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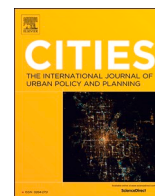
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Examining Sponge City coverage and perceptions in global news media

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ABSTRACT

Many countries are developing sustainable urban water management approaches to tackle the increasing risks of rainstorms due to climate change. As such, in China the Sponge City Program (SCP) was adopted in 2013. To ensure successful adoption, the SCP should incorporate social indicators, such as public perception and uptake. News media is a key channel to relay information to the public, yet the role and influence of media outlets in portraying the SCP have not been investigated. We reviewed 786 online news articles published from 2014 to 2022. Our analysis found alignment between media reports and academic research on high-level SCP functions (mainly urban water management, and its ecological, socio-cultural, and economic co-function) and its challenges (financial constraints, technical difficulties, and governance issues). However, the media often lacked nuance, such as the detailed extent to which SCP can mitigate flooding, which could pose risks for future practices. This study highlights the critical role of online media in shaping public perceptions and influencing decision-making within SCP similar approaches, and the need to understand the complexities of flood processes and SCP to drive policy changes. As the narrative and coverage of such approaches evolve and mature, we recommend greater engagement between academics and the media.

1. Introduction

In recent years, the intensity, frequency and distribution of extreme weather conditions, especially short-duration, convective rainstorms have been increasing due to climate change. This is a particular issue for highly urbanised areas and results in urban flooding when impermeable surfaces are unable to cope with rapid influxes of rainfall (Dharmarathne et al., 2024). As a result, urban flooding continues to cause damage, loss and disruption to people and society (IPCC, 2023). These problems are exacerbated by rapid urbanisation and land use changes, concentrated population growth in cities and climate change which alters precipitation intensity and frequency.

Cities have been developing sustainable urban water management approaches from the 1970s onwards to reduce flood risk while

conserving water and improving water quality (Yao, 2019). In response, Green Infrastructure (GI) which works with natural processes to address holistic urban water challenges are being adopted globally (Green et al., 2021). GI is an umbrella term and used somewhat synonymously with a range of regional-specific terms including Low Impact Developments (LIDs) and Best Management Practices (BMPs) in the USA and Canada, Water Sensitive Urban Design (WSUD) in Australia, Nature-based Solutions (NbS) in the Europe, Sustainable Drainage Systems (SuDs) in the United Kingdom and Sponge City Program in China (Fletcher et al., 2015; Li et al., 2020). All terms refer collectively to the sustainable management of urban water using varying degrees of natural 'green' processes (i.e. vegetation and soil).

Within China, the Sponge City Program (SCP) refers to a new urban planning model for integrated and sustainable water management,

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featuring both green and grey infrastructure. The SCP was initiated in China in 2013 with an initial focus on urban flood management and has since become further established as a sustainable and holistic water management paradigm (Chan et al., 2018). In 2015 and 2016, the central government of China selected 30 pilot cities with diverse natural and social conditions for the SCP trial. By the end of 2019, all pilot cities had completed performance assessments. Building upon these trials, China initiated the nationwide promotion of Sponge City demonstrations in 2021 (Yin et al., 2022). However, despite the potential benefits for both society and biodiversity, the SCP is rarely conducted at a larger, catchment-wide scale. This is similar to Natural Flood Management (NFM), which has often been implemented in a small-scale, ad hoc, and unsystematic manner (Wingfield et al., 2019). Due to the lack of widespread adoption at larger spatial scales, the effectiveness of the SCP on flood control is relatively limited and source-level compared to traditional grey infrastructure (e.g. dams and reservoirs) (Costa et al., 2021; Qi et al., 2020). As such, it has been demonstrated that the SCP can only deal with small-to-medium size stormwater events (e.g. up to 1-in-30-year return period rainfall events) without protecting cities against high magnitude, extreme events (Chan et al., 2018; Li et al., 2020). This is likely to affect public perceptions and media portrayal of sponge city performance. However, the extent to which the role of the SCP has been covered portrayed and understood in the news media is still unexplored.

As a publicly funded and fronted project, the Sponge City concept needs a strong social foundation including timely publicity, effective promotion, and public support (Chan et al., 2020; Mankad et al., 2019; Vojinovic et al., 2021; Wang, Shen, et al., 2021). Public acceptance is imperative to contribute to the better delivery of sustainable stormwater management, urban planning, and sustainability goals for future generations. Current indicators of success are based upon data-driven, technocratic metrics of performance. However, to ensure adoption and success, SCP must incorporate social indicators, such as public perception and uptake (Deng et al., 2019; Kumar et al., 2021; Xia et al., 2017; Zevenbergen et al., 2018). Building on this, there is a need for studies that incorporate different forms of knowledge and broader actor perspectives on the SCP. Co-production of scientific knowledge, social order, and scientific, cultural, and policy change is important for enhancing the resilience of policies and practices and leading to more sustainable and impactful outcomes (Jasanoff, 2004). Research investigating the co-production of SCP themes such as institutional arrangement, stakeholders perceptions and engagement in the development of the SCP has been conducted (Wang, Cai, et al., 2021; Qiao et al., 2019; Lu et al., 2022; Li et al., 2020; Qi et al., 2020).

However, the ways in which public discourse, media narratives, and everyday urban experiences influence the interpretation, legitimacy, and on-the-ground outcomes of SCP initiatives remain underexplored. This paper addresses this gap by introducing a novel analytical lens: the perspective of news media as both a reflector and shaper of public and governmental discourse (Adekola & Lamond, 2018). Although several studies have tracked media reporting and representation of climate change (Chand, 2017; Hulme, 2009), and how flooding is framed in various countries (Adekola & Lamond, 2018; Bohensky & Leitch, 2014; Devitt & O'Neill, 2017; Rashid, 2011), the majority of these studies are for cities in developed regions. Far less is known about how Chinese public infrastructure and construction (PIC) projects—such as the SCP, designed to address urban flooding—are reported and framed in local, national, and international media, and what policy implications arise from these narratives. Studying media narratives of sponge cities is essential because, as a relatively new concept, most information available and public understanding and perception of the approach are primarily shaped through communication in the media. More importantly, it remains unclear whether the concept of the SCP and its implementation challenges have been reported to the public in a scientifically accurate manner that aligns with research findings.

Media representation is not value-free, but rarely used as primary research materials in the planning field (Lyytimäki, 2014). Given the

growing influence of digital platforms, global online news media now play a critical role in shaping public discourse and framing attitudes surrounding the SCP (Chan et al., 2017; Majó-Vázquez et al., 2020). Accurate and balanced media coverage can inform the public, and help dispel myths and misconceptions (Hameleers, 2022). Analyzing media responses to urban flooding within the SCP context offers valuable insights for policymakers and stakeholders (Lu et al., 2022). Comparing Chinese and international media coverage further reveals how different contexts interpret and adapt similar initiatives, supporting more informed, locally tailored decision-making. Overall, news media analysis can enhance public awareness, guide policy, and help identify and address misunderstandings in SCP governance.

This study aims to understand how the SCP is portrayed by various online news sources including both Chinese and non-Chinese news sources (in English) between the period 2014–2022. The study is grounded in a combined theoretical framework of agenda-setting and framing theory. According to McCombs and Shaw (1972), agenda-setting suggests that repeated and prominent media coverage influences public priorities by determining what people think about. Framing theory (Entman, 1993) extends this by exploring how people are encouraged to think about an issue—through the selection, emphasis, and exclusion of certain elements within media narratives.

