



Co-producing representations of summer rainfall in Bangladesh

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Received: 29 March 2022 / Accepted: 9 March 2023 / Published online: 5 April 2023
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Abstract

Climate adaptation governance increasingly investigates the cultural capacities of communities to cope with climate variability and change. This paper reports on research of the symbolic representations of summer rainfall in the cultural repertoires guiding diverse institutionalised fields of activity in Sylhet Division. The research conducted interviews and co-created ‘cognitive maps’ with communities, to critically reflect on their changing seasonal symbols. The study revealed a common stock of summer symbols in Sylhet communities, which individuals reconfigure for strategizing and justifying particular practices. Symbols are stable but not static. As people’s uses of knowledge systems change—moving toward scientific representations—so too does their use of symbols. Moreover, environmental and climatic changes, such as a drying summer, are undermining long-held semiotic templates. Many local and traditional signs no longer hold, leaving communities without cultural templates for timely seasonal action. This work highlights the importance of cultural frameworks for organising communities’ seasonal adaptation, and the imperative for critically revisiting frameworks in rapid flux.

Keywords Climate adaptation · Co-production · Culture · Institutions · Seasonality · Symbols

Introduction

This paper is about how communities in northeast Bangladesh draw on cultural representations of seasons as a resource for adapting to seasonal variability and change.

Communicated by Chandni Singh.

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Anthropologists and archaeologists have long contended that seasonal calendars are central to how societies are ordered (Orlove 2003; Kwiecien et al. 2021). As culturally ordering time calendars confer meaning and identity, coordinate activities, anticipate environmental conditions and provide a repertoire of skills and practices (Bastian 2012; Bourdieu 1977; Hastrup 2016). Communities’ cultural frameworks of seasons are neither homogenous nor static (Strauss 2012). However, rapid and complex environmental and social changes are destabilising how communities—including in Bangladesh (Deb & Haque 2017)—represent climate, seasons and weather (e.g. Jasanoff 2010; Rayner 2003; Strauss 2016). These changes undermine the stock of ‘signs and significations, codes and knowledge’ (Harvey 1990) communities accrued over generations. We need to critically examine whether seasonal frameworks serve as an adaptive capacity or lock communities into maladaptive pathways.

Work on seasonal adaptation has come under the umbrella of climate adaptation scholarship and introduces concern for how communities live by seasonal rhythms. The most prominent work focuses on connecting scientific information to peoples’ conscious, calculative decision-making, via seasonal forecasts (see, e.g. Findlater et al. 2021). But with a cultural turn in adaptation (Adger et al. 2013), some scholars are investigating the extra-scientific knowledge and cultural understandings that work to (sometimes pre-consciously)

influence seasonal decisions and practices (Feola et al. 2019; Fischer and Macauley 2021; Hulme 2016). This includes an increasing regard for the cultural frameworks of symbols, values, practices and material objects that set a seasonal pattern to community life in formal and informal institutions (Geoghegan & Leyson 2012; McNeeley & Lazrus 2014; Sheridan 2012).

Our study sought to study seasonal cultures as heterogeneous and dynamic frameworks that guide people's decisions in diverse Sylhet community institutions, from municipalities to temples or schools. Starting from sociological schools of new institutionalism, we contended that seasonal frameworks become most starkly apparent in institutions, which culturally and cognitively structure social life (Scott 2014). This research specifically focused on the symbolic representations of summer rainfall that mediate people's summer practices in institutions, and how these symbols and their use may be changing. We deployed concepts of co-production (Bremer & Meisch 2017) for investigating these changes, where co-production was both *descriptive* work—looking at the emerging rainfall representations 'produced' at the confluence of different ways of understanding weather—and *normative* work—working with communities to deliberately co-create representations.

Here we report on our research findings, structured around three objectives, to (i) access the symbolic representations of summer rainfall utilised by individuals in Sylhet community institutions; (ii) comment on how these representations are changing with various climatic, environmental and social changes and (iii) facilitate a process for Sylhet community actors to co-create synthetic representations of summer rainfall to critically rethink seasonal cultures and as a basis for future adaptation efforts. We finish by discussing this research's implications for adaptation governance, notably a need to complement policy, infrastructure and forecasts with initiatives to critically revisit communities' long-held seasonal cultures as adaptive templates.

