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Reframing the narrative: an analysis of print media reporting on Bihar floods

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In modern ways of “knowing water,” some narratives have gained greater acceptance than others. Mass media is a major component of the complex cultural process through which such narratives are created and sustained. This article elucidates vernacular print media as the site of the construction of the dominant water meanings. Taking the case study of *Hindustan*, a popular Hindi newspaper from Bihar, India, this article analyzes patterns of media reporting and the resulting discourse development on water management. Newspaper articles reporting on water issues were collected for the three monsoon months of July, August, and September, 2019. The sample was taken for the monsoon season when floods and other water-related events are expected to be more heavily reported in the news. A total of 376 news items were found to report on water, in which seven major themes of reporting were identified. Second, discourse analysis was carried out on the 139 articles under the theme “monsoon floods.” These news items were analyzed according to five aspects: (i) spatial outlook; (ii) holistic approach; (iii) fact-based reporting; (iv) flood mitigation; and (v) gender-balanced reporting. Monsoon floods were the most frequently reported theme. Articles reported on both damage due to floods and the measures of flood management. It was found that news items present a spatially disconnected and parochial pattern of reporting. News stories focused more on the short-term impacts of floods than on the underlying policy problems. Fact-based reporting was limited. News items on flood mitigation were favorable to structural interventions, particularly, and embankments. The gender lens was completely absent from the study. Through this pattern of reporting, the news items created two narratives. Firstly, the news items frame floods as unwelcome disasters that are exacerbated by rainfall in the catchment areas of the upper riparian country Nepal and sluggish discharge from the Farakka Barrage. Secondly, news items also reported on the interlinking of rivers and the construction of embankments as favorable methods of flood control. This article problematizes these narratives and suggests a counter in terms of “living with floods.” Some suggestions for more nuanced and diversified reporting on the topic are discussed.

KEYWORDS

water, floods, media, media narrative, Bihar, India, Hindi

1 Introduction

“Mausam, the daughter of Kantilal Choudhary, a paralyzed laborer, is 18 years old. As she grew, so did his dreams of her wedding one day. However, dreams of marrying her and seeing her off with pomp remain just dreams. Mausam is still at home, but the gifts that had been collected for her wedding have gone with the flood waters of Lakhandehi. Kantilal is now standing at the crossroads with a ruined house, dilapidated body, a young daughter, and a family crying out of hunger”—Lakhandehi has washed away Kantilal’s dreams, Hindustan, 3rd August, 2019.

This is a glimpse of the human tragedy and economic damage that the flood-prone region of north Bihar in India annually goes through. Located in the middle Ganga plains, and sharing a boundary with the mountainous country of Nepal to its north, water is at the heart of governance issues in the state. Bihar faces the problem of water surplus in the form of annual floods that impact three-quarters of the state (Government of Bihar, 2017). Recurring floods of a devastating nature have negatively impacted the socio-economic development in the region (Rorabacher, 2016). Today, the region is one of the most underdeveloped in the world, with 51% of the population classed as poor according to the Multidimensional Poverty Index in 2021 (Aayog, 2021). Efforts toward flood management have been focused largely on structural interventions to regulate the flow of rivers. Over the past six decades, several barrages have been constructed at the foothills of the Himalayas with Nepal’s cooperation. Simultaneously, extensive embankments have also been carried out across all the tributaries. Yet, the intensity of flooding has only increased over the decades (Mishra, 2001; Somnath, 2017; Singh, 2020; Sahani et al., 2023). Even so, heavy engineering measures continue to be the most popular flood control interventions. This water governance model in Bihar evolved over the colonial period when the process of embankments first started. After the independence, the process was further intensified (D’Souza, 2006). Flood management in the region also requires transnational cooperation with Nepal, where most of the rivers originate (Gupta et al., 2021). In recent times, there has been a trend in the state administration of blaming Nepal for releasing water from the barrages, leading to the annual floods (Iyer, 2008; Kumar, 2020). Thus, while the cause of floods is framed as Nepal’s fault, the solutions are generally seen in terms of the construction of even more embankments (Mishra, 2019).

The State Government in Bihar formulated the Irrigation, Flood Management and Drainage Rules 2003, implemented through the Bihar Irrigation Act 1997, which outlines an action plan for flood management. It shows that state policy on flood management has been heavily reliant on the management and construction of structural measures like barrage and embankment. Since 1950, major dams and 3,790 km of embankments have been built across the state to control floods (Singh, 2020). The State Disaster Management Plan 2019 is a more recent document that puts greater emphasis on nature-based solutions and seasonal reservoirs. However, it acknowledges that until recently “our entire flood related [sic] mitigation and preparedness have been inundation and erosion centric” (Government of Bihar, 2014, p. 78).

The “hydrological mission” (Molle et al., 2009) still captures the imagination of the state and citizens in Bihar. The efforts to control water through dams, levees, and interlinked basins have been a hallmark of the 20th century across the globe. These engineering projects have also provided legitimacy to a centralized water control system often controlled by the state (Molle et al., 2009). However, within decades, the negative environmental and social impacts of these mega projects started to come to light. Efforts to straight-jacket rivers through dams and levees often overlook the ecological system within which water runs, as well as the organic relationship between water systems and social systems. In other words, water is “materialized” and “de-territorialized,” alienating water from its ecological and socio-cultural rooting (Linton, 2010, p. 28). Rather than being separate entities, water and society have complex interconnections. The human agency is “endogenous to water systems” (Sivapalan et al., 2012, p. 5). Thus, there is a “need to consider the two-way feedbacks [sic] between human and water systems in order to explain puzzles, paradoxes, and unintended consequences that arise in the context of water management, and to suggest ways to avoid or overcome these challenges” (Pande and Sivapalan, 2017).

Mass media is a major component of the complex cultural process through which such environmental meanings are created and sustained. By the logic of its sheer reach, omission, and commission of content, the media has the ability to create “publics” out of masses based on shared realities. These are different from masses or crowds and “emerge in relation to a specific discourse” (Warner, 2002). Using tools of rhetoric, agenda setting, and news framing, mass media can influence people’s opinions and outlooks (Peeples, 2015). In the naming and construction of knowledge through text and speech, in print and on online platforms, power is exercised (Burgess, 1990; Hansen, 2015). In this sense, media performances are a part of the “sub-politics” (Beck, 1997) occurring outside the parliament and political parties. Media therefore has symbolic power in shaping our social realities (Udapa and McDowell, 2017).

Research on water narratives has been expanding (Boelens et al., 2016; Karpouzoglou and Vij, 2017; Leong, 2021). However, media narratives on water from the global south remain under-researched. Though there have been recent advances in the research (Belay et al., 2020; Mihalopoulos, 2021; Warner and Meissner, 2021), there is scope for further exploration. In particular, the media framing of floods in the region requires further exploration (Jaung and Carrasco, 2022; Vij, 2022; Deka et al., 2023). Secondly, most of the previous research on this region is based on English language media. It is also relevant to explore news reporting in other regional languages, especially in decolonized societies, as despite the language of the elite being English, local politics often occur in regional languages.

This article addresses this gap in the literature by analyzing the patterns of reporting on water in a vernacular newspaper from the Global South. This article elucidates local language print media as the site of the construction of the dominant water meanings. Taking the example of media framing of floods, it analyses patterns of media reporting and the resulting discourse development on water management. According to the latest Indian Readership Survey, 25% of the population in Bihar reads at least one newspaper daily

([Indian Readership Survey, 2019](#)); thus, newspapers remain a major source of news in this region.