This study examines the extent and frequency to which specific issues of the SCP, including its multifunctionality and challenges to implementation, are covered and depicted in the media. The agenda-setting and framing theory are employed by looking at the following parameters in the SCP reporting: 1) quantum of coverage; 2) themes; 3) dominant frames. This approach not only strengthens the empirical base of SCP research—where media representations are often overlooked—but also bridges disciplinary insights from urban planning, environmental policy, flood risk management, and media studies. The inclusion of both Chinese and non-Chinese news sources further enables a comparative perspective, revealing evolving framings of SCP as not only a technical solution but a contested governance issue with implications for state-society relations. Theoretically, this study examines agenda-setting and framing theories within the context of the SCP, contributing to the literature on urban environmental governance by foregrounding the communicative and discursive dimensions of policy-making. This is particularly relevant in China's context as a collectivist, socialist state where mainstream media is largely state-controlled. China has been characterized as a case of “digital authoritarianism,” where discourse power is deeply rooted in and reinforced by top-level decision-makers (Seibicke & Michailidou, 2022). The findings will shed light on the evolving relationship between the state and the public in co-constructing PIC projects for urban resilience, offering a more nuanced understanding of how SCP policies are interpreted, contested, and reshaped through mediated communication.

2. Literature review

Recent research on the SCP primarily focuses on three main key themes: urban water management, governance and policy implementation, and public engagement (Li et al., 2018; Li et al., 2023). Previous studies have evaluated the hydrological effectiveness of SCP measures in controlling stormwater and mitigating floods, as well as the water quality and pollution control. Governance-related work highlights challenges such as fragmented institutional coordination, inconsistent implementation, and limited integration across planning systems (Li et al., 2020; Qiao et al., 2019). Meanwhile, emerging literature explores public perception and willingness to buy, and stakeholder engagement in supporting SCP justice (Wang et al., 2020; Wang & Palazzo, 2021). Among all governance factors, public knowledge, risk perception, social acceptance and level of engagement are identified to be some main challenges for SCP long-term management (Li et al., 2017a, 2017b; Qiao et al., 2019; Li et al., 2020; Jiang et al., 2017). A better understanding of the SCP could help formulate higher-quality pro-SCP policies and deliver

SCP practices more easily, further enhancing multiple benefits, such as potentially fostering markets to establish GI stewardship system and green city branding (Chan et al., 2021). However, the traditional roles of government and technical experts in SCP have been extensively researched, while there is presently a dearth of studies on the media sector's engagement with SCP, particularly within traditional news media.

According to McQuail (2005), '*...news exhibits a rather stable and predictable overall pattern when measured according to conventional categories of subject matter.*' The news responses (e.g., coverage and narratives) to natural disasters and extreme weather events could reflect patterns of public attention and shape public sentiments and perceptions. The role of the news media has been recognized in shaping the public's understanding of environmental risks, and determines whether and how these issues are framed as social issues of broader public concern (Demeritt, 2013). As the global community contends with the increasing frequency and magnitude of climate-related disasters, the importance of Disaster Journalism is becoming increasingly pivotal (Mishra, 2021). Similarly, United Nations (2015) advocated for the media to '*take an active and inclusive role at the local, national, regional and global levels in contributing to the raising of public awareness and understanding and disseminate accurate and non-sensitive disaster risk, hazard and disaster information.*'

News usually supports specific ideological positions (Hulme, 2009). Despite this, Shanahan et al. (1997) and Hilmi Abbas and Ogadimma (2015) contend that the media contributes significantly to educating the public on environmental issues. However, other studies have characterized media portrayal of the environment as weakened by distortions, inconsistencies, manipulations, and misrepresentation of data (Nitz & West, 2004, p. 207), thereby presenting a negative perception of the role of the media in public debate. For example, Dudo (2005) assessed how a selection of newspapers framed coverage of the Bush Administration's proposal to drill for oil and natural gas in Alaska's Arctic National Wildlife Refuge (ANWR), examining 214 ANWR-related articles between 2001 and 2003 in five US newspapers. The analysis of potentially problematic media content reflected its favoured episodic coverage, government sources and limited framing of consequences. As a result, reporting was likely to foster a nebulous, decontextualised understanding of the ANWR issue, without presenting critical voices, perspectives and considerations for audiences. Media attention shapes public attitudes to the environment, and in turn exerts considerations and pressures on ongoing scientific and political activities, policies and legislation (Boykoff & Boykoff, 2004). The media coverage of environmental issues often reflects underlying political ideologies.

In the Chinese context, the media's agenda-setting function appears to influence collective or social agendas rather than individual concerns; personal agendas show little correlation with the media agenda (Zhang et al., 2012). Furthermore, topics entering public discussion do not always align with their significance as determined by experts, such as environmental scholars or urban planners (Lyytimäki, 2014). Regarding the Chinese media, all media are managed by the Chinese government to some extent, especially the state-owned media have long been criticized as 'mouthpieces' for the Chinese government, as a result, it can promote techno-optimism around environmental issues, making of soft propaganda in China (Wang et al., 2023; Zou, 2023).

The relationship between central and local media in China is a critical lens through which to understand the dissemination and framing of public policy, including environmental initiatives such as the SCP. Central media, such as *People's Daily* and *Xinhua News Agency*, operate under the direct control of the Chinese Communist Party (CCP)'s Central Propaganda Department and primarily serve to propagate national policy agendas and reinforce the legitimacy of central authorities. These outlets often adopt a supervisory tone towards local governments, highlighting discrepancies in local implementation to signal central resolve. For instance, a *People's Daily* article (Chen, 2016 *People's Daily*) criticized certain municipalities for failing to grasp the "connotation" of

Sponge City development, thereby framing local misalignment as a barrier to policy success.

In contrast, local media—governed by regional propaganda departments—tend to focus on local achievements and positive narratives, often avoiding critical discussion of implementation challenges (Hassid, 2012). This divergence in media framing reflects the broader phenomenon of "fragmented authoritarianism," where local actors enjoy a degree of discretion in interpreting and implementing central directives (Mertha, 2009). However, coverage is guided by the Propaganda Department, which sets boundaries on tone, scope, and politically sensitive topics. While there is increasing tolerance for livelihood-related issues like environmental protection and civil rights (Hassid, 2012; Wang, 2019), critical evaluations of the SCP's top-down policy design are largely absent in domestic reporting. In contrast, international media sometimes offer more critical perspectives, questioning the programme's high costs and limited demonstrated outcomes. Local propaganda offices monitor media closely, and journalists may face penalties for overly negative reporting (He, 2004, p. 17). Content deemed sensitive is often censored, typically through the deletion of articles or social media posts, depending on the topic's perceived risk and public reaction. In this context, media—particularly state-owned outlets—act as gatekeepers of information, exercising control over what can be publicly discussed. This role contrasts significantly with that of media in liberal democracies. Additionally, research suggests that agenda-setting effects in China are not as pronounced as in Western contexts, partly due to state control and the different media-political dynamics (Zhang et al., 2012). Consequently, the varied discursive strategies between central and local media not only reveal tensions within China's multilevel governance system but also contribute to uneven policy interpretation and public understanding across different regions.

In addition to the government-media relationship, the interaction between media and the public is complex and mutually constitutive rather than unidirectional (Devitt & O'Neill, 2017). The public both shapes and is shaped by media frames through a dynamic interplay between media framing—the emphasis and narrative structure of news—and individual framing, or the cognitive schemas people use to interpret information. Media reporting thus serves not only to influence public perception but also to reflect public opinion, functioning as a barometer of societal concerns, as illustrated in cases such as flood events in the UK and China (Escobar & Demeritt, 2014; Lu et al., 2022). The news media is a key channel for relaying information to the public, and can build a bridge between scientists and layperson audiences. As a primary channel of communication, the news media plays a vital role in translating scientific and policy knowledge for the general public, especially given that most citizens do not engage directly with scientists (Hulme, 2009). In this context, both the quality and quantity of environmental reporting significantly shape public understanding, though media narratives are often selectively framed and not entirely neutral. Incorporating media analysis into SCP research therefore provides a critical lens for assessing policy reception, identifying implementation gaps, and gauging public sentiment—particularly in settings where direct public participation may be limited.