Background and concepts: working with symbols of summer rainfall

The TRACKS Project in Sylhet Division

TRACKS (*Transforming Climate Knowledge with and for Society*) was a 3-year climate adaptation research project, funded by the Norwegian Research Council and carried out by an interdisciplinary group of scientists from across seven institutions in Bangladesh, Norway and the USA. TRACKS aspired to attain a robust understanding of climate variability and its impacts in the Sylhet Division through a post-normal science (Funtowicz & Ravetz 1993; Meisch et al. 2022) approach with local communities, to increase communities'

capacity to use knowledge in support of their daily activities. The project focused on communities in lowland Sunamganj (Sunamganj Sadar and Jamalganj Upazila¹) and in the hillier Moulvibazar (Barlekha Upazila), which face different impacts from the local rains (see also Bremer et al. 2017; Fig. 1).

The TRACKS project came to focus on summer rainfall after two focus groups and more than 230 qualitative interviews (Bremer et al. 2017). Summer rainfall here is defined as any precipitation falling in the summer season in the Bangladeshi calendar, over the months of Boishakh (mid-April to mid-May) and Joishtho (mid-May to mid-June). This rain often falls before the monsoon season (the months of Ashaar: mid-June to mid-July and Shrabon: mid-July to mid-August), so that in Sylhet the summer and monsoon rains effectively merge into one extended wet period (Stiller-Reeve et al. 2015).

The communities of Sylhet Division have developed their society—and cultural repertoires of skills, habits and practices—around the summer rains, which are unique to the region and vital to their livelihoods (Blanchard & Bremer 2015). But, there are significant local and scientific uncertainties about the causes or future of this unique summer rainfall (Stiller-Reeve et al. 2015). These uncertainties are compounded by experienced and measured changes to rainfall patterns from 1984 to 2016 (Bashar et al. 2017; Bremer et al. 2017), and the limited capacity of local meteorological and climate science (Haque et al. 2017). At the same time, Sylhet peoples have identified their livelihoods—their haor² based agriculture and fisheries—as highly vulnerable to variability in these rains (Mamun et al. 2013). If there is too little rain, then the annual boro³ rice crop is starved of water and the haor do not fill with water and fish. If there is too much rain, then the area is inundated by flash floods, which sometimes means food aid becomes necessary (The Daily Star 2017). Faced with uncertainties and high stakes, Sylhet communities are reflecting on their connection to summer rains, and the ways they represent them.

Key concept: systems of symbols in institutional cultures

Our study focused on the cultural frameworks of seasons in Sylhet community institutions. The adaptation literature has long maintained that institutions influence how communities adapt to climate variability and change (Bremer et al. 2021;

¹ *Upazila* is a Bengali term for sub-district.

² A *haor* is a local term for a wetland ecosystem in northeast Bangladesh, which is physically a bowl or saucer shaped shallow depression, also known as a back swamp.

³ *Boro rice* refer to rice grown in low-lying lands with irrigation during November to May, hence harvested during pre-monsoon.