This study poses two research questions: (1) What is the pattern of water-related news reporting in the selected newspaper? (2) What kind of understanding of the floods do the news items convey? Based on the social constructivist paradigm of knowledge creation ([Feindt and Oels, 2005](#); [Fischer, 2000](#)), a qualitative analysis using a case study method is used to address the research questions ([Yin, 2011](#); [Bazeley, 2013](#)). Referring to the case study of a popular vernacular newspaper (*Hindustan*), this article explains how certain water world views are magnified and reinforced by the institution of print media. As the leading newspaper in the region ([Vardan, 2018](#)), *Hindustan* is powerful in shaping public view. Its reports can therefore be considered one of the dominant media narratives on floods in the region. By analyzing the limitations of the dominant narrative, this article builds a case for an alternative discourse on water.

2 Material and methodology

2.1 Region, newspaper, and time frame chosen

The study area chosen was Bihar, one of the most flood-prone states in India ([Figure 1](#)). Lying in the foothills of the Himalayas, it has the mountainous country of Nepal to its north. The Ganga flows through the middle of the state where several major tributaries originating in Nepal join it. In total, 70% of the state is flood-prone.

The news items published on water in a popular vernacular newspaper were taken up as the data set. The newspaper chosen was the Patna (Bihar's capital) edition of *Hindustan*, a Hindi daily. *Hindustan* is the leading newspaper in the state, with a wide circulation reach of 998,000 Average Issue Readership¹ ([Vardan, 2018](#)). It is a private newspaper where 75% of ownership is with Hindustan Media Ventures Limited (HMV Ltd.) and the rest is public. HMV Ltd. is a subsidiary of Hindustan Media, a leading mass media company in India with the majority of ownership stakes lying with a leading business family in India. It owns other print and digital media as well as other business ventures. Because of a lack of adequate legislation, Indian media suffers from concentration of power in a few families as well as significant cross holding of firms. Evidence of both has been found in *Hindustan* by [Vardan \(2018\)](#). Secondly, the independence of media reporting in an advertisement-based revenue generation model of business is inherently difficult. The government is one of the major advertisers in such models. It makes media houses vulnerable to external pressure by giving or withdrawing business in the form of advertisements. Some policies adopted by the state government in Bihar further accentuate this. Since 2005, the Bihar government has followed an advertisement policy whereby all advertisements go through a centralized unit rather than through individual departments. This change was made in 2005 and has

¹ A readership metric within the Indian Readership Survey (mruc.net), which measures the number of respondents who read the newspaper on the day previous to the survey.

made complete boycott of any newspaper possible ([Ray, 2019](#)). Heavy dependence on government advertisements, concentrated holdings, and cross holdings are key aspects of the *Hindustan* newspaper and are widely valid for media in India in general ([Reporters without Frontiers, 2019](#)). It affects the independence of media reporting. This is also reflected in the constant placing of India in the bottom quartile of the World Press Freedom Rank.

The time frame chosen was the 3 months in 2019 with the highest rainfall, i.e., July, August, and September, covering one year's monsoon season. Between June and September 2019, India received the highest volume of monsoon rainfall in the last 25 years. In 2019, the overall monsoon rainfall in India was 110% of the long-term average. Bihar also received above-average rainfall. It was expected that water-related news would receive significant media coverage in this period.

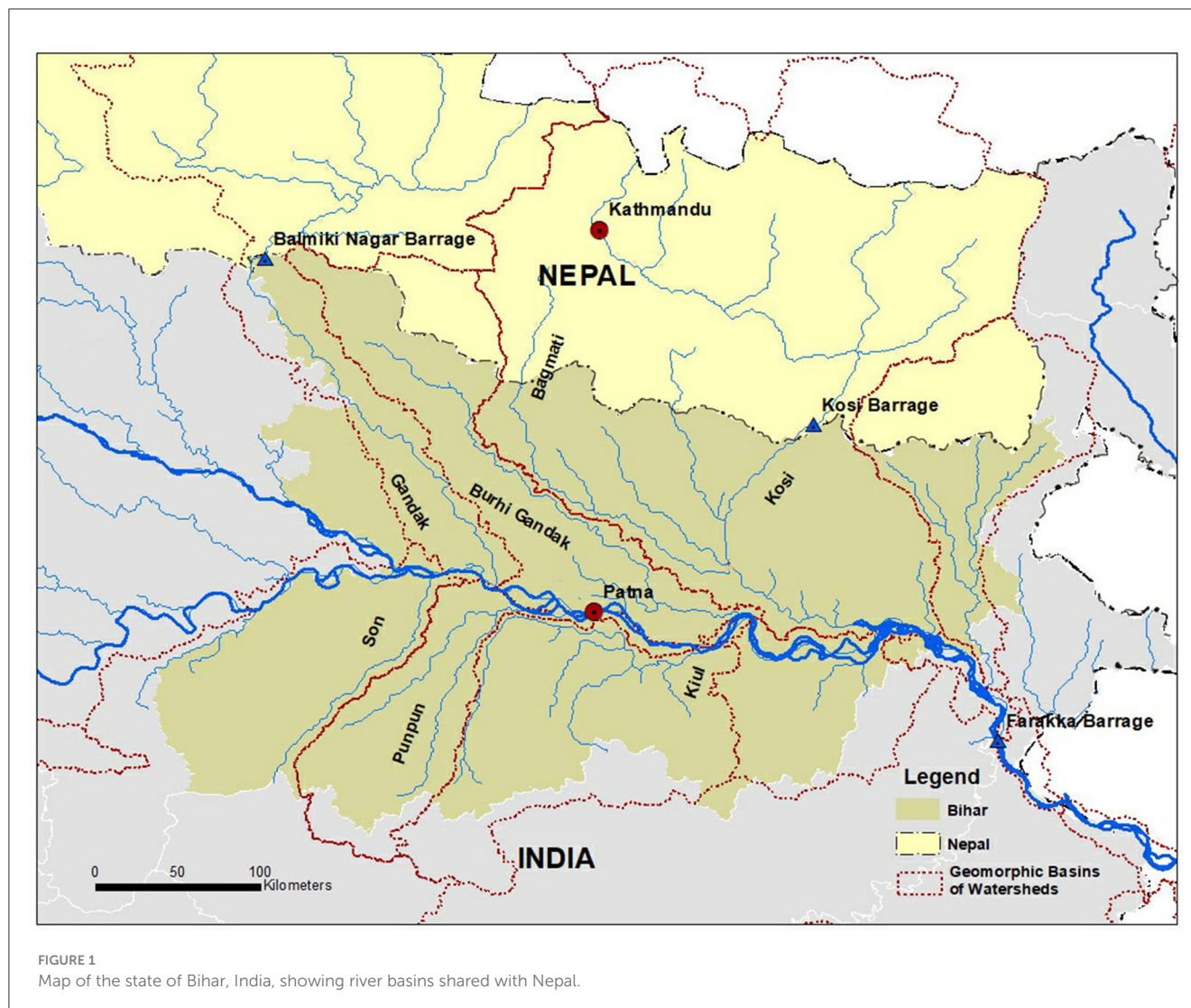
2.2 Data collection

The online version of *Hindustan* (Patna edition) was accessed through the news website [jionews.com](#). Through manual scanning, any news item covering water-related news was collected. These included two types of items. Firstly, articles with the words associated with water (*jal, paani, megh, varsha, dooba, barh, mansoon*),² as well as "Ganga" and names of its tributaries in the title were selected. Secondly, items that gave significant coverage to water-related issues (at least one paragraph) were also included even though they did not have any associated words in the title.