In summary, while the role of media in shaping environmental discourse and influencing public perception has been acknowledged, as well as the relationship between national and local media - particularly within China's state-owned media landscape, its specific function in reporting and framing the SCP remains underexplored. Considering the immense value of understanding local news despite potential government influence, any objective study must integrate perspectives from both local and international sources to provide a balanced and comprehensive analysis. This study addresses that gap by examining how SCP is represented across local, national, and international online news platforms, offering insights into the interactions between government messaging, public understanding, and media dynamics. By conducting a systematic content analysis of diverse media sources, this research provides a novel perspective on SCP development and

contributes to broader discussions on the socio-political dimensions of urban flood management and sustainable planning in China and beyond.

3. Methods

3.1. Data collection

A systematic review of news media publications was conducted to identify online news articles relevant to “Sponge City” published over the last 9 years, from December 2013 to December 2022. The study methodology is shown in Fig. 1. This study focused on online news due to the increasing prevalence of internet news coverage, its easy access via digital technologies and the increasing influence that this form of media has on public perceptions (Thadani et al., 2020). December 2013 was selected as the starting date because the term Sponge City, used as a specific urban water management strategy, first appeared in December 2013 (Chan et al., 2018). The year 2022 was selected as the end date because this corresponded with the project’s completion. Given the variety of terminologies describing Sponge City initiatives, a range of keywords were searched including “Sponge City”, “Sponge City Program”, “Sponge City Project”, “Sponge City Construction”, “SCP”, “SPC”, as well as associated synonyms in Chinese such as “海绵城市” and “海绵化建设”.

To build the data pool, we identified online news articles across various sources, using (1) Internet-based search engine in Google News (all archived news); (2) Websites of major national online news outlets in China (the full list including *Xinhua News*, *People’s Daily*, *China Daily*, *Xinmin News*, *China News*, *Reference News*, *Nanfang Daily*); We translated the published news content manually from Chinese to English in the analysis (3) Websites of major international online news outlets outside China (i.e. *Huffington Post*, *CNN*, *The New York Times*, *Fox News*, *Mail Online*, *Washington Post*, *The Guardian*, *ABC News*, *BBC News*, *USA Today*, *The Wall Street Journal*, *Los Angeles Times*, *Bloomberg*, *The Sun*, *The Daily Mail*, *The Mirror*, *The Daily Telegraph*, *Daily Express*). News outlets were selected considering the popularity of these newspapers and their online platforms, and the ease of accessibility online via websites and portals. Further, these newspapers represent a range of positions across the political and ideological spectrum. Although the above international news outlets are mainly from the US and UK, the diverse international outlets (from both Google News and major international online news outlets) enabled this study to cover 17 countries and 190 news agencies from around the world such as VOA, Hindu, Deutsche Welle, and Times of India.

The collected newspapers without online archives (dating back to 2013) were supplemented by direct search using the Google News search engine. Google News is the world’s largest news aggregator and presents a continuous flow of articles organized by thousands of

publishers and magazines. Additional articles were identified iteratively (i.e. snowball methodology) including the identification of other news articles referenced within them. This process was repeated in an iterative cycle of searching, studying and selecting relevant news articles several times given that the SCP topic is dynamic, new and emerging. During each iteration, the database was supplemented with new news articles and reports.

The second step constituted screening articles according to designed inclusion and exclusion criteria. Articles were included if they focused on broad water management topics and urban planning, or specifically on the SCP concept and related practice. Articles containing correct terms but discussing unrelated topics were excluded. Visual inspection of titles (and where necessary the full text) revealed that several news articles referred to unrelated topics such as movies, food, shopping advertisements and marine organisms. Only news articles written in Chinese and English were included in the database because of the limitation of languages of the research team. Two researchers carefully read and analysed all news articles, to ensure validity of all data used within the study. News articles were also cross-checked for further verification and to ensure no repetition of inclusion. The selection procedure was adapted from the methodology included by Moher et al. (2009) (see Fig. 2). After the separate data selection and coding steps, the results were put into a final complete database for analysis. If any conflicts were identified, agreement was reached through discussion among the research team concerning the inclusion criteria. 786 news articles out of 936 were included in the database and reviewed in detail.

3.2. Data analysis

This study employed both qualitative and quantitative methods. A quantitative analysis was initially carried out to show the volumes and trends of news articles, followed by a qualitative analysis of the context and thematic values of the SCP news articles (specifically focusing on the term SCP rather than other similar terminologies such as LID or GI).

Firstly, the statistical numerical analysis of news article numbers, indicating the SCP news reporting trends and patterns over time, was conducted. The news agencies and international cases mentioned alongside SCP, with sources listed from high to low frequency were also summarised. Secondly, qualitative analyses including thematic and content analyses were then applied to code SCP themes deductively (Matthes, 2009). The frequency of each sub-theme from themes of Chinese and non-Chinese news articles was calculated separately and summarised to supplement the qualitative analysis. A content analysis was conducted on the text of selected articles to identify and quantify key themes (Hilmi Abbas & Ogadimma, 2015) related to reported SCP functions and the perceived challenges to the SCP implementation. All included news articles (in Chinese and English) were imported into

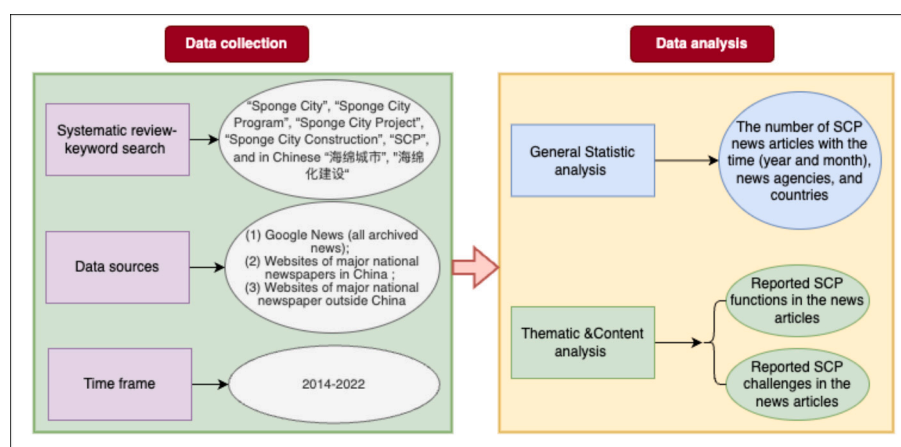


Fig. 1. Schematic diagram of the study.