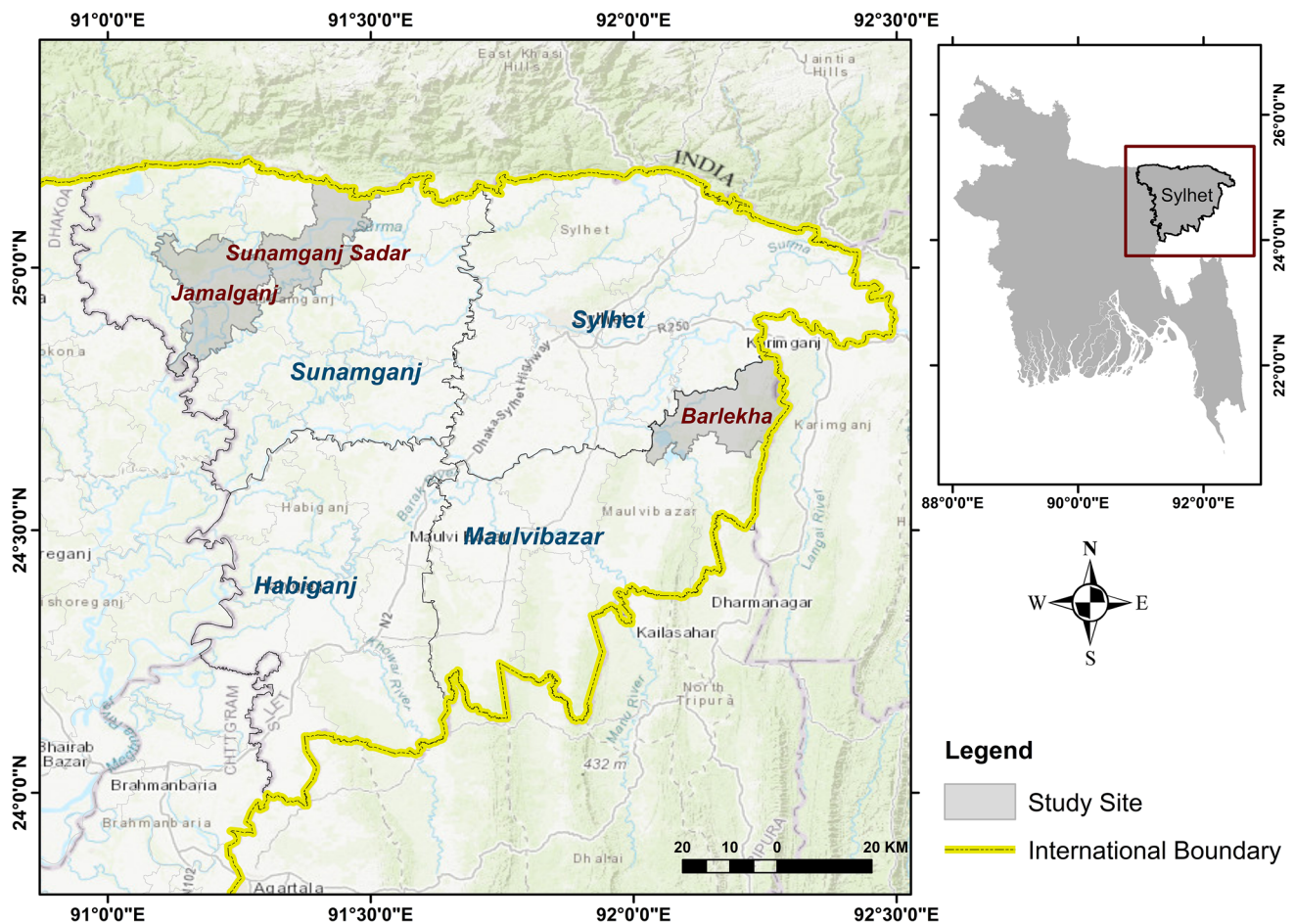


Fig. 1 Map of Sylhet Division of Bangladesh and the study sites

Dovers & Hezri 2010; Garschagen 2013). For us, institutions are the social worlds people pass through each day in their communities, wherein they act and interact in specifically appropriate ways. Following sociological schools of new institutionalism, we see institutions as, ‘comprising regulative, normative and cultural-cognitive elements that, together with associated activities and resources, provide stability and meaning to social life’ (Scott 2014; p. 56). Institutions comprise whole fields of social life and practice (DiMaggio & Powell 1991). For instance, rather than focus on one rice farm, institutional analysis appreciates the extended network of rice farmers, the rules they collectively work under, their norms of appropriate conduct and their shared knowledge and belief systems.

We studied how *cultural-cognitive* knowledge and beliefs of summer rains provide templates of thought guiding what people do in institutionalised fields of practice (Douglas 1986); culture in action. Functionally, institutions’ seasonal cultures and calendars provide a repertoire of symbols, cues, values and patterns of thought and action, guiding how people interpret and respond to certain situations in

certain seasons (see Swidler 1986; Sewell 2004). There is a nascent field of study of institutional cultures as mediating groups’ relationship to seasons and climate (Bremer et al. 2021; Geoghegan & Leyson 2012; McNeeley & Lazrus 2014; Totin et al. 2018). This paper analyses institutions’ semiotic representations of summer rain influencing action.

