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RESEARCH ARTICLE

Climate Justice on the Kosi: Averting, Minimising and Addressing Flood Loss and Damage in North Bihar

Sanjay Kumar Srivastava
National Institute of Advanced Studies (NIAS), Indian Institute of Science Campus, Bengaluru 560012, India.

Corresponding author: sanjay.sri2025@gmail.com

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Abstract

Every monsoon, families on the Kosi floodplain of North Bihar pay for a crisis they did little to cause. The rain that swells their rivers falls largely in Nepal, warming has made it heavier, and the households it reaches are among the poorest in India. This integrative review reads their situation through the justice architecture of the United Nations Framework Convention on Climate Change (UNFCCC). That architecture runs from equity and common but differentiated responsibilities, through the Paris Agreement's language of averting, minimising and addressing loss and damage, to the 2025 Advisory Opinion of the International Court of Justice (ICJ) and the first funding round of the Fund for responding to Loss and Damage (FRLD). Using satellite flood records, the National Remote Sensing Centre's (NRSC) Flood Hazard Atlas, NITI Aayog's Multidimensional Poverty Index (MPI) and a survey of 2,290 flood-hit households, I show how a transboundary hazard, entrenched poverty and thin adaptive capacity add up to compound injustice. Warming intensifies the hazard, but embankment failure, sediment dynamics and growing exposure also drive the losses, and their shares cannot yet be separated for any Bihar flood event. After the September 2024 flood, the typical surveyed household had lost ₹2.11 lakh, between two

and a half and four years of earnings; the state's relief payment two years later was ₹7,000. I argue that Earth observation, data science and artificial intelligence can help justice along by making such losses visible, attributable and fundable, so long as the data are governed fairly. The paper ends with a policy agenda for North Bihar organised around the UNFCCC's three verbs: avert, minimise and address, with six priority actions, a lead institution for each and indicators against which progress can be monitored.

Keywords: Climate justice; loss and damage; transboundary floods; multidimensional poverty; adaptive capacity; Kosi; North Bihar; Earth observation; data justice; UNFCCC

1. Introduction

Climate justice starts from an uncomfortable asymmetry: those who have contributed the least to global warming often bear its heaviest costs. North Bihar makes that asymmetry hard to ignore. An average Indian emits about 2.2 tonnes of carbon dioxide a year (Global Carbon Project, 2025), less than half the global figure per person, while a resident of rural Bihar emits considerably less. Yet Bihar has more flood-affected land than any other Indian state. Close to 6.9 million hectares, about three-quarters of the state, is officially classed as flood-prone (NRSC, 2020).

Much of that water arrives from across an international border. The Kosi, Gandak and Bagmati drain the Himalaya in China and Nepal, so a storm over the hills can become, within days, a breached embankment in Supaul or a submerged village in Sitamarhi. That is what happened in late September 2024. Rain that scientists judged about a tenth heavier than it would otherwise have been because of global warming, an estimate that carries wide uncertainty, set off floods and landslides that killed 244 people in Nepal (World Weather Attribution [WWA], 2024). Shortly afterwards, the Kosi barrage discharged roughly 6.6 lakh cusecs, the highest in almost 60 years, and embankments downstream in Bihar failed (SANDRP, 2025). Two years on, in September 2026, nearly 50 lakh people across 15 districts were affected by floods (Government of Bihar, 2026; ThePrint, 2026).

People living in the water's path have very little to fall back on. In 2019–21, one in every three people in Bihar was multidimensionally poor, which is the highest proportion in any state (NITI Aayog, 2023); in the Kosi and Seemanchal districts the figure is over 45%. When floods hit households like these, the damage does not last just one season. It continues, year after year (Srivastava, 2026a).

This review sets out to do three things. It reads the UNFCCC regime, up to and including the 2025 Advisory Opinion of the ICJ, as a body of justice principles that can be put to work in a single floodplain. It pulls together the evidence on three conditions that turn a cross-border flood into an injustice: a climate-intensified hazard, deep multidimensional poverty and limited capacity to adapt. And it asks what Earth observation, data science and artificial intelligence (AI) can

contribute, before setting out what Bihar, India and the international regime can do to avert, minimise and address the losses. The argument runs from principle, to place, to practice. Section 2 explains how the evidence was selected and combined. Section 3 reads the climate regime, and separates what the ICJ Opinion says about the general obligations of States from what it says about compensation. Sections 4 and 5 trace how a hazard that warming intensifies, but does not alone create, meets deep poverty and thin adaptive capacity on the Kosi floodplain. Section 6 examines what new data tools can and cannot do. Section 7 turns these findings into a prioritised agenda with named institutions and indicators, and Section 8 concludes.

2. Review Approach and Evidence Base

This is an integrative, narrative review rather than a systematic one. Its purpose is to bring together three bodies of material that are seldom read side by side: the legal and policy texts of the climate regime, the science of Himalayan floods, and the empirical record on poverty and adaptation in North Bihar. It then tests the justice principles of the first against the evidence of the other two. A fixed search protocol works well for a narrow empirical question. It works less well for one that crosses law, hydrology and development economics, where much of the relevant evidence sits in treaty texts, official datasets and agency reports rather than in indexed journals (Snyder, 2019).

Four kinds of sources, published between the adoption of the UNFCCC in 1992 and October 2026, were used. The first is primary legal and policy text: the Convention, the Paris Agreement and its adopting decision, later Conference of the Parties (COP) decisions, and the ICJ Advisory Opinion. The second is peer-reviewed research on climate justice, flood hydrology and attribution, and poverty and resilience in the Ganga plains, found by keyword searches of bibliographic databases and by following the references of key papers. The third is official data and reports: the NRSC Flood Hazard Atlas of Bihar, NITI Aayog's National MPI, the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), World Bank project records and Government of Bihar releases. The fourth is grey literature and specialist press reports, used mainly to follow fast-moving events such as the first funding round of the FRLD. A source was kept if it dealt directly with North Bihar or the Kosi basin, or with the international principles and institutions that apply to them, and if its methods or origin could be checked. Press reports were used only for recent events and were checked against a second source where one existed.

Much of the household and district evidence in Sections 4 to 6 comes from the author's own primary studies, some of which are still under review or in preparation. To guard against the narrowing that self-citation can bring, Box 1 summarises how those data were produced and where their limits lie, and the main estimates are set beside independent sources (NRSC, NITI Aayog, WWA, the World Bank) wherever one exists. Figures from unpublished studies should be read as provisional.

