessment (2021)** — conducted for 612 districts using only secondary data⁶³.
- **Meghalaya District-Level Assessment (2025)** — Tier 1, secondary-data-only approach specifically designed for "conditions of limited primary data".
- **UNDP DSVI methodology** — explicitly reduces the need for new surveys by using already available, geotagged data⁶⁴.
- **CEEW Climate Vulnerability Index** — computed for 640 districts using secondary datasets⁶⁵.

8.2 Recommended Pilot: Nuh District

Why Nuh: Nuh is Haryana's most socio-economically vulnerable district — classified as an Aspirational District by NITI Aayog⁶⁶. It has the lowest literacy (~54%)⁵⁶, distinct hazard profile (salinity, heat, flash flooding from Aravallis), and high data scarcity. A successful pilot here proves the model's robustness in the most challenging data environment.

8.3 Five-Step Pilot Roadmap

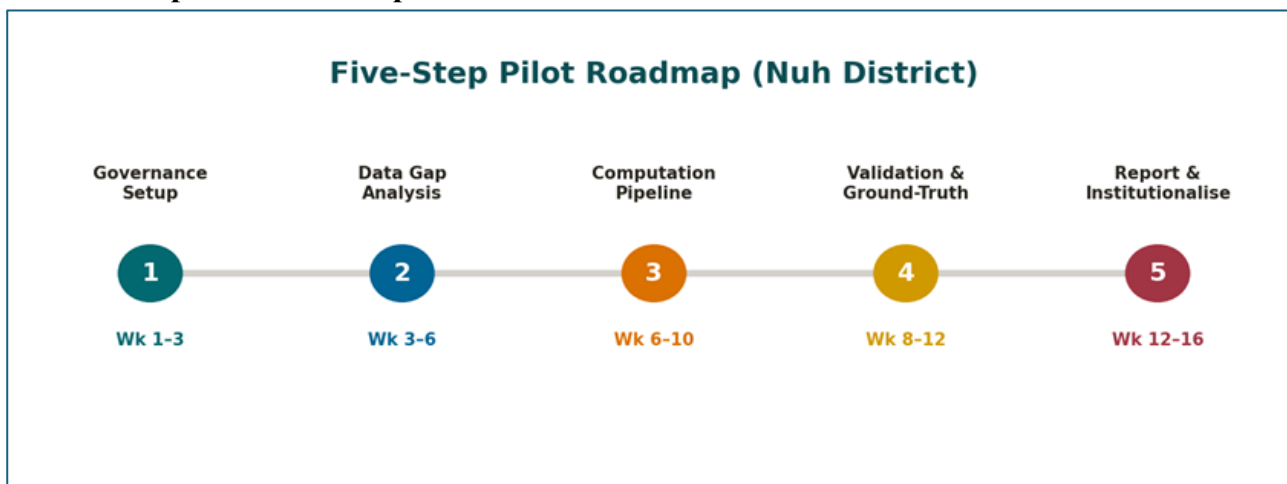


Figure 7: Five-Step Pilot Roadmap for Nuh District (12–16 weeks)

⁶³ Department of Science and Technology (DST). (2021). *Climate Vulnerability Assessment for Adaptation Planning in India Using a Common Framework*. Ministry of Science and Technology. <https://dst.gov.in/>

⁶⁴ UNDP. (2022). *Guidance Note on Data Ecosystems for Sustainable Development*. <https://www.undp.org/>

⁶⁵ Council on Energy, Environment and Water (CEEW). (2021). *Mapping India's Climate Vulnerability: A District-level Assessment*. <https://www.ceew.in/>

⁶⁶ NITI Aayog. (2023). *Aspirational Districts Programme: Nuh District Profile*. <https://niti.gov.in/>