The analysis of symbols was a conceptual and methodological choice. Conceptually, we were interested in ways of knowing the rains—where symbolic representations are a means of making sense of the world—and investigating how this knowledge is translated into conduct. How do people assemble and deploy symbolic representations of rainfall as resources for planning summer activities (López et al. 2017; Hastrup 2016)? How do symbols take shape in routines or objects used (Sewell 2004)? Methodologically, we elicited cultural meanings through narrative interviews, but this likewise limited the insights we could access. An account of practices and material culture would lend itself to participant observation methods for instance. The decision to demarcate institutional fields by practices was to explore whether people symbolised summer rainfall differently according to the activities they engaged in,

toward different functions. Does a rice farmer harvesting their boro crop relate differently to summer rain than a boatman waiting for rising water, or a poet?

How representations change through processes of co-production

We saw institutions' symbolic representations of summer as undergoing constant change and studied the processes re-making symbolic representations through the conceptual lens of 'co-production'. For Bremer and Meisch (2017), co-production is a composite concept that can help to recognise and tease out the various processes tied up in producing knowledge and beliefs. The co-production framework is typically used in one of two broad ways: for structuring (i) the descriptive observation of the tangled processes concurrently producing knowledge-in-society and transforming social institutions or (ii) the normative intervention in these processes to deliberately create and disseminate new knowledge.

As a descriptive concept, co-production invites interpretive study into how institutions' seasonal symbols are shaped by influences from their wider environmental, social and cultural context (including other institutions) and simultaneously shape that context; the 'co-' denotes the mutual evolution of institutions in society (Jasanoff 2004). It lets us see how different ways of understanding seasons—from meteorological, local and traditional knowledge for example—converge in institutions to produce seasonal representations. It shows how representations change or become stable (Dahan and Aykut 2013; Jasanoff 2010; Mayer 2012; Miller 2004).

As a normative concept, co-production invites approaches and technologies for consciously developing new representations in institutions through collaborative work across different social groups such as scientists and local communities; here co-production is synonymous with 'co-creation'. For example, this would require reframing and recommunicating Western science in ways appropriate to a specific institutional culture, like agriculture and how farmers interpret and live by seasonal rhythms (e.g. Roncoli et al. 2003; Stiller-Reeve et al. 2016).

The study presented here is unique in that, following Bremer and Meisch (2017), it seeks to connect descriptive and normative frameworks of co-production in a piece of empirical work.

Method and analysis

We set out to better understand Sylhet's summer rainfall as captured in institutions' symbolic representations, both by describing the stock of extant representations emerging in and moving between institutions in that context, and

normatively co-creating new representations through collaboration between community actors and scientists. Our research thus split into two phases.

Describing emerging representations of rainfall: interviews and analysis

The first phase sought to describe summer rainfall as symbolised in institutional fields. Methodologically, we used qualitative, semi-structured narrative interviews to access these deeply embedded and place-based cultural symbols. We conducted 234 narrative interviews with interviewees engaged in different activities and from different age groups in the study sites, with around 20% of interviews with women (detail on the interviews in Supplementary material Section 1 and detailed reflections in Bremer et al. (2017)). The interviews yielded a rich corpus of transcribed stories of how people think about and live with these rains.

In analysing the interview transcripts, we first limited our focus to interviews with complete English-translated transcripts, leaving 198 transcripts. Second, we decided the data set was not large or representative enough to offer quantitative claims. Third, we categorised the transcripts by 11 institutions to study seasonality in differential fields of practice: rice farmers (25), non-rice farmers (14), day labourers (17), fishers and boatmen (25), government employees and politicians (26), medical practitioners (7), NGO workers researchers and journalists (7), religious and cultural Figs. (12), secondary sector workers (shop-keepers, factory owners, taxi drivers and those who did not mention a vocation) (37), students (14) and teachers (14).