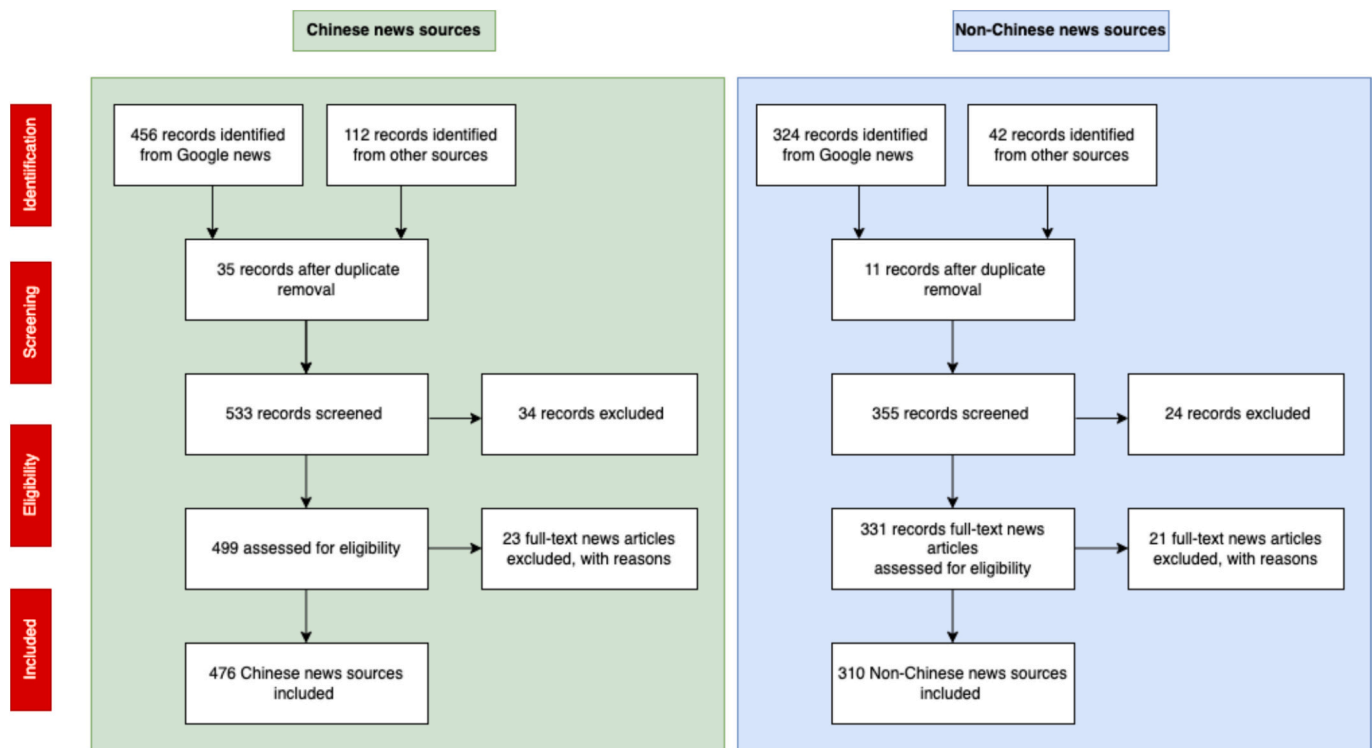


Fig. 2. Flowchart of the whole selection process of SCP news articles (both Chinese and non-Chinese news articles).

NVivo 12 and coded according to two main themes and additional sub-themes. Chinese news and non-Chinese news were analysed separately. The Chinese codes were translated into English by the authors in the final stage of content analysis. The thematic analysis draws upon two main themes from all collected data sources between 2014 and 2022, the perceived SCP functions and the perceived challenges to the SCP implementation. The sub-themes within each theme emerged via analysis, i.e. inductively coded (Huang, 2023; Mayring, 2022). Within each theme, the number of times (i.e. frequency) they were identified in all sampled news articles analysed for each theme was computed. The term ‘frequency’ refers to the percentage of references attributed to each theme. This measurement considers that there may be multiple references to a single theme within one news report. Quantitative coding enabled measurement of the frequency of references to each theme/code to be measured. The themes were further described with representative examples of contexts identified directly from news articles. Specifically, some sources were selected, analysed and presented with sampled news references to show the narratives of SCP and activities during the reporting of flood incidents in SCP news.

4. Results

The results of the statistical analysis of the dominant SCP news sources, SCP news reporting patterns and trends over time are shown in Section 4.1. Section 4.2 analyses the reported SCP functions and challenges included within the online SCP news.

4.1. Statistical analysis results

Among the Chinese news sources, the most news articles related to SCP were published in state-owned national mainstream press agencies (Xinhua News [$n = 58$], People’s Daily [$n = 56$]), followed by the enterprise business news platform (Polaris Electricity News [$n = 22$] and Polaris Water Treatment News [$n = 11$]). For Non-Chinese news sources, The Guardian had the highest number of news articles ($n = 12$), followed by The Hindu ($n = 10$), Deutsche Welle ($n = 9$), Forbes ($n = 6$),

VOA ($n = 6$), Reuters ($n = 6$), Fast Company ($n = 6$), New Security Beat ($n = 6$), CNN ($n = 5$), Eco-business ($n = 5$), and the BBC ($n = 4$). The international cases mentioned alongside SCP, with sources listed from high to low frequency, encompassed the US (e.g. New York, LA, Houston, Brooklyn, Philadelphia, New Orleans, Washington DC, Seattle, Chicago, Pittsburgh, Miami, California), Europe mainly in Northern area (e.g. Netherlands, Denmark, Sweden), Asia (e.g. Malaysia-Penang, Singapore, Thailand-Bangkok, Vietnam, Pakistan), the UK (Manchester, Glasgow and Kent), Australia (Melbourne, Sydney and Brisbane), South Africa (Jamaica), Canada (Toronto), Ukraine and Egypt.

There was a steady increase in the total number of relevant SCP news articles published between 2015 and 2019, and a sharp increase in the first and last of these years (Fig. 3) due to the first batch of pilot SCP projects starting in 2015. Between 2016 and 2019, there was a stable fluctuation in Chinese news followed by a sharp increase in 2020 during an evaluation stage by the Ministry of Housing and Urban-Rural Development (MoHURD), resulting in increased reporting coverage within China. The number of Chinese SCP news has declined since 2021, contrasting with a sharp increasing trend for non-Chinese news in 2022. Monthly coverage (see Fig. 4) was correlated with the annual frequency of rainfall in the wet season months, giving July the highest number of SCP news articles.

4.2. Thematic analysis results

Fig. 5 shows the frequency of all themes included within Chinese and non-Chinese news articles across four sub-themes of SCP functions and three sub-themes of SCP challenges. Among the sub-themes of SCP functions, “urban water management” especially urban flood management, “waterlogging prevention and mitigation” were dominant (frequency: between 38 %–40 % of all sampled references), followed by “social-cultural”, “ecological” and “economic” functions. Other reported urban water management SCP functions include “water quality improvement” and “water resources conservation and reuse”, which were mentioned by both Chinese and non-Chinese news sources. Perceived ecological functions (26 %) consist of “air purification”,

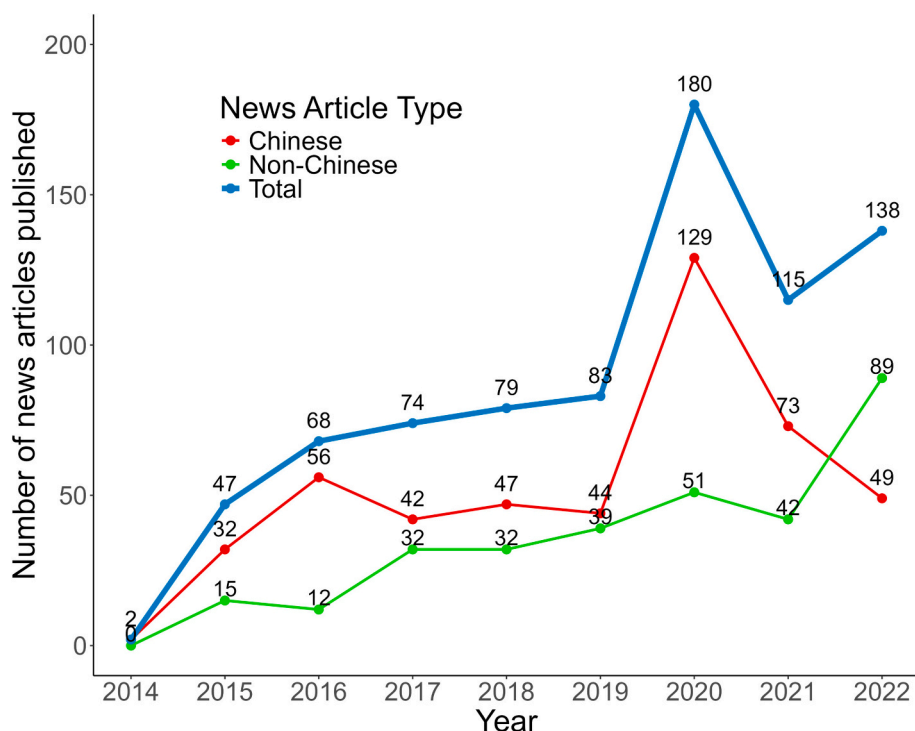


Fig. 3. The number of SCP news articles analysed with year trend (2014–2022) including both Chinese and non-Chinese news articles.