2.3 Step 1: identifying themes in water-related news items

In the first step, an inductive approach was used to generate coding categories ([Adu, 2019](#)). This step was based on descriptive analysis of data and aimed to be closely representative of the database. Sections of the news item were coded into sub-themes to describe their content. Descriptive indicators were defined to ensure codes were exhaustive and mutually exclusive. The aim was to maintain reliability throughout the coding process. Several articles had more than one sub-theme. Some sections within the news item also had overlapping themes. All these were coded as unique items. Sub-themes with a frequency of <two were disregarded. Using this method, 24 sub-themes were identified with a total frequency of 514. These 24 sub-themes were then grouped under 7 major themes. For example, sub-themes of water conservation, pollution, and climate change were put together under the theme of Ecological concerns. [Table 1](#) describes the 7 major themes and 24 sub-themes and provides their frequency of occurrence in the data set. The sub-themes that could not be put in any group were categorized as "Others." [Figure 2](#) explains the methodology through a flowchart.

² Water, clouds, rain, drowning, floods, monsoon.



2.4 Step 2: discourse analysis of news items under the theme “monsoon floods”

The next step was a thematic discourse analysis of news items reporting on floods. A total of 139 news items falling under the macro theme of monsoon floods were selected for this. “Discourses are diverse representations of social life which are inherently positioned—differently positioned social actors ‘see’ and represent social life in different ways, different discourses” (Fairclough, 2001, p. 123). Taking a critical approach, thematic discourse analysis identifies meanings other than what is explicitly communicated through “the systematic investigation of semiotic data (written, spoken, or visual)” (Wodak, 2002, p. 2). The 139 news items were analyzed to identify how discourses within the text construct the meaning of “flood” and legitimize certain viewpoints.

The coding and data selection were also informed by the author’s personal experiences as a resident of the study region.

Every effort was made to ensure the coding and empirical evidence collection was free from potential personal biases and to ensure the nuances were maintained while translating the news reports from Hindi to English for coding.

2.4.1 Developing the questionnaire and text analysis

After a review of related research literature in light of the discourse analysis method, five anchor questions were found relevant for the data set (Wodak, 2004):

i) *Is the news item spatially situated?* Emphasis on local events can blur the understanding of environmental problems that cross regional boundaries (Wagner and Payne, 2017). It “decontextualizes” the spatial connectedness and functional complexity of the event being covered (DiFrancesco and Young, 2011). A contextual understanding is relevant to the flood problem in Bihar, which is part of a transboundary river system. “Inward-focused” reports can create false perceptions of localized disasters.

TABLE 1 The 7 major themes and 24 sub-themes with their frequency of occurrence in water-related news items, *Hindustan*, 2019 (frequency of occurrence in bold).

Theme	Sub-theme	Description
1. Monsoon Floods 175	1. Damage due to floods 60	Information regarding damage and destruction due to floods, such as lives lost, property damaged, roads damaged, crops damaged, economic loss, cutting away of fertile lands, and disease.
	2. Flood management 54	Any information related to (1) measures to control the flood and reduce the intensity, such as reinforcement of embankments, piling sandbags, and monitoring of dykes; (2) measures taken for rescue and relief, such as distribution of relief money, rescue and relief action by National Disaster Relief Force and state administration, and demands of financial aid from the state to central government; (3) measures to mitigate floods in future, such as building new embankments, river interlinking, and dialogue with the Prime Minister.
	3. Rising rivers 51	Increase in water levels of rivers.
	4. Grievances against flood management 10	Public grievances related to any aspect of flooding, such as political demonstrations by opposition parties against flood management, local protests demanding flood relief distribution, local protests to be ratified by government as flood affected, and cases of corruption in the distribution of relief.
2. Water governance/policy 97	5. Government Schemes 60	Any information on government schemes related to water, such as (1) Schemes launched by government such as the <i>Jal Jeevan Hariyali</i> (for water conservation), <i>Har Ghar Jal</i> and <i>Nal Jal Yojna</i> (piped drinking water), Tube Well Scheme (irrigation), <i>7 Nischay</i> , <i>Jal Chaupal</i> (local water governance), Water Bank, etc.; (2) Expected benefits from the government schemes; (3) Implementation and inspection of schemes.
	6. Public Protest and politics 19	Protest by citizens and political groups on water issues, such as drinking water shortage, against corruption in flood relief distribution.
	7. Domestic water use policy 15	Information on existing and proposed government policy on water-related issues, such as access to potable water, disaster management policy, and removing encroachment along river beds.
	8. Diplomacy 3	Transboundary water management, cooperation and conflict with neighboring countries.
3. Ecological concerns 55	9. Water Conservation 42	Any information related to declining water levels and conserving water bodies and groundwater, such as renovation and restoration of water bodies, groundwater conservation, rules on conservation, and schemes for water conservation such as <i>Jal Jeevan Hariyali</i> , <i>Jal Shakti</i> , and rainwater harvesting.
	10. Pollution 8	Reports on water pollution, polluted river lakes, impact on people and aquatic animals, ways to control pollution, measuring river quality, and human chain for clean Ganga.
	11. Climate change 5	Scheme for addressing climate change, awareness about climate change
4. Urban water management 63	12. Waterlogging and sewerage management 36	Information related to waterlogging in cities, such as (1) excessive rainfall, damage in suction pumps, water pipeline leakage, traffic problems, damage, and health hazards; (2) damage to roads and property due to heavy rain and waterlogging in urban areas, and; (3) management of city sewage, such as dysfunctional sewage pumps and repair work.

(Continued)

TABLE 1 (Continued)

Theme	Sub-theme	Description
	13. Patna Flash flood, 2019* 27	Information related to sudden short-duration floods in the capital city and its surroundings after heavy rainfall in September 2019. Its aftermath, such as flooding in residential areas and roads, damage to property, etc., and relief and control measures are also included.
5. Public health and water 44	14. Potable water 31	Any information related to drinking water, such as shortage of drinking water, pollution in drinking water, schemes for piped drinking water, public protests for drinking water supply
	15. Health hazards 13	Health hazards due to waterlogging, stagnant water, and dengue
6. Agricultural water use 21	16. Irrigation 18	Information related to irrigation, such as current irrigation schemes, proposed schemes, and benefits provided by the schemes to farmers.
	17. Fishery 3	Information related to fishery such as promotion of fishery by state, impact of pollution.
7. Cultural relevance 17	18. <i>Pind Dana</i> 11	The <i>Pind Dana</i> is a Hindu ceremony of paying homage to ancestors by performing the last rites. Information regarding the ceremony included coverage of the event, participation by devotees, interviews with local pundits, and rituals being carried out.
	19. Recreational 4	Any recreational news item based on water, such as monsoon poetry, news stories of people enjoying the rain, and river bank strolling.
	20. <i>Chhath</i> 2	Information related to the upcoming <i>Chhath</i> (which is the most important folk festival in the region, celebrated by worshiping the sun at the banks of a river) such as preparations being made for the upcoming event, including cleaning up river banks and making <i>ghats</i> (steps to enter into the water).
8. Others 42	21. Death due to Drowning 15	Accidental deaths due to drowning in the river while bathing, suicides, and deaths due to boats capsizing
	22. Weather Report 14	News on expected rainfall in the next day and week, weather report of the previous day, i.e., rainfall that occurred
	23. Drought 11	Any information related to drought, such as the occurrence of drought, loss due to drought, and government schemes for relief and irrigation
	24. Hydropower 2	Hydropower generation

*News on the urban flash flood in Patna in September 2019 has been coded as a unique theme as it was a rare disaster affecting the urban center (Khan et al., 2022).