The synthesis proceeded in two passes. The first sorted the evidence by the three conditions that turn a flood into an injustice: a climate-intensified hazard, deep poverty and limited adaptive capacity. The second read the same evidence against the distributive, procedural and recognitional dimensions of justice (Schlosberg, 2007; Fraser, 2009) and against the Paris Agreement's triad of averting, minimising and addressing loss and damage. The policy actions in Section 7 come from that cross-reading. An action was included where the evidence showed a gap, an existing institution able to fill it, and a way to measure progress. Where sources disagree, as they do on attribution and on the size of losses, the review reports the range and says which estimate it relies on. The account begins with the principles themselves.

Box 1. Primary datasets and procedures behind the North Bihar evidence

Study area. Seven Kosi-belt districts (Supaul, Saharsa, Madhepura, Darbhanga, Sitamarhi, Madhubani and Paschim Champaran), chosen purposively because they lie in the Kosi–Bagmati–Kamla flood regime, have poverty headcounts above the state median and were covered by the household survey (Srivastava et al., under review).

Household survey. Megh Pyne Abhiyan Flood Loss Assessment after the September 2024 flood: 2,290 households in 134 wards of 21 gram panchayats, interviewed October–December 2024. Districts were chosen purposively; panchayats were sampled with probability proportional to the radar-mapped inundated area; all inundated wards were covered, and households were drawn by systematic random sampling from ward lists. Locally recruited enumerators recorded losses in five categories (land, housing, water and sanitation, livestock, other productive assets) and post-flood borrowing by lender, amount and interest rate. Reported losses were cross-checked against inspection of the dwelling and plot and against panchayat damage registers. Consent was taken in Hindi or Maithili; results are reported at ward level only (Megh Pyne Abhiyan & Tata Trusts, 2025). Limits: losses are self-reported, cover a single flood phase, and the sample is not representative of North Bihar as a whole.

Satellite flood mapping. Sentinel-1 C-band radar (GRD, VV/VH, 10 m, 6–12-day revisit) for the 2019–2024 monsoons, processed in Google Earth Engine: orbit correction, thermal-noise removal, radiometric calibration, 3×3 Lee speckle filtering and terrain correction with the SRTM 30 m elevation model. Water was classified with an adaptive Otsu threshold on VH backscatter (about −22 to −28 dB) and permanent water removed with the JRC Global Surface Water layer. Overall accuracy was 89–96% against Central Water Commission gauge records and state damage reports. The NRSC atlas (274 scenes, 1998–2019) provides an independent record. Limits: radar under-detects water beneath dense crops and in built-up areas, and a 6–12-day revisit can miss short peaks.

Climate projections. NASA NEX-GDDP-CMIP6 (0.25°), 12 global climate models, six ETCCDI extreme-rainfall indices for the Ganga–Kosi box (23°–27°N, 84°–88°E); baseline 1991–2020; periods 2031–2060 and 2051–2080 under SSP2-4.5 and SSP5-8.5; quantile-mapping bias correction against IMD gridded rainfall, with uncertainty carried through by Monte Carlo sampling. Limits: the projections describe rainfall, not river flow or inundation, and models disagree widely; multi-model medians are reported.

Machine-learning susceptibility model. Random forest and XGBoost classifiers on a 500 m grid; 10 predictors kept from 27 candidates after screening for collinearity; cells flooded at least once in 2019–2024 labelled positive, with balanced class weights. Area under the curve (AUC) was 0.91–0.94 on a 70/30 hold-out split, and five-fold spatially blocked cross-validation was used to limit the optimism that comes from neighbouring cells resembling one another. SHAP values ranked the predictors, and the output was checked against district damage records. Limits: the model learns where flooding recurs, not why; its predictor rankings are associations.

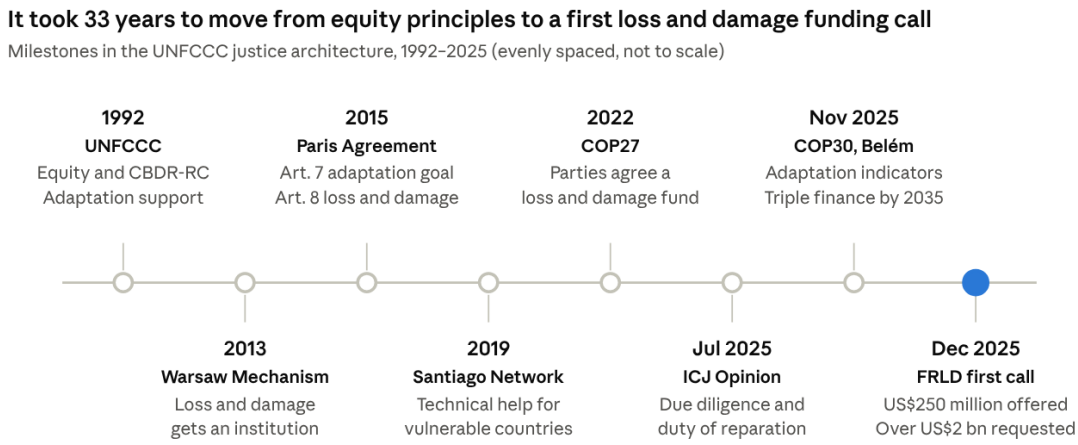
SHG study. JEEViKA records and household data for 12 flood-prone blocks, 2021–2024; regressions controlling for landholding, caste and female headship, with district fixed effects; a resilience index built from six equally weighted standardised indicators (Srivastava, 2026c). Limits: observational design, so self-selection into groups cannot be ruled out.

3. Climate Justice in the UNFCCC Framework

"Climate justice" appears nowhere in the operative text of the UNFCCC, yet the idea runs through it. Article 3.1 asks Parties to act "on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities (CBDR-RC)." Article 4.4 asks developed countries to help developing countries that are "particularly vulnerable" with the costs of adapting (UNFCCC, 1992). Read together, the two clauses make a simple distributive claim. Those who have done more to cause the problem, and who can better afford it, should carry more of the bill.

The Paris Agreement pushed further on three fronts. Its preamble acknowledges, somewhat cautiously, "the importance for some of the concept of 'climate justice'." Article 7 set a Global Goal on Adaptation, putting adaptation on an equal footing with cutting emissions. Article 8 recognised the need for "averting, minimizing and addressing loss and damage": the harm left over once mitigation and adaptation have done what they can (UNFCCC, 2015). Those three verbs now frame a large share of the policy debate, and Section 7 adopts them.