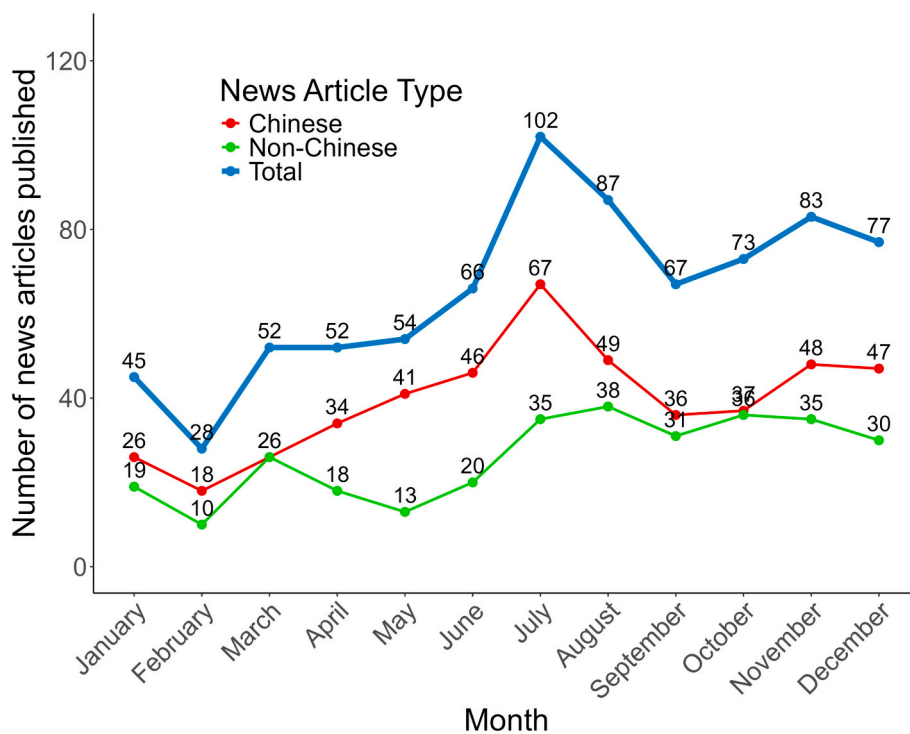


Fig. 4. The number of SCP news articles analysed by month (2014–2022) including both Chinese and non-Chinese news articles.

“urban heat island effects mitigation”, and “biodiversity conservation”. Social-cultural functions (between 28 %–30 %) include “well-being”, “aesthetic values”, and “social interactions and entertainment”. The role of the SCP in enhancing the life quality and social cohesion in local communities is also highlighted in news articles. Economic functions were also acknowledged (20 %–21 %), including “creating business and job opportunities”, “increasing property and market values”,

“generating revenue”, and “lowering the cost of traditional engineering solutions”.

In terms of reported challenges linked to SCP implementation, the thematic analysis demonstrated that governance and finance are two main themes. ‘Governance’ terms here included “the policy framework (e.g. legislation, regulation, and guidance support)”, “institution arrangement”, “leadership and responsibility”, “the transformation of

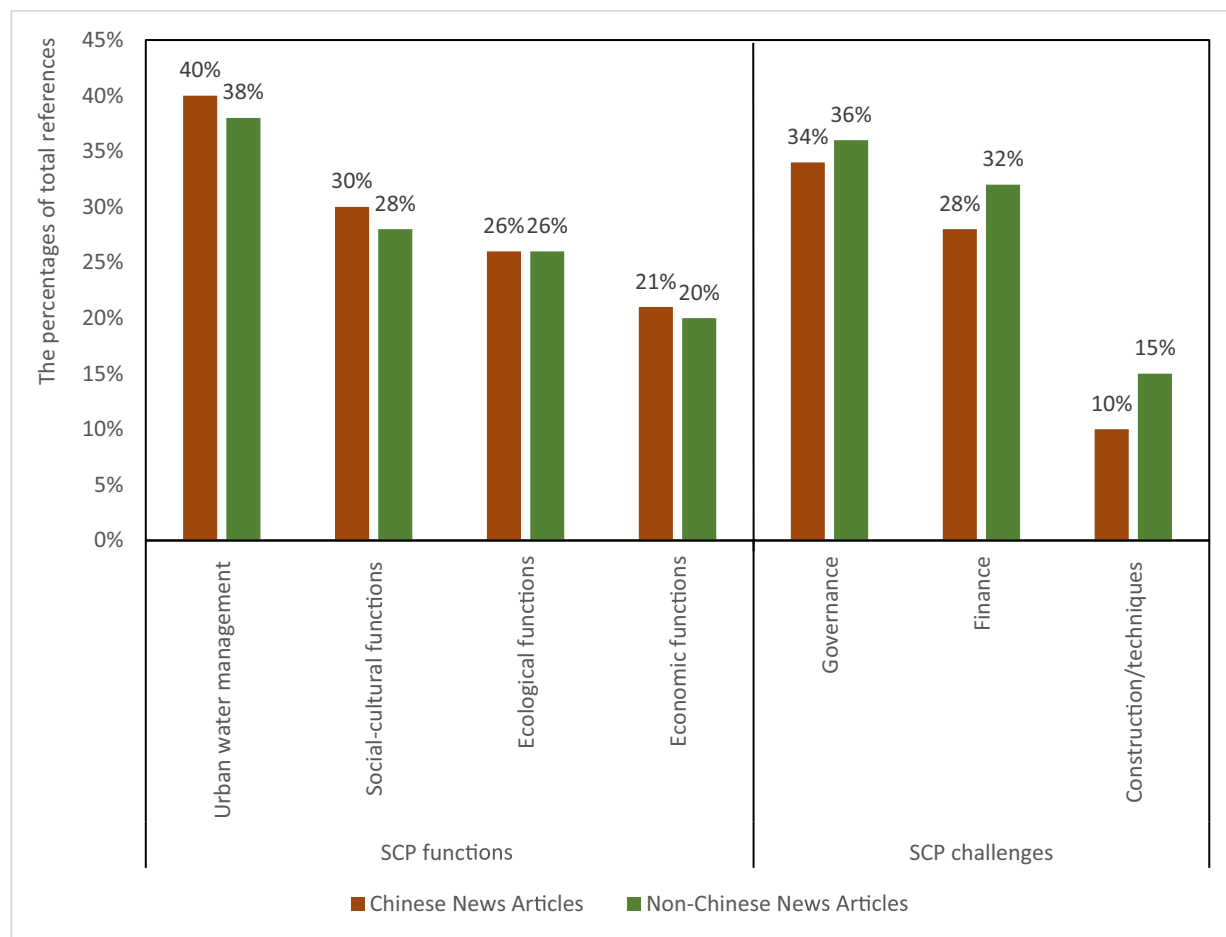


Fig. 5. The percentages of each theme's references of all SCP news sample's references from high to low (both Chinese and non-Chinese news articles).

mindset and mechanisms towards SCP" (Dai et al., 2018; Qiao et al., 2019). Finance challenges identified via the review included "the effective market incentives", "financial sources for SCP initial investment (e.g. public-private partnerships, government funding)", and "maintenance fee" (ibid). In the following sub-sections, we analysed the content of reported SCP functions and the challenges to implementing SCP based on online news. Particularly, we focus on the most frequent sub-themes.

4.2.1. Reported SCP functions

In the news reporting reviewed within this study, the concept of SCP has been increasingly considered as a promising approach to improve urban sustainability and resilience, working alongside and integrated with traditional engineering solutions and grey infrastructure. Among urban water management functions (including water resources, water environment, water ecology, and water security), reducing surface water flooding is identified as the primary function of SCP. Water quality improvement covered within news articles consists of wastewater treatment of metals and other pollutants, and river ecology enhancement.

The functionality of SCP concerning urban water management has been widely reported by Chinese news outlets. For example, the implementation of SCP has supported the reduction of urban pluvial flooding and the elimination of black and odorous water bodies (referring to polluted water). In Chinese news, the most frequently mentioned effect of SCP is the reduction of surface water flooding in the SCP pilot areas compared to areas without SCP construction or retrofitting. In the urban area of the first batch of 16 pilot cities, problems linked to 13 black and odorous water bodies (accounting for 46 % of the total

number of polluted water bodies in the pilot areas) and 171 locations prone to surface water flooding (accounting for 60 % of the total number of locations prone to surface water flooding in the pilot areas) have been addressed (Ye et al., 2017 Xinhua News). Furthermore, MOHURD stated that, by the end of 2020, the annual utilization of rainwater resources linked to SCP sites has reached 350 million tons (Nie, 2021 Xinhua News).