There were two layers of descriptive analysis run simultaneously. The first layer looked at the symbols of summer rainfall in the transcripts, especially relative to the interview question; 'how does the weather change with the seasons in this area over a typical year?' This invited a hermeneutic, interpretive reading of interviewees' stories, looking at how people draw meaning and typify the seasons. The second layer analysed transcripts for how these representations are produced, according to what influences. Importantly, we adopted an emergent approach that avoided imposing a priori conceptual framings on what community members discussed.

Co-creating new representations of rainfall: cognitive maps and analysis

The second phase convened a subset of the interviewees in workshops in the two study sites, where project scientists and community members collaboratively interrogated communities' symbolic representations of summer rain. We intended to co-create visual diagrams of seasonal representations to study the process by which

groups assemble and use symbols for inferring meaning for their daily activities, as a complement to the interviews. The workshops were also designed for participants to (i) critically reflect on their ways of representing and knowing the rains and (ii) jointly identify aspects of the rains deserving of deeper investigation, as a basis for their own (citizen science) study of rain and impacts. We convened 21 community members in Sunamganj and 27 participants in Moulvibazar in Spring 2016 (see Supplementary material Section 2 and Bremer et al. 2018 for a detailed account). We divided participants into four groups, sitting together with project scientists, to draw ‘cognitive maps’ of what happens before, during and after summer rainfall, and showing the relationship between these elements.

Cognitive maps were used to assemble multiple worldviews within coherent and holistic systems diagrams, without amplifying one worldview over another. The maps enable a group to take stock of a particular situation or phenomenon—in this case summer rainfall—and understand how elements fit together and influence each other (Papageorgiou & Salmeron 2012). Elements were written as variables capable of increasing or decreasing, with arrows between variables showing how different elements impact each other, much like a correlation. Relationships between elements could either be positive (where both impact and cause increase/decrease together) or negative (where impact and cause diverge), and were shown with ‘+’ or ‘−’ on the arrows between the elements. Cognitive maps have been widely used in development studies (Isaac et al. 2009; Shahvi et al. 2020).

In co-creating cognitive maps, workshop groups assembled and appraised the different representations of summer rainfall they draw on in their communities. The map-making made explicit the process of bricolage (Levi-Strauss 1962) through which groups put together seasonal symbols as components in a comprehensive picture of the rains and what they mean; a process also revealed in individuals’ narratives. But unlike the interviews, in groups people

critically challenged each other’s representations, providing insights into the ‘quality’ of representations for acting seasonally, and the ways in which symbols are changing. We decided to create groups of mixed institutions for four reasons. First, we wanted to further explore the commonalities across institutions we found in interviews. Second, we wanted to cultivate critical discussion. Third, we wanted to bracket local power dynamics by creating uncommon social groupings. And fourth, we wanted to use the maps as a basis to design a wider *community-led* citizen science project (Bremer et al. 2019).

Results: changing representations of rainfall in Sylhet Division

A common stock of summer rainfall representations

Interviewees’ narratives revealed a common stock of symbolic representations of summer. Our analysis grouped interviews according to the 11 institutional categories (see [Describing emerging representations of rainfall: interviews and analysis](#)), and within each category coded for what the summer means for interviewees and the way they adapted their practices, and how they symbolise these meanings in verbal utterances. We expected to find quite distinct symbols in different institutions, but we were surprised to find a stock of eight symbolic representations in common use in Sylhet communities, emerging across almost all institutions (see Table 1). Indeed, it is unclear if there is any significance that some symbols were not mentioned by interviewees active in certain institutional fields.

Hot and sunny

Summer is a hot season with temperatures building over the spring month of Choitro (mid-March to mid-April) and into early summer until the ‘scorching sun is excessive’

Table 1 Symbols of summer rainfall used in Sylhet communities’ institutions

Symbols of summer	Institutional fields of practice
Hot and sunny	Used in all institutions except ‘other agriculturalists’
The onset of the wet season	Used in all 11 institutional fields
A stormy season	Used in all 11 institutional fields
The rising waters	Used in all 11 institutional fields
A season of plenty	Used in all institutions except ‘NGOs’
Ecological changes	Used in all institutions except ‘NGOs’
Challenges to health and well-being	Used in all institutions except ‘other agriculturalists’, ‘NGOs’ and ‘religious and cultural figures’
A changing climate	Used in all 11 institutional fields

(B6⁴), making it difficult to work outdoors. This heat brings dryness and drought-like conditions—‘The area gets dusty’ (B2). and ‘...the earth becomes dry and white’ (C13)—creating challenges for agriculture and fisheries alike. Summer’s sun and heat are also related to peoples’ health and well-being, bringing illness and fever, and a feeling of lethargy.