Institutions have been slow to catch up with the principles (Figure 1). The Warsaw International Mechanism on loss and damage dates from 2013, and the Santiago Network, which channels technical help to vulnerable countries, from 2019. Parties agreed at COP27 in 2022 to create a Fund for responding to Loss and Damage (FRLD), which had drawn pledges of about US$786 million by April 2025 (Climate Funds Update, 2025). Its first window, the Barbados Implementation Modalities, opened in December 2025 with US$250 million on offer. Applicants asked for about US$2.8 billion (Eco-Business, 2026). At its ninth meeting, in July 2026, the FRLD Board raised the envelope to US$342 million, roughly an eighth of the demand, and put off its first full funding package to its December 2026 meeting (Hdidou, 2026). Nepal, upstream on the Kosi, reported in September 2026 that US$20 million had been earmarked for its proposals, though not yet released (Kathmandu Post, 2026). At COP30 in Belém in November 2025, governments adopted a set of 59 Belém Adaptation Indicators and called for adaptation finance to be tripled by 2035, without fixing the baseline against which tripling is to be measured (SEI, 2025; Srivastava, 2026b).



Source: UNFCCC (1992, 2015); ICJ (2025); SEI (2025); Eco-Business (2026).

Figure 1. How the UNFCCC's justice architecture was built up over three decades. The principles came early; money for loss and damage arrived only in 2025, and in sums far smaller than the demand.

The sharpest shift came from a courtroom rather than a negotiating hall. On 23 July 2025 the ICJ unanimously gave its Advisory Opinion on what States owe one another in respect of climate change. Two layers of the Opinion need to be kept apart. The first is a set of general obligations. Under the climate treaties and customary international law, States must prevent significant harm to the climate system, cooperate with one another, and apply stringent due diligence when they set and carry out their nationally determined contributions, with 1.5°C global warming limit as the benchmark. Several of these duties are owed to the international community as a whole (*erga omnes*). It is the breach of such an obligation, not emissions as such, that can amount to an internationally wrongful act, which brings duties of cessation, guarantees of non-repetition and full reparation (ICJ, 2025).

The second layer concerns specific claims for compensation, and here the Opinion is far more guarded. Reparation, whether as restitution, compensation or satisfaction, needs a "sufficiently direct and certain causal nexus" between a particular State's wrongful act and a particular injury. The Court accepted that such a link can in principle be shown, but only case by case and in two steps: scientific attribution of the harm to climate change, and legal attribution of a share of it to the conduct of an identifiable State. Advisory opinions are not binding in themselves, and the COP decision that adopted the Paris Agreement states that Article 8 "does not involve or provide a basis for any liability or compensation" (UNFCCC, 2016, para. 51). The Opinion therefore does not hand a household in Saharsa, or the Government of Bihar, a ready claim against any emitter, and this review does not argue for one. What it does is narrower but still significant. It places

support for loss and damage within what States owe under international law, not within charity, and it sets the evidential bar that any future claim, or any funding request framed in those terms, will have to clear. The rest of the paper uses the Opinion in this limited sense.

Justice theorists usually separate at least three questions (Schlosberg, 2007; Fraser, 2009). The distributive question is who suffers and who pays. The procedural question is who gets a say. The recognitional question is whose losses count and whose knowledge is taken seriously. Each one has a sharp edge in North Bihar. Who should pay when an embankment fails under rain that fell in another country? Who chooses where a panchayat spends its adaptation money? And does anyone record the lost school year, the lost dignity or the field buried under sand, alongside the lost harvest? The rest of the paper takes up these questions, beginning with the hazard itself and with how much of it can fairly be put down to climate change.

4. Transboundary, Climate-intensified Floods

In North Bihar, flooding is less an emergency than a season. Radar images from Sentinel-1 for 2019–2024 show that, on average, almost a quarter (24.3%) of seven Kosi-belt districts lay under water at the monsoon peak each year. Supaul and Darbhanga flooded in all six years, and around 15 million people lived inside the peak flood zone (Srivastava et al., under review). The longer NRSC record, compiled from 274 satellite scenes between 1998 and 2019, classes 87% of Darbhanga as flood-hazard area, with Khagaria, Sitamarhi and Madhubani above 60% (NRSC, 2020).

The fingerprint of warming is becoming easier to see. The IPCC reports that heavy rainfall has grown more frequent and more intense over most land areas and expects South Asian monsoon extremes to strengthen further (IPCC, 2021). For Nepal's Koshi province, the WWA team estimated that the September 2024 downpour was about 10% more intense, and roughly 70% more likely, than it would have been in a cooler climate (WWA, 2024). The same study cautioned that the observational datasets disagree on the trend, so the estimate is uncertain, and that rapid urbanisation and building on floodplains shaped the death toll as much as the rain did. Looking ahead, downscaled Coupled Model Intercomparison Project Phase 6 (CMIP6) projections for the Ganga–Kosi region suggest that the wettest five-day rainfall of the year, the usual trigger for embankment failure, could grow by about 20% under Shared Socioeconomic Pathway 2–4.5 (SSP2-4.5) and 40% under SSP5-8.5 by 2051–2080 (Srivastava et al., under review; Box 1). These are projections of rainfall, not of floods or losses.

4.1 What Climate Change Does, and Does Not, Explain

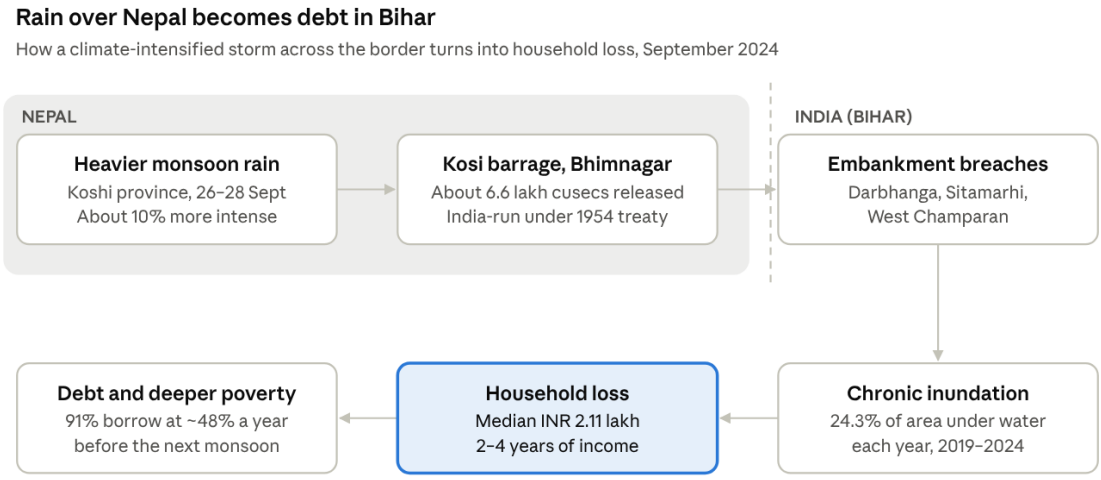
Climate is only part of the story; history and concrete supply the rest. Under the 1954 Kosi Agreement, the barrage at Bhimnagar and the embankments above it stand in Nepal but are looked after by India. In August 2008 the eastern embankment gave way at Kusaha, in Nepal,