Step	Activity	Timeline	Deliverables
Step 1: Governance Setup	Form Technical Working Group (TWG) under HSDMA with representatives from Revenue/DM, DESA, Water Resources, Health, Agriculture, Local Bodies. Lock final indicator list and data-sharing protocols.	Weeks 1–3	Final Indicator List (15–20 core indicators); Data-sharing MoU with departments
Step 2: Data Gap Analysis	Map data availability at block level using Statistical Abstract, DDMP annexures ⁶⁷ , MGNREGA MIS, HMIS, PMFBY portal. Identify gaps and fallback data sources.	Weeks 3–6	Data Inventory Matrix (indicator × source × time period × geo level × owner); Missingness Report with fallback decisions
Step 3: Computation Pipeline	Implement: (a) Directionality tagging, (b) Min-Max normalisation, (c) Iyengar–Sudarshan weighting within S and ACD groups ⁹ , (d) Aggregation to DVI, (e) Scale to 0–100.	Weeks 6–10	Reproducible dataset (raw → normalised → weighted); DVI table by block and district; Driver decomposition (top 5 indicators per block)
Step 4: Ground-Truthing & Validation	Overlay high-DVI blocks with: (a) 2023 flood inundation maps (NRSC) ⁶⁸ , (b) PMFBY claim data, (c) SDRF disbursement records. Compute Spearman rank correlations. Conduct stakeholder workshops with DDMA, Agriculture, PHE, local Panchayats.	Weeks 8–12 (overlapping)	Validation Note (rank correlations, hit-rate analysis); Revised indicator set
Step 5: Institutionalisation	Dock DVI into DDMP update cycle; present to DDMA; produce Annual District Vulnerability Brief; plan state-wide rollout.	Weeks 12–16	District Vulnerability Brief (Nuh pilot report); Presentation to HSDMA; Rollout plan for remaining districts

9. Institutional Architecture for Implementation

9.1 Three-Tier Structure

Tier	Agency	Role
Apex (State Level)	Haryana State Disaster Management Authority (HSDMA)	Policy approval; linking DVI to SDRF/SDMF allocation; integration into State Action Plan on Climate Change (SAPCC).
Technical Nodal	Department of Economic & Statistical Affairs (DESA) + CRID	Statistical computation (DESA); PPP data pipeline (CRID); annual index update.

⁶⁷ Haryana State Disaster Management Authority (HSDMA). (2023). *Guidelines for Preparation of District Disaster Management Plans*. <https://hsdma.org/>

⁶⁸ National Remote Sensing Centre (NRSC). (2023). *Bhuvan - Indian Geo-Platform of ISRO: Flood Inundation Reports*. <https://bhuvan.nrsc.gov.in/>

District Level	District Disaster Management Authority (DDMA) / Deputy Commissioner	Utilise DVI scores for District Disaster Management Plan (DDMP) drafting; prioritise block-level resilience interventions.
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9.2 Integration Points

- **Haryana SDG District Index:** The existing SDG framework provides a ready institutional ecosystem. DVI can be integrated as an "SDG 13 + SDG 11.5 module" within the SDG dashboard.
- **SDGCAC:** SDG coordination ecosystem for translating DVI outputs into budget-aligned actions.
- **Department of Future:** Explicitly framed around data analysis, forecasting, and integrated policy-making — a natural home for DVI analytics.
- **DDMP Update Cycles:** DVI reporting can be docked into the biennial DDMP revision mandated under the Disaster Management Act, 2005.
- **Sachet / CAP Early Warning System:** High-DVI blocks receive prioritised, impact-based warnings during heatwave/flood events.

9.3 Proposed SDRF Allocation Formula

$$\text{District Allocation} \propto \text{DVI Score}_i \times \text{Population}_i$$

This ensures districts like Nuh receive funds proportional to their vulnerability and resilience needs, not just population or geographic size.