ii) *Does the news item adopt a holistic approach?* Water reports, particularly disaster reporting and conflict reporting, deal with multidimensional and complex issues. However, it has been observed that media reports, working under time and financial limitations, often oversimplify the context of the matter being discussed. This also results in errors of omission, emphasis, or facts (Singer, 1990). Emphasizing certain aspects at the cost of others also leads to agenda-setting by the media (Hansen, 2011; Trumbo and Kim, 2015). Often, news items remain focused on a singular “event,” without situating it in the larger narrative or “issue.” This type of reporting can lead to misrepresentation as well as a rise in tension across borders (Dewedar, 2021; Vij, 2022). Holistic reporting is

important in Bihar, which shares boundaries with Nepal and is prone to transboundary conflict.

iii) *Is the reporting factually sound?* Fact-based reporting can help build a culture of trust in media reports and help avoid sensationalism. Providing data points as well as their sources is one of the good practices of journalism (Bourassa, 2013; Rögener and Wormer, 2017). In water reporting, stories of surplus and shortage can be substantiated with such verifiable data. Moreover, while reporting on the official statements, they can be complemented with facts to reduce bias toward political parties and governments.

iv) *What kinds of solutions are proposed and supported by the news item?* In the context of floods, different options

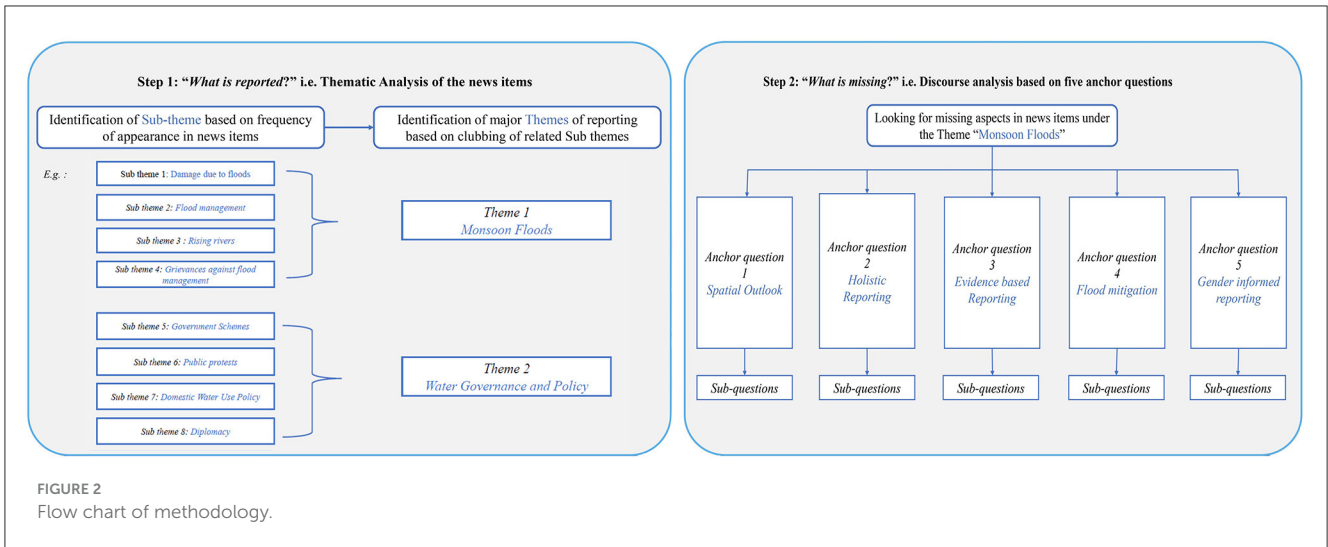


FIGURE 2
Flow chart of methodology.

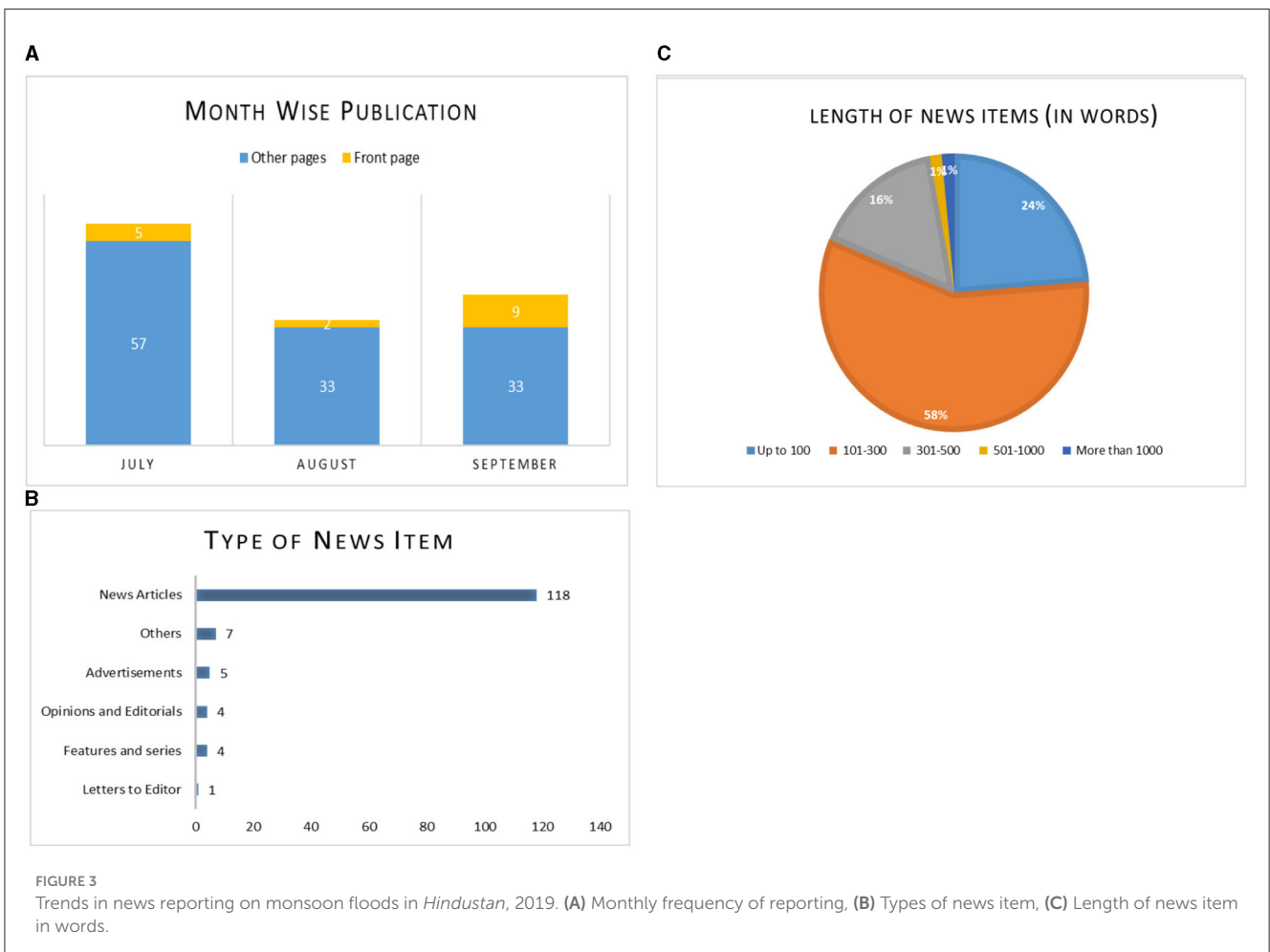


FIGURE 3
Trends in news reporting on monsoon floods in Hindustan, 2019. (A) Monthly frequency of reporting, (B) Types of news item, (C) Length of news item in words.

for flood management and mitigation exist. These range from heavy engineering-based solutions, such as building dams and embankments, to nature-based solutions based on local water management. News items favoring one set of solutions leads to agenda-setting by the media (Hansen, 2011; Trumbo and Kim, 2015).

iv) Is the news reporting gender-balanced? Wood (1994) identified three ways in which media reporting is problematic from a gendered perspective. Women are generally underrepresented. When mentioned, they are presented in stereotypical ways that affirm gendered social and cultural norms. Thirdly, when both men and women are mentioned, the media emphasizes the traditional

roles of each gender. This pattern of reporting continues to be seen even in current times (Gallagher, 2013; Krijnen and Van Bauwel, 2021). In the context of reporting on natural hazards, women and children are among the most vulnerable groups. While reporting on devastation and damage due to floods, news items can give space to the concerns of the most vulnerable groups. News items with a gender lens can highlight this (Murthy, 2010; Joseph, 2013).