about 12 km upstream of the barrage. The river was carrying only about 1.3 lakh cusecs at the time, a fraction of its design flood and of the 2024 peak; the breach is usually traced to poor maintenance and to silt raising the bed between the embankments, not to extreme rain (Sinha, 2009). The river jumped into an abandoned channel some 120 km to the east, and some 3.3 million people in Bihar were affected (World Bank, 2025). Over the decades in which embankments multiplied, the area exposed to flooding grew as well: about 2.5 million hectares was flood-affected in 1954, while roughly 6.9 million hectares are classed as flood-prone today (Gill & Paswan, 2018; NRSC, 2020). The two figures measure different things, so the comparison shows a direction rather than a precise increase. Embankments shelter some villages by pushing water and silt onto others, very often the poorest settlements left stranded between the two walls.

Losses on the Kosi floodplain therefore have at least five interacting drivers. Monsoon rainfall over the Himalaya, which warming is intensifying, sets the hazard. The Kosi's very heavy sediment load raises its bed and pushes it to change course (Sinha, 2009). The design, upkeep and operation of embankments decide where and when water escapes. Exposure has grown as people and assets have spread across the floodplain. And poverty, debt and insecure tenure decide how much each flood costs a family. Only the first is altered directly by climate change, and its effect has to pass through a chain that runs from rainfall to river flow, from flow to breach and inundation, and from inundation to loss.

Three limits follow for any claim that Bihar's flood losses are caused by climate change. First, the attribution evidence that exists concerns rainfall in Nepal, not floods or losses in Bihar, and the WWA estimate for September 2024 cannot be carried over to Bihar's damage without modelling each link in that chain. Second, the rainfall estimate itself is uncertain, because the observed records disagree and one event is a small sample. Third, much of the loss reflects choices about embankments and settlement that would cause damage in a stable climate. No attribution study has yet examined a flood event on the Bihar side of the border. This review therefore treats climate change as an amplifier of a hazard whose costs are already shaped by infrastructure and inequality, not as the sole cause of any particular loss. The framing matters for justice. It places duties on the Indian and Nepali authorities that build and maintain the embankments as well as on high emitters, and it is consistent with the causal standard the ICJ has set for reparation (Section 3).

The cross-border origin of the hazard raises a justice problem of its own (Figure 2). A farming family in Saharsa has no voice in how a barrage in Nepal is run, how quickly upstream river data reaches Patna, or how a 1954 treaty divides maintenance duties. Its fate is shaped by decisions in two capitals and by emissions from many more. Procedural justice for North Bihar therefore has to operate at the scale of the basin, through shared real-time data and joint forecasting, and not only through national adaptation plans. Who bears the cost when these upstream decisions and downstream defences fail is the subject of the next section.

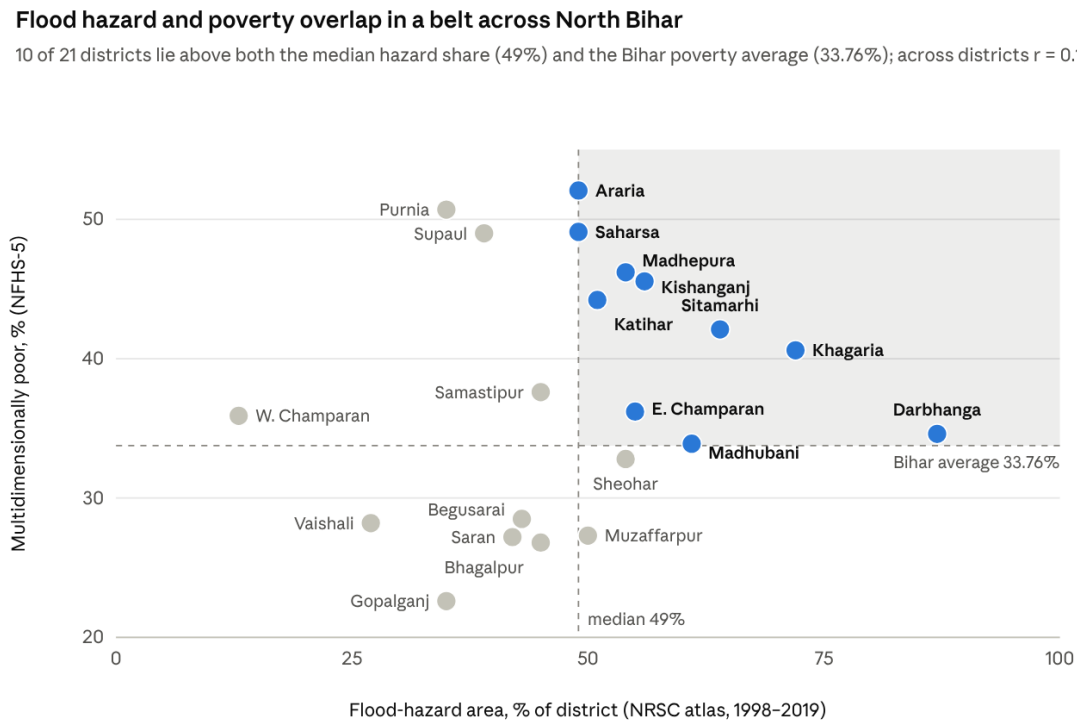


Source: WWA (2024); SANDRP (2025); Srivastava et al. (under review); Megh Pyne Abhiyan & Tata Trusts (2025).

Figure 2. The September 2024 flood traced as a chain across an international border. Different authorities control different links, so no single government can break the chain on its own.