Based on the content of news articles, it was reported that the public appreciated SCP construction and recognize associated improvements to public amenities and well-being. The public was portrayed as feeling safer because of the role of SCP in reducing surface water flood risk in older urban areas. Some news outlets reported that the Sponge City as a new concept of urban construction in China is becoming a reality. "Light rain is not stagnant, heavy rain is not waterlogged, water body is not black and odorous, heat island effect is alleviated", was originally required in the 'Evaluation Standard for Sponge City Construction (draft)' released by MOHURD in 2018. It reflected multiple functions of SCP at the same time, while also emphasised the main function on flood management. This requirement has been reported and achieved in pilot sponge cities including Ningbo, Sanya, Suining, Baicheng, Shanghai, Pingxiang etc. according to over half the number of the news articles reviewed within this study. An example of a related statement as below,

"In the last two years, Suining citizens have gradually felt the change: most communities and streets are getting fewer and fewer waterlogging spots. On light rainy days, if go out with an umbrella, the shoes are still dry when come back home. Experienced a few heavy rains but no flood anymore, even on 6th July after suffering the most extensive and intense regional rainstorm since the start of flood season."

(Chen et al., 2017 Xinhua News)

In recent years, more news articles have covered the co-functions of SCP including micro-climate regulation and social-cultural benefits. The environmental function of SCP is most frequently mentioned, aside from water management, is the urban cooling effect, which can be a cost-effective approach for energy saving and heat regulation. The SCP is mainly reported alongside climate change adaptation and urban resilience programmes. Further, SCP implementation is described as favourable for conserving local ecosystems, creating urban habitats and improving biodiversity. Blue-green space created in the Sponge City projects (e.g. urban sponge parks) are also recognized to provide aesthetic and amenity value, entertainment and mental health benefits for local people and tourists, which further improve the living quality of citizens and can increase real estate values nearby SCP facilities. The SCP provides an opportunity to boost greenery in Chinese cities, while managing water challenges and offering further benefits, as reported by international news outlets:

"In the long run, sponge cities will reduce carbon emissions and help fight climate change."

(Harris, 2015 The Guardian)

"The results are fit-for-purpose urban services, and cool green places that also provide a variety of broader ecological, liveability, and community benefits."

(Parletta, 2019 Forbes)

"And if well-designed, natural infrastructure can have repercussions which flow well beyond stormwater, like reducing air pollution, storing carbon dioxide, or boosting tourism."

(Evans, 2022 BBC)

Economic benefits of SCP have also been gradually recognized, including increased land and property value nearby SCP (Deutsche Welle, 2017; Foreground, 2018), decreased cost compared to traditional drainage systems and engineering infrastructure (Westcott & Wang, 2017 CNN News; Harris, 2015 The Guardian; Evans, 2022 BBC), creating job opportunities, and boosting related businesses and industries (e.g. special materials, garden and ecological restoration industry, municipal construction, municipal water-related industries, smart sponge related industries) according to Polaris Water Treatment (2017) and Wu and Qin (2019 People's Daily):

"The changes can make financial sense in the long term. When Changde, a city 1,200km west of Shanghai, replaced 15% of its hard-standing with bioswales, it cut its engineering bill for new drains in half."

(Harris, 2015 The Guardian)

"We did a whole project and the land values doubled in one year, and the real estate prices climbed even more. So that's payback for the people who surround it."

(Westcott & Wang, 2017 CNN News)

"Pingxiang city has more than 100 "sponge industry" related enterprises, with annual output value of more than 8 billion yuan, leading the country in "sponge building materials" and other fields."

(Wu & Qin, 2019 People's Daily)

"These solutions cost about \$600 million less than traditional hard infrastructure projects and protect against a 30-year storm rather than a 1-in-10-year storm."

(Schlossberg, 2022 New York Times)

The most obvious contribution of SCP is urban flooding control, with the typical description by mainstream state-owned news agencies including, "Sponge City construction enables more cities to say goodbye to the mode of 'seeing the sea' after rainfall" or "the time of seeing the sea in the city will pass" (Chai et al., 2015 CCP news; Nie, 2021 Xinhua News; Yi, 2021 People's Daily). The SCP is now at a crossroad after 10 years since

the program was initiated. However, once the summer flood season comes, "seeing the sea in the city" is still a main issue, and often refers to the discussion about 'SCP' effectiveness. As such, the public developed high expectations of SCP through misinterpreting the related aspirational descriptions of these approaches. For example, more news covered this in 2016, because a total of 19 cities among the 30 pilot cities were hit by waterlogging, accounting for 63 %. Doubts and questions have been raised from the media regarding the effectiveness of SCP on flood control, including headlines such as: 'Pilots of 30 sponge cities nationwide, 19 cities experienced flooding this year, pilot cities failed?' (Wang, 2016 China Economic Weekly), and "'Sponge City' needs to be open to suspicion" (Beijing Youth Daily, 2016). To respond to the public doubts and mistrust, on 12th September 2016, the official website of the MOHURD pointed out that Sponge City construction was still being accelerated and the effects of sponge city cannot be achieved immediately. The interpretation in the governmental article followed the report by many other Chinese news agencies (mostly state-owned) in the next few days to correct public perception and deepen their understanding towards SCP, such as entitled with 'Building sponge cities requires patience' (Chen, 2016 People's Daily), "We must return to rationality in the face of sponge cities" (Zi, 2016 Nanfang Daily), "Current Commentary: Wait a minute to criticize the construction of sponge cities" (Peng, 2016 Sciencenet).

According to the Chinese State Council's guidelines, the timeline for the Sponge pilot cities assessment should be 5 to 10 years. Thus, the doubts aroused in 2016 just after one year of construction of the SCP were too early to conclude the success or failure of SCP. However, the news admitted that the public's doubts are not completely unreasonable and useless (Chen, 2016 People's Daily; Beijing Youth Daily, 2016). Their expressions of SCP reflected the problems existing in the construction process in some places to some extent. For example, People's Daily in 2016 reported that 'some localities do not understand the connotation of Sponge City, thinking it is simply expanding pipelines, laying permeable pavements, or placing water storage, while ignoring the ecological protection and restoration, which is against the original purpose of Sponge City construction'. Now at the implementation and post-construction stage, the government should learn lessons from SCP news to understand the complexity of the flood process, city construction and urban management.

4.2.2. Reported challenges to SCP implementation

Three main challenges to the construction of sponge cities were reported in the news articles reviewed within this study. These are linked to governance (17–18 % of all references), financial bottlenecks (14–16 %), and technical challenges to taking SCP from planning to implementation in practice (10 %). In this section, we focus predominantly on the transformation of mindsets and mechanisms for public participation and engagement, which emerged as key governance factors.

Although the news coverage on SCP increased annually between 2014 and 2020, a large part of the public was still unaware and unclear about the SCP according to "The construction of 'Sponge City' is a new thing. The people are not clear about what Sponge City is, what problems it can solve and what benefits it can bring to the residents, so they do not support it" (CCTV, 2019). Local communities may not have strong interests in and concerns over such projects as it is not one of their main priorities. Therefore, not all residents are eager to see related approaches implemented near their estates. In addition, the public may focus on the consequences and losses of disasters rather than the causes, which is reflected in news articles: "One problem is that people care about flooding, because it's dramatic and catastrophic. They don't care about stormwater management, which is where the real issue lies" (Bogost, 2017 The Atlantic). There is also a lack of participation in related planning processes. "Many folks know that they have a local city council and school board, but local planning, zoning, and urban design agencies also hold regular public meetings—unfortunately, most people only participate in this aspect of local governance when they have an axe to grind" (Bogost, 2017 The

Atlantic). This reflects the public's low interest in stormwater projects, which is evident even when there are opportunities to engage. Therefore, a key priority is to address the lack of awareness and curiosity in SCP to create long-term public interest to facilitate a community-driven and equitable flood risk management strategy.