These five anchor questions were operationalized by developing sub-questions that could capture relevant text (Table 2). Through this method, a detailed questionnaire was developed. All the questions were in one of the following three formats: Boolean (yes/no), string (whole sentences), and multiple option type questions (Appendix I). Reliability was maintained by ensuring the questions were exhaustive as well as mutually exclusive. Each news item was then analyzed through this series of questions to generate codes.

2.4.2 Key informant interviews

The results from the news reports were triangulated with opinions from the media people through key informant interviews. Key informant interviews were conducted with one field reporter and three senior reporters to gather additional information on the process of news report creation and the media expert's perspective. In the text, they are referred to as R1, R2, R3, and R4. All four of them were employed by *Hindustan*. Three of them were based in the Patna office of the newspaper. They were contacted and interviewed in person there. The field reporter based in Darbhanga was interviewed via telephone.

2.5 Limitations

The conclusions of this study are based on the media coverage of a single flood season, i.e., the time frame of 3 months. The small time frame limits the generalizability of the results. Moreover, as the questionnaire in Step 2 (Section 2.4) is theoretically derived, it is limited to the exploration of already established themes. Finally, all the documents were coded solely by the author. The conclusions must be read within these limitations.

3 Results

3.1 Pattern of media reporting on water-related news

As the sample was taken for the monsoon season when floods and other water-related events are frequent, wide coverage of these issues is seen in the newspaper. For the months of July, August, and September 2019, 376 articles reporting on water-related issues were found. Out of these, 110 (29.3%) news items were published in July, 122 (32.4%) news items were published in August, and 144 (38.3%) news items were published in September. Water remained an important issue in the media. This can be gauged from the fact that more than 9% of all the news items were printed on the front page of the paper. Water news was covered through various types of

news items ranging from news articles, opinion articles, editorials, feature series, advertisements, and photo articles (Figure 3).

3.2 Patterns of flood reporting

Based on the thematic coding, 139 articles reporting on the monsoon floods in the state were found. Out of these articles, 16 (11.5%) were published on the front page. In 10 cases, full-page or three-quarter-page coverage was given to flood news. Out of these news items, the majority (80.3%) were news articles. The newspaper ran a series on damages due to floods called “*barh se barbadi*” or sometimes “*barh ka kahar*,” both meaning “devastation due to floods,” which recorded the daily damage caused by floods in different regions. A total of 26 (18.7%) articles were found to be tagged under this series. The articles were of varying length: 81% of articles were <300 words and 23.7% of these were up to 100 words only. Authorship of the items was credited to the *Hindustan* Bureau for 72 (51.8%) items, individual reporters for 39 (28.1%) items, a news agency for 1 (0.7%) article, and government advertisements for 6 (4.32%) items, and 21 (15.1%) items had no authors mentioned. During the interview, R1 explained that it is a standard practice at the newspaper to mention the reporter by name only for exclusive news items: “If a reporter files 5–6 stories, only the exclusive content carries the name of the reporter. Others are published under the bureau’s name.”³ In fact, this is a trend in all Hindi newspapers and many reports are published under “correspondent.”

3.2.1 Spatial outlook

Monsoon floods affect Bihar and Nepal as they share several transboundary tributaries of Ganga, such as the Gandak, Bagmati, Burhi Ganndak, and Kosi. However, most news items fail to highlight the spatial interconnectedness of the floods as a basin-wide and transboundary phenomenon. Out of the total 139 articles, most (93%) have a localized, state-centric outlook. They exclusively cover the flood situation in different parts of Bihar. The articles remain focused on the singular flood events within the state, with little space given to events and their impacts in upper or lower riparian regions. This fosters a sense of spatial disconnect. Only 9 articles (6.5%) covering the situation across the provincial or national border were found. Out of these, the majority of the articles reported on the expected rainfall in Nepal and its possible impact in Bihar. Only three reported on the simultaneous devastation caused by floods in the foothill (*tarai*) regions of Nepal. While the reports are largely parochial in outlook, an exception is that the cause of floods is often framed as lying outside the state. Most of the reports on rising waters and threats of floods begin with the mention of Nepal. A total of 17 articles explicitly mention rainfall in catchment areas of rivers lying in Nepal as the cause of floods and 10 other articles indirectly refer to Nepal and other neighboring states in the context of flood occurrences. Overall, there is a pattern of spatial disconnect in the reporting. In interviews, reporters highlighted the obvious need to cover local impact in greater detail. They said they

³ 5th of June 2023, *Hindustan* Patna office, Senior Reporter at *Hindustan*.

TABLE 2 Anchor questions and sub-questions developed for discourse analysis.

Anchor question	Sub-questions
A. Is the news item spatially situated?	1. River/tributary being discussed 2. Districts covered; cities covered 3. Geographical position/outlook: Regional, National, Bilateral, State centric, Other 4. Does the article cover Situation on the other side of the boundary (transboundary)? 5. Does the article blame another country/province for the water-related issues? (Explicit and direct or implicit and indirect) 6. Does the article cover an issue that is about water cooperation, water conflict, or. both?
B. Does the news item adopt a holistic approach?	1. Event-based (unidimensional) or Issue-based (holistic) 2. How strongly does the article link the event and issue? (Coverage given) 3. Does the article differentiate between proposed plans and actual execution? Does the entire article consist of an official's quote or a summary of such without contextualization? 4. What is the article dealing with? a. reporting death, damage, etc.; b. need and availability of relief; c. mitigation
C. Is the reporting factually sound?	1. Does the article have any data? 2. What is the source of data? 3. What type of statistics are used? 4. Does it include a quote/statement from a resource person? 5. Professional background of the person?
D. What kinds of solutions are proposed/supported?	1. Does the article propose a solution to the discussed water and water plus problem? 2. What type of solution is proposed? 3. Does the article include analytical reporting or advocacy of a particular solution?
E. Is the news reporting gender-balanced?	1. Are gender-relevant concerns addressed in the article? 2. Does the article include examples of the impact on women/young children/pregnant women? 3. Are there any images of women or any other gender-relevant images in the news report? 4. Is the language gender-neutral? (Or is there evidence of gender bias in the language of the article?) 5. Are the data provided in the article gender disaggregated where relevant?

had little incentive to cover cross-border impact as the newspaper caters to readers in Bihar, who are more interested in local news. R4 also highlighted the lack of general awareness of floods as an interconnected phenomenon among reporters alongside the lack of resources to cover these issues across borders.