5. Multidimensional Poverty and Low Adaptive Capacity

A flood becomes an injustice when it falls on people with nothing in reserve. Bihar cut its multidimensional poverty headcount from 51.89% in 2015–16 to 33.76% in 2019–21, a real achievement, but it still has the highest rate in India (NITI Aayog, 2023). Araria (52.07%) and Purnia (50.70%), both in North Bihar, are the poorest districts in the state. When district poverty is plotted against the NRSC hazard share, 10 of North Bihar's 21 districts sit above both the regional median for hazard (49% of area) and the state average for poverty (Figure 3). Together they form an unbroken belt from Sitamarhi and Darbhanga, through Saharsa and Madhepura, to Araria, Kishanganj and Katihar. Across all 21 districts, though, the two measures hardly move together ($r \approx 0.14$). Neither can stand in for the other, so a programme that targets on one alone will miss many of the places that need it most.



Source: NRSC Flood Hazard Atlas of Bihar (2020); NITI Aayog National MPI 2023 (NFHS-5), district values partly via CRY (2025) · 21 North Bihar districts.

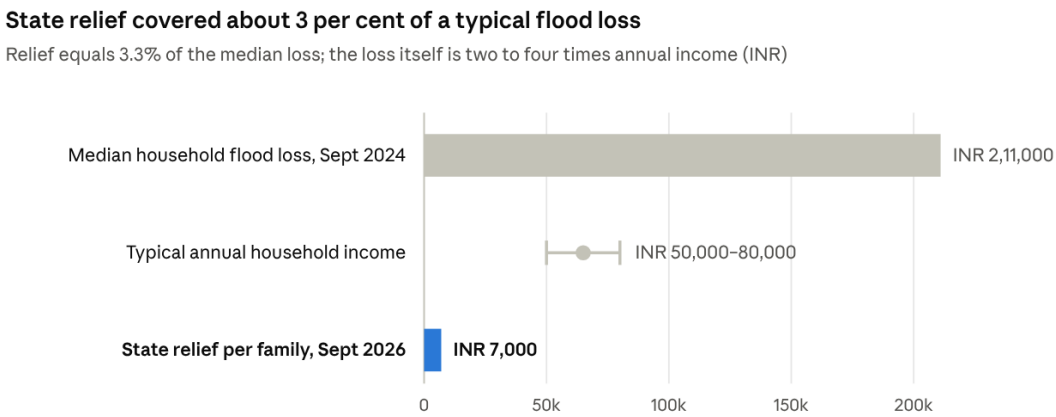
Figure 3. Share of each district mapped as flood-hazard area, plotted against the share of people who are multidimensionally poor. Highlighted districts lie above both the North Bihar median for hazard and the Bihar average for poverty.

Survey data show what this overlap means for a family. After the September 2024 floods, enumerators visited 2,290 households in 134 flooded wards of 21 gram panchayats, sampled in proportion to the inundated area (Box 1), and recorded ₹126.3 crore of losses from one flood phase alone. The median household lost ₹2.11 lakh, at a time when annual incomes were in the range of ₹50,000–80,000 (Megh Pyne Abhiyan & Tata Trusts, 2025; Srivastava, 2026a). Damaged land and houses made up most of the bill. The burden was uneven. Landless families lost up to 70% of their productive assets, compared with 35% for families with medium holdings, and households headed by women saw consumption fall by about half as much again as those headed by men (Srivastava, 2026c). Rivers decide who gets wet; caste, land and gender decide who is ruined.

What keeps families down is the way recovery is paid for. Fewer than 8% of the households surveyed had any crop insurance. Within a month of the flood, 91% had borrowed from moneylenders, relatives or shopkeepers, at a median rate of 48% a year (Srivastava et al., under review). Repayments eat into savings, so a household is still rebuilding when the next monsoon comes.

Where five or six years out of six bring floods, families slide towards a low-asset, high-debt equilibrium, below the point at which a second income, a bank loan or an insurance policy is within reach. In bad months, poor households may cut consumption by as much as 60%, which shows up in meals skipped, children kept home and medicines not bought (Srivastava et al., 2024).

The state's response has become faster, but it still compensates rather than restores. In September 2026, Bihar sent ₹7,000 to each of the 8.27 lakh flood-hit families by Direct Benefit Transfer within days (Government of Bihar, 2026). That is about 3% of the median loss recorded in 2024 (Figure 4). Families cover the rest by borrowing, selling livestock or going without. Non-economic losses, such as displacement, girls' interrupted schooling and distress migration, rarely make it into any official record (Srivastava et al., 2024).



Source: Megh Pyne Abhiyan & Tata Trusts (2025), n = 2,290; Srivastava (2026a); Government of Bihar (2026).

Figure 4. Median household loss in the 2024 Kosi-belt floods, set against typical annual income and the per-family relief payment made in 2026. The gap between the first and last bars is filled largely by informal debt.

Adaptive capacity is low on average, but it is not absent, and where it exists it tends to be collective. Bihar's JEEViKA programme has brought more than 13 million women into self-help groups (SHGs) (BRLPS, 2024). In 12 flood-prone blocks followed from 2021 to 2024 (Box 1), SHG households scored 0.62 on a composite flood-resilience index; non-members scored 0.18. Once land, caste and female headship were held constant, membership went with roughly 41% higher income and a 22-percentage-point better chance of recovering within a year (Srivastava, 2026c). These are associations and not proof of cause, since families who join groups may differ in other ways. Still, they point to the institutions through which fairer adaptation could reach households.

Whether such institutions can be found, strengthened and funded depends in part on what can be measured, which is the subject of the next section.

6. Data Justice: Earth Observation, Data Science and AI

Losses that nobody measures are losses that nobody pays for. Earth observation, data science and AI cannot deliver justice on their own, but they can supply what each of its three dimensions needs: a way of seeing loss, a way of targeting help, and a way of proving a claim.

Seeing loss (recognition). Radar satellites can image the ground through monsoon cloud. Sentinel-1 data are free at 10-metre resolution, and NISAR, launched jointly by NASA and ISRO in July 2025, adds a longer-wavelength view (processing steps and accuracy are given in Box 1). Six years of radar images can show that a village goes under water every year, which changes an "exceptional" event into a standing claim on ordinary budgets. Combined with household surveys, the same images let analysts map losses, including non-economic ones, by ward, gender and caste rather than by district average. Averages can mislead badly. In Patna, top-down and household-level flood vulnerability assessments of the same neighbourhoods differed by about half (Kumari et al., 2024).