Besides the individual obstacles (e.g., interest, time, resources), the systemic impediments to SCP promotion include the weak legal guarantees, institutional cooperation, commitment, and leadership, which generate public mistrust. More specifically, the poor governance of SCP as mentioned in the news is attributed to poorly detailed construction planning, regulations and selective enforcement (Chen, 2019 Xinhua News), the lack of expertise of local government (Fleming, 2020 The Guardian), insufficient training for practitioners, fragmented responsibilities and ownership of related issues between different departments (Yamei, 2018 Xinhua News), and logistical and bureaucratic issues (Welles, 2018 Boss Magazine). Further, leadership problems in local governments include the capacity to enforce regulations (Liu, 2015 New Security Beat), limitations in knowledge needed to build green and smart cities (Shepard, 2016 Forbes), lack of capacity to set up development plans to match the technical construction (Andrews, 2017 Cities Today), the control of projects by state-owned organisations and reluctance to cede to private investors (The Economists, 2016), the need for clarification of who is running the program and the competing priorities of the investors and developers (Steve, 2021 VOA). Related statements taken from news articles include,

"Since 2013, few city officials or other directly responsible people have been held accountable for urban flooding, according to a search of public records by journalists...Lin also believes that the urban waterlogging problem cannot be solved simply by holding people accountable in accordance with the law."

(Chen, 2019 Xinhua News)

"Moreover, Xi has backed up his rhetoric with strict timetables, hard financing structures, clear governance and sharp technical measures. Urban planners and water professionals—struggling to turn a poetic vision into street-level execution—can't escape the healthy tension between top-down mandates and bottom-up realities."

(Andrews, 2017 Cities Today)

Another systemic barrier is the underestimation of the role and value of public perception and participation. Opinions of local communities can often be disregarded by decision-makers, which accelerates public indifference. This is a global problem and is not limited to China:

"They started pleading with us, 'Oh, we're listening to the community, we're listening to our stakeholders.' But they haven't done any meaningful revisions based on community input. It's a show."

(DeMause, 2019 City Limits)

"But indigenous voices have long been shut out from urban and rural planning, and from basic social services."

(Schlanger, 2018 Quartz)

The SCP may bring some social-cultural concerns such as new urbanism, green gentrification, social and environmental inequity (Bogost, 2017 The Atlantic; Loughran, 2020), although this problem is not only limited to the SCP (Bonakdar & Audirac, 2020; Curran & Hamilton, 2012; Wolch et al., 2014). The competition for land use between green spaces, underground space, old and new buildings, alongside conflicts with economic development and social justice, led to complexities in SCP promotion at larger scales.

Once SCP facilities are built, those living in deprived areas usually have fewer chances to access urban sponge parks. The increasing real estate values nearby SCP facilities may further accelerate and amplify this social inequality. More reliance on public-private-partnership (PPP) financing is caused by the cessation of state funding of the SCP. In such cases, developers have the power and influence on the siting and design

of SCP projects, to maximize SCP profits. However, lower income residents and migrant workers are less able to afford houses in such areas and their access to co-benefits of SCP (e.g., wellbeing, aesthetic and amenity values) may therefore be limited. Furthermore, equity issues also arise regarding SCP maintenance costs. A conventional piped drainage system typically has a high capital cost/low running cost, while BGI-based drainage systems are usually the opposite with higher running costs because of required regular maintenance such as permeable pavement cleaning, periodic sediment removal, vegetation management (Lashford et al., 2019). SCP maintenance costs raise an equity issue as those residents nearby the BGI enjoy the most benefits, nevertheless running costs are paid by all taxpayers (common in PPP projects).

5. Discussion

There has been increasing amounts of online news media coverage of the SCP topic since 2014, especially in 2020 after the construction of 30 sponge pilot cities. The amount of news articles each month aligned with the annual frequency of rainfall. The wet season months of July and August had the highest number of SCP news articles, which is consistent with the findings in previous studies such as the news analysis of flooding in Nigeria (Adekola & Lamond, 2018) and urban flooding in China's SCP (Lu et al., 2022). This finding follows the concept of the 'issue-attention cycle' (Downs, 2016) with SCP news intensifying during the wet seasons and flood events, revealing consistent public attention.

It is noticeable that a pattern change of news reporting in terms of their reporting attitudes and themes on a temporal scale can be recognized. For example, for the first five years, more news emphasised describing the SCP about why they are built, how they work and related Chinese ambitious plans. By noticing that 'Sponge City' was adopted as an ideological concept, initially, few people fully understood what it meant from a practical perspective. It was found that after the first five years, more news started to highlight its effectiveness, influences and potential role in a positive attitude. This study demonstrates the importance of developing media narratives at the onset of the introduction of new scientific approaches. Prominent non-Chinese sources such as the Guardian, Forbes, CNN and the Bloomberg, focused more on why China builds SCP and 'how' Chinese ambitious plans could solve urban flooding, rather than stressing the benefits of SCP which was more a feature of Chinese state-owned news. Interestingly, positive terms such as "completed," "finished," "solved," "increased," "improved," "promoted," "innovation," and "effectively" appeared more frequently in Chinese news coverage, suggesting a stronger emphasis on achievement and progress. In contrast, the term "challenge" was more commonly found in non-Chinese news, indicating a more critical or problem-focused framing. It is also notable that terms related to social objectives and outcomes—such as "access," "justice," and "vulnerability"—were very limited overall. However, references to "public" and "community" were more prominent in discussions of outcomes. As expected, economic references were mostly associated with "cost," but these appeared less frequently than environmental terms, reinforcing the tendency of media coverage to prioritise physical and ecological aspects of Sponge City Planning.

The reported SCP functions and challenges in the news articles were similar to the covered themes from the academic research, indicating that academic research is making its way into media outlets sufficiently. The news analysis of the challenges towards SCP implementation in this study was consistent with a related study (Li et al., 2020) based on experts' interviews about SCP for urban flooding management, where governance and finance were identified as broad barriers for SCP implementation. In the research, the social-political factors including local leader/government priorities, the weak power of policies and regulations, insufficient financial support, maintenance investment, and the lack of knowledge and understanding of SCP were most frequently mentioned barriers (Li et al., 2020; Qiao et al., 2019). All these themes

have been covered in the SCP news from various sources.

In the SCP news reporting, many of them also quote experts from practitioners and academics. Featuring insights from them can add depth and credibility to news stories, clarify complex issues and present informed opinions. It is also beneficial to enhance the public trust, educate the public, bridge the knowledge gap, draw attention of policymakers, and even influence the decision-making processes. This symbiotic relationship benefits both researchers and the wider community by promoting the dissemination and application of knowledge. However, experts may not always be accessible, and their viewpoints can be underrepresented in favor of more sensational or easily understandable content, resulting in a failure to convey the full spectrum of issues. Furthermore, certain prioritized political agendas may lead to unbalanced coverage that misrepresents the complexity of urban management. The media may not properly interpret the science behind the stories by either exaggerating or underestimating the facts, which may mislead the public to expect that Sponge City is a ‘panacea’ for all types of floods.

The media attention and public sentiment towards urban floods were considerably negative during urban flood events considering public’s lives being threatened and affected and where enormous investment and effectiveness of the SCP are not proportional. The most negative sentiment occurred on the 21st July 2021, directly after the Zhengzhou ‘7.20’ flood event that caused 292 deaths in this Sponge pilot city (Lu et al., 2022). Relatively more news, especially state-owned, was posted after this event to mitigate misinformation towards SCP and calm public anger. It was clarified by quoting experts’ perspectives that the stormwater which flooded Zhengzhou would have overwhelmed the drainage system capacity of any city (Baragona, 2021 VOA News; Global Times, 2021). Specifically, the SCP cannot effectively handle the rainfall levels recorded in Zhengzhou in 2021, which far exceeded the classification standard of extremely heavy rainfall (the maximum precipitation reached over 200 mm within an hour and the maximum daily rainfall passed 624 mm) (Du and Wang, 2021 Caixin News). Indeed, besides the role of ‘loudspeaker’ and ‘facilitator’, Chinese news agencies are compared as ‘safety valves or pressure cookers’ (Hassid, 2012; Majó-Vázquez et al., 2020), by releasing emotions of the public, building trust between the government and the public, and maintaining stability and harmony of society.