3.2.2 Holistic approach

It was observed that news stories focused more on the immediate causes of floods than on the policy problems that underpin them. Most news items covered a singular flood “event,” without situating it within the context of the larger narrative or “issue.” This contributes to an oversimplification of the understanding of floods in the region. Out of a total of 139 news items, 136 reported on singular events, such as the rising levels of rivers and damage caused by them, without contextualizing them. Thus, it is evident that daily news items remain event-driven. R4 said that the focus of ground-level reporters is more on immediate concerns such as damage caused or disease spreading. R2 said, “More detailed news is generally published in the form of series, divided into several parts (see footnote 3).” Overall, reporters believe that fact-based and concise news retains the attention of readers. All of them agreed that due to limited word space, more detailed and analytical news cannot be published in an article.

Another trend observed in the text is reproducing the official statement without contextualizing or corroborating with other sources. These news items capture post-event press news, often related to disaster and flood control measures. Statements from official sources are summarized uncritically in the form of news report. As can be seen, such news reports end up amplifying government press releases rather than critically reporting on

them. Six such news items were found in the data set. R1 said that if the press release comes from an authority such as the District Magistrate office, it is generally assumed to be authentic, explaining that “Sometimes data is cross-checked by getting ground-level information from local contacts. If there is a significant discrepancy, we publish it (see footnote 3).” But this is not the usual practice.

3.2.3 Fact-based reporting

Only 40 (28.8%) news stories were supported with relevant data. These included data on expected rainfall and rising water levels in rivers, damage and death due to floods, and expected benefits from new projects. Only 16 (11.5%) articles mentioned the source of their data, many of which were reports on the rising water level of rivers and expected rainfall. Most of the articles reporting on rising water levels in the rivers cited the Central Water Commission of India as their source. Articles reporting on expected rainfall cited the State Weather Department as the source. The third frequently mentioned source of data was the State Water Resource Department. Secondly, 10 (7%) news items had a direct quotation from a resource person to support the news item. These included a quotation from the district administration officers regarding flood preparedness and statements from the State Water Resource Minister and the Chief Minister of the state. Government data and officials were the most often cited sources in the news items. In the entire data set, there was only one article that quoted a non-official source, i.e., an expert. News articles are thus amplifying the state narrative.

In the interview, journalists corroborated that government press releases are often their primary source of news, and their

factual correctness is taken for granted. Similarly, R1 said, “When a press release is coming from the District Administration Office, we assume that it is authentic (see footnote 3).” Reporters work in close collaboration with government officials. All of them emphasized their role as amplifiers of flood relief provisions made by the government.

3.2.4 Flood mitigation

Though floods are a major problem in the region, very little print space was occupied in the newspapers by discussion on flood mitigation. Only 15 news items (10.8%) reported any kind of solution to the current water management problems. The flood mitigation measures proposed were found to be of five categories: technical/engineering-based, nature-based solution, political/diplomatic solution, community-based, and administrative reforms. Most articles suggested a combination of these measures. The most commonly reported were technological and heavy engineering solutions (in 10 news items), followed by state-led political solutions (in 2 news items) and community-led solutions (in 2 news items). One editorial and one opinion article presented a comprehensive picture of the flood situation and were more analytical. The other 12 items were news reports that advocated the construction of more embankments and the proposed Kosi-Mechi River interlinking scheme. All the reports are for proposed projects to be implemented in the future. All four reporters believe that engineering solutions are most suitable to help control floods. R3 gave specific examples regarding information on the Farakka, explaining “I have developed this opinion based on articles of local experts. I also gathered information while covering the Chief Minister *Janta Darbar* (Public Meetings) where he frequently talked about these issues (see footnote 3).”

3.2.5 Gender

No articles on the floods in the region were found to be reported by women. Only one female author was identified, who was a reader writing back to the paper on flood management. Only 4 (2.8%) articles out of a total of 139 were focused on women. One was a report on a rescue mission by the National Disaster Relief Force to help a pregnant woman; the second reported on the administration prohibiting women from taking baths on ghats with rising water; and the third mentioned relief amounts claimed for *Anganwadi*, a government scheme for young children and lactating women. The fourth article only included an image of a woman in a temporary hut over the highway. Women reporters were found to be underrepresented and the reports, stereotypical. This is a trend in the journalism sector in general in the region. R1 reported that there were currently only two women reporters at the Patna desk of *Hindustan* and no women editors. R4 believes that it is especially difficult for women to cover flood-related news: “Reporting from flood-affected areas is risky. It is inconvenient for female reporters to travel in such areas. Moreover, sometimes flood-affected people are angry with the administration as they have lost houses and property. It is unsafe for women reporters to interact with such an aggressive crowd.”⁴

4 9th July 2023, Field Reporter at *Hindustan* Darbhanga desk, via telephone.

4 Discussion

4.1 Narratives on floods emerging from the data set

The news items frame floods as natural disasters that are exacerbated by rainfall in the catchment areas of Nepal as well as sluggish discharge from the Farakka Barrage. News items also reported on the interlinking of rivers and the construction of embankments as the most suitable methods of flood control. These are the two most dominant themes in the discourse on floods in the data set of this study. It appears that through these themes, the news reports reinforce the state’s narrative on floods in the region. However, this portrayal of floods is problematic.

4.1.1 Framing floods as natural disasters

The news items mention heavy rainfall in the catchment area of the Ganga as the cause of devastating floods. They also heavily emphasize the destruction caused by the floods. During the monsoon season of 2019, the newspaper ran a series named “Destruction due to Floods” that reported on all the destruction to life and property caused by the floods. The series had 26 articles across the months of July, August, and September. The newspaper, thus, framed floods in the state as an unwelcome natural disaster caused by excessive rainfall in the huge catchment areas. The following is an example:

*“The impact of torrential rainfall in Nepal and north Bihar is now visible in the rising water levels of rivers in North Bihar. . . Because of copious rainfall in Nepal, the pressure on the Gandak barrage in Valmikinagar has increased. So, 1 lakh cusec water was released from the Gandak barrage, the highest release this season.” (“Pressure on embankments increase due to rainfall in North Bihar,” *Hindustan*, 11th July 2019)*

A large number of reported items also mention the rainfall in Nepal, insinuating a link between the rainfall in Nepal and threats of devastating floods in Bihar. For example, in this very short report of approximately 150 words, Nepal is mentioned three times:

*“Due to heavy rainfall in Nepal and Bihar on Saturday, the threats of floods in the state have increased. The situation is continuously deteriorating. The Bagmati River has registered a record increase in its water level. . . It must be noted that there is a possibility of heavy rainfall on Sunday in the catchment of all rivers originating from Nepal. . . Because of heavy rainfall in Nepal and Bihar, the Bagmati, Kamla Balan, Bhuthi Balan, Adhvara, and Mahananda rivers are flowing above the danger mark.” (“Situation in north Bihar deteriorates” *Hindustan*, 15th July 2019)*

Overall, 27 (19.4%) news items mention rainfall in the neighboring country or province as the cause of flood events. Out of these, 17 (12%) news items mention Nepal explicitly and directly. Often the news items mention Nepal in the very first sentence. Similarly, an argument is built against the slow discharge of water from Farakka Barrage at the India-Bangladesh border, blaming it

for the water woes in September. In one news article, the Chief Minister of the state was quoted as saying the following:

"In view of the rising water levels in the Ganga and the water spreading in the surrounding areas, the Chief Minister spoke to the central government on Saturday. The Chief Minister has informed the central government that the water of the river Ganga is not flowing adequately from the Farakka Barrage. Due to this, a serious flood situation may arise in 12 districts along the banks of the Ganga." (Hindustan, 22nd September 2019)

Seven similar articles were published in September, when the state experienced heavy rainfall and extensive waterlogging.