Targeting help (distribution). Machine-learning models trained on the radar flood record predict which parts of the Kosi belt are most flood-susceptible with an area under the curve of 0.91–0.94 on a held-out 30% sample, with spatially blocked cross-validation used to check that the score is not inflated by neighbouring cells (Box 1). When the models are asked what drives their predictions, poverty incidence comes fourth, after distance to an embankment, rainfall and elevation (Srivastava et al., under review). A Compound Economic Vulnerability Index built from hazard, exposure, deprivation, economic loss and financial stress projects a 34–52% deterioration by 2070 if nothing is done. Under a community-based adaptation scenario it shows a gain of 0.15–0.23 index points, an "adaptation dividend." These are model scenarios, not forecasts, and their ranges reflect the spread of the climate projections. An index of this kind could steer prevention funds towards places where hazard and poverty overlap, instead of towards districts that happened to report past damage most effectively.

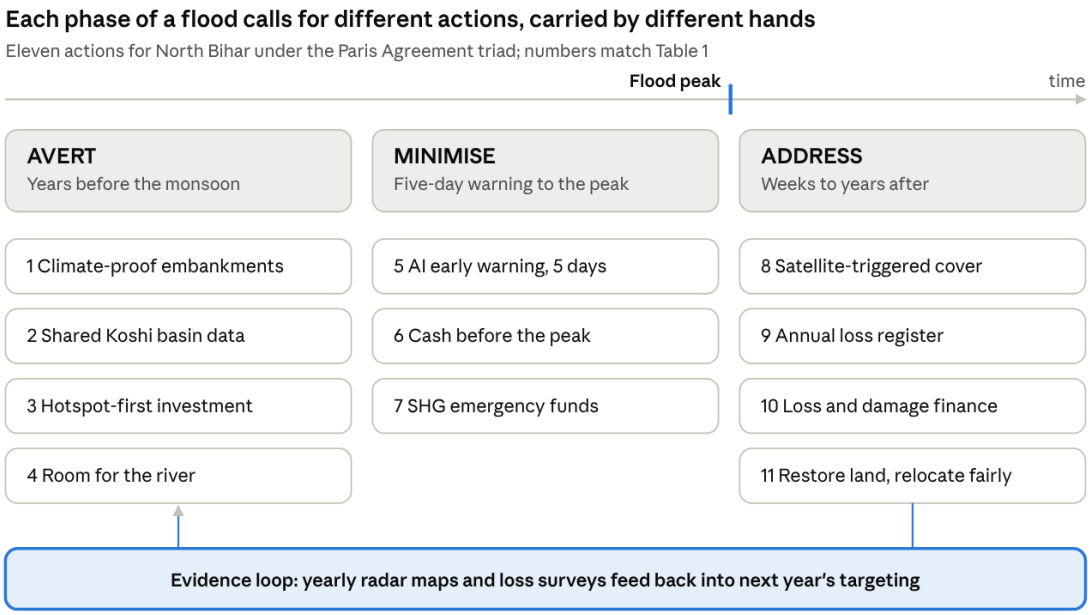
Proving a claim (corrective justice). Requests to the FRLD or to national disaster funds increasingly need to show that losses recur, can be quantified and are at least partly linked to climate change. As Section 4 showed, that last link is at present the weakest for Bihar, and building it is a research priority. A yearly record that brings together satellite observations, surveyed household losses and scenario projections is close to what such a request requires. Satellite flood maps can also trigger parametric insurance payouts within weeks, not the months a field assessment can take.

None of this is neutral. Data justice asks who is made visible, who is represented and who controls the information (Taylor, 2017). A predictive model reports correlations, not causes, and

the poverty signal in a flood model must never become an excuse to write places off. Index triggers carry basis risk: a family can suffer a real loss that falls just below the payout threshold. Planning built around satellites can also push aside the local and traditional knowledge that riverine communities hold, a worry already voiced about India's National Adaptation Plan (Mongabay India, 2026). Fair data governance therefore means publishing at ward level rather than naming households, complying with India's Digital Personal Data Protection Act 2023, opening methods to scrutiny, checking results on the ground and seeking community consent. With these safeguards in view, Section 7 sets out what should be done, by whom and in what order.

7. Policy Actions to Avert, Minimise and Address Flood Loss and Damage

A fair response for North Bihar would lower risk long before the monsoon, cut losses in the days around the flood peak, and repair the damage afterwards, aiming each step at households where hazard and poverty meet. Figure 5 places eleven actions along that timeline. Table 1 adds the instrument, the responsible institutions and the dimension of justice each one serves.



Source: Author's synthesis; actions detailed in Table 1.

Figure 5. Policy actions for North Bihar placed along the flood timeline. The evidence loop at the foot links what is learned after each flood to the next year's prevention.

Table 1. Policy Actions for North Bihar Under the UNFCCC Triad of Averting, Minimising and Addressing Loss and Damage

Triad	Action	Instrument and data	Lead institutions	Justice dimension
Avert	1. Climate-proof embankment design and maintenance	Design standards recalibrated to projected maximum five-day rainfall (+20% to +40%); annual radar flood-frequency layer for pre-monsoon inspection	Water Resources Department, Bihar; BSDMA; State Action Plan on Climate Change	Distributive
Avert	2. Basin-scale transboundary governance	Real-time hydrological data sharing and joint Koshi forecasting; review of barrage and embankment operation under the Koshi Agreement	Governments of India and Nepal; Central Water Commission; ICIMOD	Procedural
Avert	3. Hotspot-first adaptation investment	Compound vulnerability index as an allocation weight for state mitigation funds and the climate-resilience works of VB-G RAM G	Finance and Planning Departments; Rural Development; gram panchayats	Distributive
Avert	4. Floodplain room for water	Restore wetlands (chaurs) and drainage; raised platforms and flood-resilient housing in recurrently flooded wards	Rural Development; Environment Department	Distributive
Minimise	5. Five-day AI early warning to the last mile	AI river forecasts, delivered through SACHET alerts and SHG networks in local languages	BSDMA; India Meteorological Department; JEEViKA	Recognitional
Minimise	6. Anticipatory cash before the peak	Forecast-triggered transfers through Direct Benefit Transfer to pre-verified household lists	Disaster Management Department; banks	Distributive
Minimise	7. SHGs as disaster-risk infrastructure	SHG emergency funds eligible for State Disaster Response Fund support; community grain banks	JEEViKA; BSDMA; NABARD	Procedural
Address	8. Satellite-triggered risk transfer	Radar flood extent as the trigger for crop and livestock payouts within 30 days	Agriculture Department (Bihar Rajya Fasal Sahayata Yojana); insurers; NABARD	Corrective
Address	9. Annual loss and damage assessment protocol	Economic and non-economic loss, disaggregated by gender, caste and landholding; published by ward	Planning Department; Disaster Management Department; universities	Recognitional

Triad	Action	Instrument and data	Lead institutions	Justice dimension
Address	10. Access to international loss and damage finance	Evidence packages for the FRLD; Santiago Network technical assistance; a loss and damage window in state disaster funds	MoEFCC; Ministry of Finance; Government of Bihar	Corrective
Address	11. Restoration and voluntary relocation	Rehabilitation of sand-cast land; relocation with land titles and consent for households trapped between embankments	Revenue and Land Reforms Department; panchayats	Recognitional and procedural

Note. BSDMA: Bihar State Disaster Management Authority; ICIMOD: International Centre for Integrated Mountain Development; MoEFCC: Ministry of Environment, Forest and Climate Change; VB-G RAM G: Viksit Bharat–Guarantee for Rozgar and Ajeevika Mission (Gramin).