The relationship between news media and communication, particularly regarding complex topics in urban management, is intricate and multifaceted. The inherent nature of news media often necessitates simplification for broader audience comprehension. Headlines, soundbites, and short articles might oversimplify complex issues, reducing them to binary “good” or “bad” narratives that overlook critical context. In addition, news homogenization tendency is acute considering the political agenda and professions of journalists, because many of local state-owned news media’s resources for SCP news reporting are directly from the local government rather than their own investigation. In terms of geographical focus and temporal scale (i.e., short vs. long-term issues), local and national-level media differ significantly in their reporting on SCP. Local news tends to emphasize localized and short-term issues, rarely covering developments in other cities—especially negative ones—due to intercity political sensitivities. This localized focus often reflects a limited sense of foresight or urgency in addressing the long-term consequences of climate change. Unfortunately, both national and local state-owned media frequently fail to address climate risks proactively, often taking them seriously only after a crisis has occurred such as the Zhengzhou ‘7.20’ flood disaster, where state-owned media eventually reported on the disaster’s causes but were criticized for their delayed and insensitive response, particularly when compared to the more immediate coverage by independent and social media platforms.

Understanding urban ecosystems and planning of future cities requires comprehensive and systematic thinking (Gómez Martín et al., 2020; Li et al., 2017a, 2017b) to avoid superficial reporting that misses

the complexities of urban management, the whole picture and in-depth analysis. For example, according to the latest investigation report of the “7.20” heavy rain disaster in Zhengzhou (Disaster investigation team of The State Council, 2022), apart from the physical factors such as extreme weather (i.e., heavy rainfall) and low-lying land of Zhengzhou, human factors are also main causes of this constant issue including lack of natural storage space, the outdated construction of drainage facilities and weak ability of warning and emergency management. The news reports should be easy to read and explanatory to foster public understanding. If audiences are not given enough context or if the reporting is too technical, they may not fully grasp the intricacies involved. Sensationalism and clickbait headlines can further distort the audience’s perception. The political nature of media, and journalists’ interests and professions could determine the number and quality of news reporting, the reporting angles, story framing and prioritising. Factors such as media ownership, editorial stance, agenda setting, selective reporting, use of language, source selection, and the focus on policy outcomes all contribute to shaping public perceptions (Livingstone & Lunt, 2020; Rashid, 2011). However, the background and expertise of government officials and journalists significantly influence both the level of understanding of SCP and the quality of related reporting. Many journalists, whose primary contacts are within urban planning and construction departments, often lack formal training in urban planning or environmental management. As a result, they tend to show limited motivation or capacity to engage deeply with SCP topics.

It is recommended to enhance the professional capacity of journalists to report news in a scientifically accurate and easily understandable manner, but we should also bear in mind that their job priority is usually to increase the readership of stories and promote a particular narrative. With the rise of diverse media channels and the development of a media matrix in China, content produced by local news outlets can now be distributed, shared, and disseminated across various platforms, such as Sina News, Tencent News, and official local government social media accounts. Such news homogenization will amplify official discourses but may also cause news fatigue for the public. In the SCP context, such repetition may weaken public interest, particularly if reports lack critical insight, or storytelling variety. Therefore, diversifying news content and presenting it in engaging ways is essential to maintain public interest and promote informed discourse.

As early as in 1998, Kaufman and Johnson (1998) argued about how the mass media control public perceptions, that ‘*the most profound use of media power is not in what is printed, filmed or broadcast but in what is not*’. It can still be applied to the current situation in China, where the public sees what they are allowed by the government and licensed by the media, those behind the screens are actually the core of the events and should be paid attention to by the public. According to Deutsch’s (1961) theory, public opinion flows in a multi-step cascade, moving from economic and social elites through political leaders, mass media, and opinion leaders, before reaching the general public. In China, the traditional model—where ruling and intellectual elites dominated public discourse—has been disrupted in the new media era (Liu, 2020), giving rise to a restructured opinion hierarchy. In the case of SCP, while the public remains at the downstream end of this cascade, new media and greater political openness have created more direct channels of communication between the public and elites. Previously, the government relied on traditional media as intermediaries, but now, digital platforms such as social media have reduced communication barriers, allowing public opinion to increasingly influence, or at least be considered in elite decision-making (Liu, 2020). However, a study in the UK showed that social media influencers are unlikely to drive large-scale change, and the platform’s distilled nature may weaken critical discourse. Ordinary citizens may have greater influence through face-to-face interactions, emails, or formal consultations—especially when aiming to shift public opinion or policy (Nurse, 2025).

While it is difficult to quantify a direct causal link between media coverage and policy change, news media plays an important role in

shaping public debate, legitimizing policy directions, and occasionally prompting corrective action—particularly when discrepancies between policy intentions and real-world outcomes are brought to light. In China, the media often uses positive framing to highlight SCP progress and reinforce government legitimacy, influencing policy replication. Meanwhile, international media offers more critical perspectives, contributing to reflexive learning and pressure for reform. Media coverage also channels public concerns, informs policymakers about practical challenges like funding and governance, and helps translate scientific knowledge into accessible narratives. For example, SCP reporting has evolved from portraying it solely as flood control to acknowledging its broader co-benefits. After major flood events such as the Zhengzhou “7.20” incident, media scrutiny led to investigations and tangible policy updates, including improvements in early warning systems and urban drainage standards.

6. Conclusion

This study makes an important contribution to literature in a developing country context to understand contemporary SCP development and urban flood management drawing on insights from global news sources, and by analysing the agenda-setting and framing within Chinese and non-Chinese news articles.

Media coverage of the SCP is closely related to urban water issues especially urban flooding events, while in recent years the importance of sharing experiences for widespread learning has been reinforced. The discourse is prone to advertise the multifunctionality of SCP and to promote the implementation of SCP with the significant social-political drivers in China. Governance and financial factors were considered the main barriers to the SCP implementation. Although SCP provided a new urban planning approach for water management as an alternative to traditional engineering measures on a global scale, there are some criticisms of its effectiveness and future transition. The news reporting on Sponge Cities before, during, and after the floods was inconsistent. The effectiveness of SCP in flood control was exaggerated by Chinese state-owned media before the flood disasters, and only corrected and highlighted its limitations afterwards. The reporting of simplistic narratives can hide nuances and therefore we recommend that as the coverage matures there is more nuanced debate as to the role that SCP can play in urban flood management. The SCP holds promise for a sustainable long-term advancement if the media plays its role effectively and China commits to enhancing governance in key areas such as education, finance, local leadership, policy reform, and institutional collaboration, to effectively tackle the challenges associated with SCP development in the future. We recommended a greater engagement between academics and the media, and fostering a culture to reward the accurate and comprehensive reporting in both media and readership, to understand the complexities of SCP, flood process and urban management, thereby catalyzing the policy change for delivering more sustainable urban water management and governance.

CRediT authorship contribution statement

Lei Li: Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Christopher D. Ives:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization. **Jeremy Carter:** Writing – review & editing, Supervision, Methodology. **Alexandra M. Collins:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Olalekan Adekola:** Writing – review & editing, Methodology, Conceptualization. **Daniel Green:** Writing – review & editing, Methodology, Conceptualization. **Ali Cheshmehzangi:** Writing – review & editing, Supervision, Methodology, Conceptualization. **Faith Ka Shun Chan:** Writing – review & editing, Validation, Supervision, Methodology, Formal analysis, Conceptualization.

Declaration of competing interest

All authors have approved the manuscript and have no conflicts of interest to declare.

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Data availability

Data will be made available on request.

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