The articles frame floods as natural disasters due to rainfall from Nepal that are exacerbated by sluggish discharge from Farakka Barrage. This narrative is a reproduction of the government's position on floods. Defining floods in the region as a natural disaster has been the official position of the state of Bihar for decades. For example, The District Disaster Management Plan, (Madhubani) Volume 1 describes the local disaster vulnerability as follows: "The district has traditionally been vulnerable to different disasters on account of its unique geo-climatic condition... The land pattern of the area is declining in nature, making most of the land low-lying. During monsoons, rivers get filled with water and begin flowing over the sides, causing floods" (Government of Bihar, 2013, p. 4). Thus, the media and the state narrative frame floods as events caused by heavy rainfall and leading to damage to life and property, i.e., disasters. The implication is that the rivers must be controlled so that floods can be avoided.

However, this is in stark contrast to the existing scientific knowledge on the nature of floods in Bihar. In the middle plains of a young river system like the Ganga, floods are a natural part of the hydro-geomorphology of the region. Lying in the foothills of the Himalayas, the rivers also have an unusually high sediment load. The river systems in the region, especially the Kosi, are highly dynamic due to the process of avulsion, resulting in frequent channel shifts (Kale, 2008; Gupta et al., 2021). Thus, floods in the region cannot be stopped and they are not truly undesirable. Indeed, floods have traditionally been associated with prosperity in the region. Historically, floods occurred as sheet floods for a short duration of 3 to 4 days. They brought rich alluvial silt, which replenished the agricultural fields of the region (Rorabacher, 2016; Jha, 2021). These floods were traditionally welcomed as harbingers of fertile silt. They contributed to the rich agricultural practices and social life was built around them (Mishra, 2008; Rorabacher, 2016; Jha, 2021). However, due to structural measures taken to control floods since the early 20th century, the nature of floods in the region has completely changed. The construction of railways and roads and the zamindari levees in the early 20th century interfered with the natural flow of rivers in the region (Singh, 2008). In 1954, the Bihar Flood Control Policy was launched, which also promoted structural interventions like barrages on foothills and embankments along rivers for flood management. Over the past seven decades, such interventions have resulted in intensified floods in villages lying within the embankments and have caused sudden and prolonged waterlogging when waters have breached the embankment and reached areas outside (Mishra, 2008; Singh, 2008; Khan, 2018; Dixit, 2020). However, the newspaper reports

have completely ignored these anthropogenic causes of floods in the region and blamed it on heavy rainfall in catchment areas.

The portrayal of floods as "natural" disasters by the media often obscures the anthropogenic influences exacerbating their intensity and frequency. This framing overlooks human activities such as land use changes, inadequate infrastructure, and urban development, which significantly contribute to the severity of flooding events. By delving into the pre-disaster and post-disaster phases, news outlets can spotlight the imperative of proactive measures in flood management and recovery (Houston et al., 2012; Bohensky and Leitch, 2014). Particularly in the Global South, this issue remains under-researched. Effectively cultivating media narratives that accentuate human agency in flood resilience and mitigation can foster broader awareness and action.

The newspaper narrative also habitually brings Nepal into the discussion on floods. Blaming Nepal for floods has been a common practice for the political class in the region (Iyer, 2008; Kumar, 2020). It has often been argued that a lack of cooperation with Nepal leaves no way to control floods as three-quarters of the catchment areas lie in that country. Every flood season, state ministers point the finger toward the upstream country for releasing water. In 2020, the ruling party spokesperson commented that the "situation worsens every year after Nepal releases water through its barrage. Amid the recent tension, flood fighting may be a challenge" (Kumar, 2020). However, this amounts to misleading the public, as control for the barrages lies with Indian engineers and Nepal cannot release any water from the barrages (Iyer, 2008). Activist and scholar Dinesh Mishra writes, "Bihar has two barrages on Gandak and Kosi and the responsibility of manning them is in the hands of Bihar engineers" (Mishra, 2019). Newspapers frequently referring to Nepal while reporting on floods reinforces the perception that floods in the state are caused by rainfall in Nepal. Reproduction of official statements as news items, without providing relevant counterfactuals, also adds to this perception.

A similar pattern of reporting is observed in the month of September when sluggish discharge from Farakka is blamed for floods in Bihar. However, there is no established linkage between the two (Khan, 2018; Das et al., 2021). A report from South Asian Rivers of South Asia (SANDRP) mentions "How far the Farakka impact is there to the [sic] upstream of the barrage in terms of such sluggish flow and prolonged flooding is again a matter of speculation since Central Water Commission does not have credible information about river behavior pre Farakka and even post Farakka" (SANDRP, 2018). Still, such claims from State Ministers were published in the newspaper without providing any factual support or context. The reports read like a reproduction of the government point of view and lack any fact-based reporting.

4.1.2 Emphasis on structural solutions

In this study, the newspaper narrative on flood mitigation was found to be in favor of structural measures like embankments and river-linking projects. The most commonly reported were technological and heavy engineering solutions (10 news items), followed by state-led political solutions (in 2 news items) and community-led solutions (in 2 news items). Among heavy engineering solutions, the most frequently reported were

embankments. An embankment is a raised mud levee seeking to regulate river flow and prevent flooding. In six reports, flood management was narrated in terms of embankment repair, construction, and breach. An article from July 2019 included the following statement:

“A permanent solution will be found for the annual flood situation in the Mahananda River valley. For this, the Parman and Riga rivers shall be dammed. Both projects will run simultaneously ... the Chief Minister addressed the chief engineer of the Flood Control Department and enquired why the Mahananda embankment, which had been breached in the 2017 floods, had not been repaired yet.” (“Permanent solution of floods due to Mahananda river-CM” *Hindustan*, 22nd July 2019)

However, there was negligible reporting on the long-term impacts of embankments. One opinion piece discussed the long-term negative effects of embankments. Two reports of protests by villagers against rebuilding a breached embankment were also found, but these were very short articles printed in the last few pages of the newspaper and published without addressing the reasons for the protest against rebuilding embankments.

Favorable reporting of flood mitigation proposed through river-linking projects was found in some news articles. The nationally approved river interlinking project to transfer water from the Kosi to the Mechi River was presented in news reports as a positive development for the state’s water management. An article from 3rd August exemplifies this narrative:

“Good news for Bihar! The central government has given approval to the state’s Kosi Mechi River Interlinking Project ... On completion, this project will irrigate 14,000 hectares of land in North Bihar... this project will benefit four districts of the state. Maximum benefit will be accrued by the Araria and Purnia districts, which will get irrigation water for 59,642 hectares of land and 59,970 hectares of land, respectively.” (*Green signal to the Kosi-Mechi River Linking Project*, 3rd August 2019)

While there were four articles discussing river linking, none of them discussed the possible negative impacts of the project. This preference for heavy engineering-based flood management policy is aligned with the state policy on flood management. The vision board of the official website of the Water Resource Department, Government of Bihar, reads as follows: “Flood management works implemented so far comprise the construction and maintenance of embankments, revetment in selected portions of river banks, land spurs, and other necessary flood protection works” (*Government of Bihar*, 2023).