Three lessons run through the table. Order matters: the hazard record and the vulnerability index (actions 1, 3 and 9) are what allow every other action to be aimed and paid for. Existing institutions should do the heavy lifting, because JEEViKA federations, DBT channels and gram panchayat plans already reach households that new projects seldom find. And the three verbs work as a chain, not a menu. Insurance with no early warning pays for losses that could have been avoided, and a warning with no cash leaves families knowing they must leave but unable to.

7.1 Priorities, Responsibilities and Indicators

Not all eleven actions can move at once, and Bihar's fiscal room is limited. Table 2 therefore picks out six as priorities for the next three years. They were chosen because they are low-regret measures that pay off whatever the pace of warming, because they build on institutions that already exist, and because each makes others possible. The loss register and hotspot allocation come first, since every other action depends on knowing where losses fall. Early warning and faster cash come next, because they act within days and run on systems already in place (SACHET, DBT and SHG networks). Embankment maintenance and data sharing follow, because the 2008 breach showed the cost of neglect, and risk transfer completes the set, because informal debt is what turns one flood into a lasting setback. Each priority has a single lead institution, so that responsibility is not spread too thinly across departments, and each has at least one indicator with a baseline that can be tracked from administrative or survey data. The targets are indicative and offered for discussion; they are not calibrated goals.

Table 2. Priority Actions for 2027–2029, Lead Institutions and Monitoring Indicators

Priority (Table 1 action)	Lead (supporting) institutions	Indicator	Baseline	Indicative target, 2029
1. Annual loss and damage register (9)	Disaster Management Department (Planning Department; universities; JEEViKA)	Ward-level register of economic and non-economic loss, by gender, caste and landholding, published by 30 June each year	None published	Published every year from 2027 for all flood-prone districts
2. Hotspot-first allocation (3)	Finance Department (Planning Department; BSDMA; gram panchayats)	Share of state mitigation and climate-resilience funds going to districts high on both hazard and poverty (Figure 3)	Not tracked	At least equal to those districts' share of poor people in flood-hazard areas
3. Last-mile early warning (5)	BSDMA (IMD; Central Water Commission; JEEViKA)	Share of households in hazard wards warned in a local language 48 hours or more before inundation, from post-flood survey	Not measured	80% or more
4. Anticipatory and faster cash (6)	Disaster Management Department (banks; DBT cell)	Days from forecast trigger to transfer; transfer as a share of median household loss	₹7,000 after flooding, about 3% of median loss (2026)	Paid before the peak to pre-verified households; share of loss reviewed each year
5. Embankment upkeep and shared river data (1, 2)	Water Resources Department, Bihar (Central Water Commission; Nepal counterparts under the Kosi Agreement)	Share of radar-flagged vulnerable reaches inspected and repaired by 15 June; delay in sharing upstream gauge data	Not published	All flagged reaches; upstream data shared in near real time
6. Risk transfer and safer credit (7, 8)	Agriculture Department (NABARD; insurers; JEEViKA)	Share of exposed households with crop or livestock cover; share borrowing informally after a flood; median interest rate	<8% insured; 91% informal borrowing at a median 48% a year (2024 survey)	30% insured; informal borrowing halved

Note. Baselines are from the 2024 household survey and Government of Bihar (2026). Targets are indicative and intended to be set with the agencies concerned.

The agenda also reaches beyond Patna. India's first National Adaptation Plan, still being finalised, could make hotspot targeting a rule for budgets and report on the Belém Adaptation Indicators

with district-level data (Srivastava, 2026b). Abroad, India could draw on the ICJ Opinion and the new FRLD to argue that loss and damage support for shared river basins should reach subnational hotspots like the Kosi belt, and not stop at national treasuries. Here too the Opinion should be read with care: as Section 3 noted, it strengthens the case for cooperation and finance, not a claim to compensation from any particular State.

8. Conclusion

North Bihar is a reminder that climate justice is not only something nations bargain over at summits. It is also the question of whether a sharecropper's family in Supaul, flooded by rain that fell in Nepal, can get back on its feet before the next monsoon. The UNFCCC regime, from CBDR-RC to the ICJ Opinion and the new loss and damage fund, now offers principles and the beginnings of money, though not, as yet, a route to compensation for any particular household. What it cannot offer by itself is the evidence that ties a global duty to a particular ward, or a delivery system that reaches a landless woman repaying a loan at 48% a year.

Both are within reach. Satellite records, poverty statistics and machine learning can make cross-border, climate-amplified losses visible and fundable at the scale where they happen. Women's collectives, DBT channels and panchayat plans can carry resources to the households that need them. Three lines of research would strengthen the case: attribution studies of flood events on the Bihar side of the border, household panels that follow the debt trap across successive floods, and rigorous causal evaluation of SHG-based resilience. Each should report its uncertainties as plainly as its findings, because a justice claim is only as strong as the evidence behind it. The rivers of North Bihar will keep flooding. Whether its poorest families keep falling further behind each time is not decided by hydrology. It is decided by policy.

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Data availability: No new data were generated. District values for Figure 3 are drawn from the NRSC Flood Hazard Atlas of Bihar (2020) and NITI Aayog's National MPI (2023), with district headcounts partly compiled from CRY (2025). Methods for the primary studies cited are summarised in Box 1.

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About the Author: Dr Sanjay K. Srivastava is the S. Radhakrishnan Chair Professor at the National Institute of Advanced Studies, Indian Institute of Science Campus, Bengaluru. With over 25 years in disaster risk reduction and climate adaptation across India and Asia-Pacific, he previously served as Chief of Disaster Risk Reduction at the UN Economic and Social Commission for Asia and the Pacific (ESCAP). He has advanced early-warning systems, regional cooperation, and the use of space-based technologies from his earlier roles at ESCAP, SAARC, and ISRO.