10. Risk Mitigation and Limitations

Risk	Mitigation
Data gaps at block level	Use district-level aggregates as fallback; flag missingness transparently; update with each data refresh cycle
Census 2011 data obsolescence	Supplement with NFHS-5 (2019-21), MGNREGA/PMFBY MIS (real-time), HWRA 2025 Atlas; progressively integrate PPP when accessible
Political sensitivity of district rankings	Frame DVI as a diagnostic tool for resource prioritisation, not a governance performance scorecard. Emphasise that high vulnerability \neq poor governance
PPP data access denial	Full alternative data stack demonstrated in Section 8.2; DVI remains computable
Indicator correlation (multicollinearity)	Iyengar–Sudarshan partially addresses this; PCA can be run as diagnostic; test Spearman correlations between indicators
One-time exercise risk	Institutionalise through DESA + DDMP cycle + SDG framework integration; mandate annual refresh
Optimum number of indicators	A key challenge is identifying the right number of indicators — too many create noise and redundancy, too few miss critical dimensions. The proposed 18–20 indicator library balances comprehensiveness with parsimony; final selection will be validated through the TWG consultation process

11. Next Steps

The following concrete actions are required by SDGCAC, SJHIFM to deliver this project within the June 2027 timeline:

#	Action	Timeline	Description	Lead
1	Stakeholder Consultation Workshop	April–May 2026	Organise a consultation workshop with key stakeholders — HSDMA, DESA, CRID, relevant line departments (Agriculture, Water Resources, Health, Revenue/DM), and UNDP technical experts — to present the DVI framework, validate the proposed indicator matrix, finalise indicator selection, and agree on data-sharing protocols.	SDGCAC/SJHIFM
2	Technical Working Group (TWG) Formation	May–June 2026	Constitute a TWG under HSDMA with departmental representatives. The TWG will lock the final indicator list (18–20 core indicators), resolve data access issues (especially PPP access via CRID), and approve the pilot district selection.	HSDMA / SDGCAC
3	Data Inventory and Gap Analysis (Nuh Pilot)	June–August 2026	Map data availability at block level for the pilot district (Nuh). Prepare a Data Inventory Matrix (indicator × source × time period × geo level × owner) and a Missingness Report with fallback decisions for gaps.	SDGCAC + DESA
4	DVI Computation and Analysis	August–November 2026	Implement the full computation mechanism: directionality tagging, Min-Max normalisation, Iyengar–Sudarshan weighting, aggregation, scaling. Conduct correlation checks among overlapping indicators. Produce block-level DVI scores and driver decomposition.	SDGCAC
5	Validation, Ground-Truthing, and Peer Review	November 2026 – January 2027	Overlay high-DVI blocks with NRSC flood maps, PMFBY claims, and SDRF records. Conduct Spearman rank correlations. Organise validation workshops with DDMA and local stakeholders. Seek technical peer review from UNDP experts.	SDGCAC + DDMA Nuh
6	District Vulnerability Brief and Report	February–April 2027	Prepare the Nuh District Vulnerability Brief (pilot report) with full methodology documentation, block-level vulnerability profiles, driver analysis, and policy recommendations. Present findings to HSDMA and state authorities.	SDGCAC
7	Institutionalisation and Scale-Up Recommendations	April–June 2027	Develop recommendations for docking DVI into the DDMP update cycle and SDG dashboard. Prepare a scale-up	SDGCAC + HSDMA

			roadmap for remaining districts. Propose SDRF allocation formula linkage. Document lessons learned and methodology for replication.	
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 **Overall Timeline: April 2026 – June 2027 (15 months)**

Key milestones: • Q1 FY 2026–27 (Apr–Jun 2026): Consultation workshop, TWG formation, and indicator finalisation • Q2 FY 2026–27 (Jul–Sep 2026): Data collection and gap analysis for Nuh pilot • Q3 FY 2026–27 (Oct–Dec 2026): DVI computation and initial validation • Q4 FY 2026–27 (Jan–Mar 2027): Final validation, peer review, and pilot report • Q1 FY 2027–28 (Apr–Jun 2027): Institutionalisation and scale-up recommendations.

APPROACH NOTE



SDGCAC

SUSTAINABLE DEVELOPMENT GOALS
COORDINATION AND ACCELERATION CENTRE