However, exclusive reliance on structural interventions for flood control has been questioned by scientists as well as grassroots activities for a long time. Growing empirical evidence suggests that despite massive investments, embankments have been unable to deliver on their promise (*Mishra*, 1997, 2008; *Shrestha et al.*, 2010; *Pritchard and Thielemans*, 2014; *Dixit*, 2020; *Singh*, 2020). The Bihar Flood Control Programme was started in 1954 and relied heavily on dams and embankments. At that time, there were 160 km of embankments, and 2.5 million hectares of land were considered flood-prone. In recent times, while the length

of embankments has increased to 3,790 km, the area affected by floods has also doubled to 6.8 million hectares (*Singh*, 2020). Even the Second Bihar State Irrigation Commission (1994), while reviewing the causes of floods between 1968 and 1991 admitted that the damages had increased gradually and significantly over the period (*Sinha*, 2008). The embankments create a false sense of security, which encourages people to settle in the low-lying flood plains (*Dixit*, 2020). While people living within the embankments face permanent waterlogging and soil degradation, the intensity of floods in regions lying outside of the embankment becomes sudden and destructive whenever embankments are breached under water force. These areas then remain waterlogged for months. Embankments have also created the problem of raised river beds. As an expert stated, “Since 1959, when the embankments were completed, the silt and sediment have had to settle within the straitjacket instead of being spread across the Kosi’s ‘in land delta’ of eastern Bihar. This has meant that more than five centimeters is added to the level of the riverbed every year. As a consequence, we now have a situation where the largest tributary of the Ganga flows on a raised platform above the outlying floodplain. Essentially, the Kosi flows on a plateau that is between four meters to five meters higher than the area outside. It is a river in disequilibrium” (*Dixit*, 2020). In the current paradigm of flood management, unexpected devastating floods have become inevitable (*Mishra*, 2008).

Experts have also been pointing to several loopholes in the Kosi-Mechi Project. Several gaps in the environmental assessment of this project have been reported (*Varma*, 2022). It is feared that the project will take water to an already surplus region and might, in fact, lead to problems of further waterlogging. Local farmers have never been in support of this project. However, these aspects were never discussed in the newspaper. None of these aspects of structural interventions made it to the reports in the *Hindustan*. One reason is that the negative impacts of embankments are not visible immediately. However, a reporter sensitized to the water management problem in the region can contextualize any report on building more embankments and question the utility and value of the already built embankments. The small size of the write-up may also be a constraint to addressing the complexity of the water issue. It nudges the author to be more event-focused rather than exploring the underlying policy issues. A quarter of the news items were <100 words. This format promotes oversimplification due to word count limitations. There is also a trend of authorless reports in the newspaper. Several reports were vaguely attributed to “*ek samvaddata*” (a reporter). This indicates a lack of dedicated journalists reporting on ground issues related to floods. There appears to be a culture of *ad-hoc* reporters who are not full affiliates of the newspaper but work on a temporary basis. Reports filed by these reporters are often nameless and lack the nuances that trained journalists would have. This was also confirmed through the KII.

4.2 Need for a new discourse on floods

The dominant media narrative paints a picture of floods that is damaging for the people living across the north Bihar plains. Thinking of floods as “natural disasters” caused by “heavy rainfall in Nepal” deflects all responsibility outside the state.

Positive reporting on embankments creates a positive public perception of structural interventions, which, in the long run, bring about even greater disasters. Overall, the current pattern of reporting creates a positive public perception of the current paradigm of flood management. However, it is precisely the technology-centric flood management policy that has kept the region in a vicious cycle of underdevelopment and poverty. In 2019, 1,724 villages in 26 districts were affected by floods and 30 people were killed (Singh, 2020). The marginalized sections are even more vulnerable to the annual deluge. In a case study on the impact of embankments in Muzaffarpur district in Bihar, Pritchard, and Thielemans called embankments a maladaptation that has contributed to “recursive cycles of vulnerability” disproportionately affecting women, children, and the landless Scheduled Castes in the region (Pritchard and Thielemans, 2014 p. 325). People living within the embankments are most affected; they often come from the poorest sections of society and their lives are uprooted by floods every year. There is also the uneven economic burden on the landless and marginal landholders who are forced to migrate in search of employment as their lands remain waterlogged or infertile due to sand depositions (Rodgers and Rodgers, 2011; Datta, 2022). The newspaper was silent on the concerns of the sections of society most impacted by current flood management. It is convenient for the administration when the flooded people target their anger toward Nepal or seek immediate relief through more embankments.

Over time, a section of society has developed that benefits from this model of flood management. Currently, three billion Indian rupees are spent annually for constructing and repairing embankments in the state (Dixit, 2020). Water activists in the region have identified an “embankment mafia” that benefits economically from the annual cycle of construction and repair of embankments (Gyawali, 2008; Dixit, 2020). The never-ending construction and repair work of embankments has ensured cash flow for a nexus of politicians, bureaucrats, and engineers in the state (Dasgupta, 2007; Mishra, 2019). Ever since the enactment of the National Disaster Management Act, 2005, huge money has also been circulating in the flood-affected districts as relief money every year. It has been reported that the process of identification of flood victims eligible for relief has witnessed rampant corruption. Moreover, the goodwill that is created by any relief that reaches the hapless people translates into votes for politicians in future elections (Mishra, 2004, 2019; Singh, 2020; Ranjan, 2022). All these people stand to benefit from the dominant media narratives on floods.

4.3 Living with the floods

The organic relationship that was previously acknowledged through a socio-economic and political-cultural system that existed in society has been gradually eroded from the public memory. From the “green society” until the mid-20th century, Bihar has been turning into a “technical society” ever more in the grips of floods (Di Baldassarre et al., 2015). Instead of the centuries-old culture of welcoming and harnessing floods, society now wants to “control”

the river and would much prefer to “prevent floods” (Mishra, 2019). There is a need in the region to go back and re-acknowledge the older ways of knowing the waters in the region and accommodate them within the system of water management. A counter to the dominant narrative can be seen through the ideology of “living with the floods” (Mishra, 2001; Gupta et al., 2021). Informed by local practices of flood management and taking into account the limitations of modern technology, there is a need for a change in the state flood management policy. Scholars and local water activists have been advocating a change in the current methods of flood management. Some online news portals have also been covering floods from this perspective. However, their reach is limited due to limited audiences. The political groups, propelled only by the next election, also have no incentives to pay heed to their suggestions.

The media can have a seminal role in rekindling a debate on the nature of floods and the best management policies possible. This requires more variety in news reporting on water in newspapers. The major issues identified in reporting are a lack of awareness of the complexity of water issues, untrained reporters, limited time and resources, and attempts to cause deliberate sensation (Jeffrey, 1993; Dewedar, 2021; Vij, 2022). In the studied data set, all these were evident. Very short news items (100 words) should be balanced with more detailed write-ups that express the nuances of the event. A culture of fact-based reporting and contextualization of press reports before publishing them could be steps in the right direction. More nuanced reporting on water issues would require reporters’ sensitization and training on environmental reporting. Big media houses could have desks dedicated to water news reporting. Transboundary workshops for reporters reporting on water, particularly floods, could make them more aware of the transboundary nature of the floods, leading to more spatially situated reporting (Dewedar, 2021; Gupta et al., 2021). Moreover, new media could fill in the gaps left by print media.

5 Conclusion

This study highlights how media reports reinforce dominant narratives on water governance and flood management. While the media house has a political economy deeply aligned with local government, there is also a lack of awareness of alternative paradigms. Though focused on a vernacular in a state in India, the study has broader relevance for media narratives on natural disasters in other similar regions across the world. It questions the framing of floods as natural disasters and overemphasis on structural resolutions.

While the media can strengthen the dominant narrative, it can also be a forum for imagining alternative methods of flood management. By shifting the focus from extensive coverage of disaster-related damage to also include pre-disaster and post-disaster scenarios, the media can play a role in creating dialogs about recovery and resilience. Highlighting the basin-wide nature of the flood phenomenon could act as a check on the rise of parochial sentiments in regions experiencing transboundary floods. Through a participative approach between the media and its readers, newspapers could be a space to explore plural ways of

understanding floods. The media has the potential to be an ideal forum to imagine alternative narratives on floods.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Author contributions

The author confirms being the sole contributor of this work and has approved it for publication.

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Supplementary material

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/frwa.2024.1039240/full#supplementary-material>

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