References

Bihar Rural Livelihoods Promotion Society. (2024). *JEEViKA annual progress report 2022–24*.

Climate Funds Update. (2025). *Fund for responding to Loss and Damage: Pledges and contributions*. Heinrich Böll Stiftung and ODI. https://climatefundsupdate.org

CRY. (2025). *Multidimensional Poverty Index, India: A social group perspective, 2019–21*. Child Rights and You. https://www.cry.org/downloads/safety-and-protection/multidimensional-poverty-index-india-report-factsheet-2025.pdf

Eco-Business. (2026, July 8). Loss and damage fund faces US$2.8bn gap as first projects move ahead. https://www.eco-business.com/ms/news/loss-and-damage-fund-faces-us28bn-gap-as-first-projects-move-ahead/

Fraser, N. (2009). *Scales of justice: Reimagining political space in a globalizing world*. Columbia University Press.

Gill, P., & Paswan, B. (2018). *A dammed history of the Koshi. Dialogue Earth.* https://dialogue.earth/en/water/koshi-river-bihar/

Global Carbon Project. (2025). *Global carbon budget 2025* [Data set]. https://globalcarbonbudget.org

Government of Bihar. (2026, September 13–15). Flood situation in Bihar: 48 lakh people affected [Press releases reported by All India Radio News].

Hdidou, Z. (2026, July 27). Loss and damage: What the ninth FRLD Board meeting revealed about the cost of being underfunded. ECO Ltd. https://ecoltdgroup.com/?p=13356

International Court of Justice. (2025, July 23). *Obligations of States in respect of climate change* (Advisory Opinion). ICJ. General List No. 187. https://www.icj-cij.org/

IPCC. (2021). *Climate change 2021: The physical science basis. Contribution of Working Group I to the Sixth Assessment Report*. Cambridge University Press.

Kathmandu Post. (2026, September 9). Nepal secures 20 million from loss and damage fund, awaits decision on Bhotekoshi plea. https://kathmandupost.com/national/2026/09/09/nepal-secures-20-million-from-loss-and-damage-fund-awaits-decision-on-bhotekoshi-plea

Kumari, N., Sharma, P., & Mishra, V. (2024). Localising vulnerability assessment to urban floods: A comparative analysis of top-down and bottom-up geospatial approaches in Patna City, India. *International Journal of Disaster Risk Reduction, 108*, 104518.

Megh Pyne Abhiyan & Tata Trusts. (2025). *Household-level flood loss assessment report in North Bihar: Post 2024 floods*. Tata Trusts.

Mongabay India. (2026, October). India needs a just adaptation agenda [Commentary]. https://india.mongabay.com/2026/10/india-needs-a-just-adaptation-agenda-commentary/

NITI Aayog. (2023). *National Multidimensional Poverty Index: A progress review 2023*. Government of India. https://www.niti.gov.in/sites/default/files/2023-08/India-National-Multidimentional-Poverty-Index-2023.pdf

NRSC. (2020). *Flood hazard atlas: Bihar. A geospatial approach*. National Remote Sensing Centre, ISRO. https://ndem.nrsc.gov.in/documents/Disaster_Document/FHZ/BR_FHZ_1998_2019_atlas1.pdf

SANDRP. (2025, January 3). 2024: Do embankments save from floods or worsen the disasters? South Asia Network on Dams, Rivers and People. https://sandrp.in/2025/01/03/2024-do-embankments-save-from-floods-or-worsen-the-disasters/

Schlosberg, D. (2007). *Defining environmental justice: Theories, movements, and nature*. Oxford University Press.

SEI. (2025, November 27). COP30 in Belém: Collective effort, constrained ambition. https://www.sei.org/perspectives/cop30-collective-effort-constrained-ambition/

Sinha, R. (2009). The great avulsion of Kosi on 18 August 2008. *Current Science, 97*(3), 429–433.

Snyder, H. (2019). Literature review as a research methodology: An overview and guidelines. *Journal of Business Research, 104*, 333–339.

Srivastava, S. K. (2026a). Flooded and left behind: Multidimensional poverty, climate loss and damage, and the promise of women-led resilience in North Bihar. *Letters in Economic Research Updates, 2*(3), 1–8. https://www.primeopenaccess.com/scholarly-articles/flooded-and-left-behind-multidimensional-poverty-climate-loss-and-damage-and-the-promise-of-womenled-resilience-in-north.pdf

Srivastava, S. K. (2026b). *The resilience dividend: Aligning adaptation, growth and equity in India* [Manuscript submitted for publication].

Srivastava, S. K. (2026c). *Poverty, floods and resilience transitions in North Bihar* [Manuscript in preparation].

Srivastava, S. K., et al. (under review). When every monsoon erases a year: Climate risk, economic vulnerability and data-driven adaptation in the Kosi floodplain of North Bihar, India. *Climate Change Economics*.

Srivastava, S., Pandey, P. S., Jha, R. K., Sattar, A., & Tanwar, N. (2024, October 18). *Addressing loss and damage of agrifood systems to protect poor*. UN ESCAP. https://www.unescap.org/blog/addressing-loss-and-damage-agrifood-systems-protect-poor

Taylor, L. (2017). What is data justice? The case for connecting digital rights and freedoms globally. *Big Data & Society, 4*(2), 1–14.

ThePrint. (2026, September). 50 lakh people affected in 15 Bihar districts as flood crisis deepens. https://theprint.in/india/50-lakh-people-affected-in-15-bihar-districts-as-flood-crisis-deepens/3050675/

UNFCCC. (1992). *United Nations Framework Convention on Climate Change*. https://unfccc.int/

UNFCCC. (2015). *Paris Agreement*. https://unfccc.int/

UNFCCC. (2016). *Decision 1/CP.21: Adoption of the Paris Agreement* (FCCC/CP/2015/10/Add.1).

World Bank. (2025). *Bihar Kosi Basin Development Project: Implementation Completion and Results Report* (ICR00490). https://documents1.worldbank.org/curated/en/099021826203578268/pdf/P127725-04991831-4108-4f2c-bcdb-94190ed0f1b6.pdf

World Weather Attribution. (2024). *Rapid urbanisation and climate change key drivers of dramatic flood impacts in Nepal*. https://www.worldweatherattribution.org/rapid-urbanisation-and-climate-change-key-drivers-of-dramatic-flood-impacts-in-nepal/