The onset of the wet season

Summer is rainy, with the summer rain brought on by the heat and arriving to break the drought and start the wet season, often depicted as part of the natural order or rhythm; ‘it is necessary for appropriate things to happen at the appropriate time, which is natural’ (D28). The summer rains mark the beginning of a long period of rainfall, sometimes raining for weeks on end, from summer into the monsoon season; ‘It rains in the months of Boishakh (mid-April to mid-May), Joishtho (mid-May to mid-June), Ashaar (mid-June to mid-July) and Shrabon (mid-July to mid-August)’ (B1). One interviewee discussed the diurnal timing of the rain, noting that summer rainfall begins in the dark hours of each day; ‘it rains in the early morning’ (C19).

A stormy season

Summer is a stormy season, when local communities are suddenly hit by different types of violent weather including hailstorms, lightning storms and ‘kalboishakhi⁵’ or nor-westers. Interviewees talked about how the high winds, rain, hail and lightning bring significant damage to houses and infrastructure, trees and crops, and take lives. Heavy downpours can trigger flash floods and erode the riverbanks, a phenomenon worsened when dams in neighbouring India are opened: ‘In 2012, fifty acres fell into fallow land in the Tahirpur⁶ area due to the flash flood caused by India’ (H24). Downpours also bring deadly landslides. The lightning storms that come in this season are particularly violent, causing significant casualties and serving as a source of dread amongst those exposed on the water, such as fishers or boatmen. Some interviewees also symbolised the lightning as important for triggering fish spawning in the haor.

⁴ Interviews were anonymised by assigning them a letter associated with the interviewer—interviewers A–D were active in Moulvibazar and interviewers E–H in Sunamganj—and a number according to the order that the interviewer ran the interview.

⁵ A storm accompanied by hailstorms and lightning that takes place mostly in the month of Boishakh (mid-April to mid-May).

⁶ Tahirpur is a sub-district of Sunamganj District in Bangladesh.

The rising waters

Summer is ‘when the water rises up’, with the persistent rain filling the rivers and haor, and inundating the surrounding area. This flooding introduces a pattern to life in this area, dictating when Sylhet’s communities live on the water, and shift their modes of livelihood: ‘The water rises up and harms the agricultural crops, but fish become easier to catch’ (E18). In anticipation of damage to property and roads, people buttress their properties on small islands in the flood waters; ‘we have to set barrages in this season. [...] Trees are cut down to repair the houses and the barrages save the houses’ (G5). On their islands, people are cut off from services such as school or healthcare, and spend more time indoors. There is less outdoor work, which is difficult for day labourers; ‘we cannot go to anyone’s house, cannot move and cannot cut down the paddy’ (F8). The high water also determines gendered activities; ‘The women do not have much work in Ashaar-Shrabon (mid-June to mid-August) so they have a lot of free time. They play ludo⁷ together in their houses’ (G5).

A season of plenty

Summer is symbolised as an important season for agriculture, a period when farms are fertile and the harvest abundant. Several interviewees discussed Joishtho (mid-May to mid-June) as the ‘the month of honey’ (F16), when jackfruit, mango, pineapple and melon become ripe for eating. One pervasive theme is the dependence of agriculture on a delicate balance between sufficient but not excessive rainfall; ‘If it rains continuously crops are damaged, but also if it rains too sparsely, then we lose our crops’ (E19). While rainfall is vital, it is important to have sufficient dry periods for the harvest and drying of the boro rice.

Ecological changes

The summer months mark important changes in local ecology. The rising water levels in the haors correspond with the arrival and spawning of fish; ‘It rains and storms, the water rises, the number of fish increases, and the number of fry (juvenile fish) increases’ (C15). Associated with this influx of fish, interviewees talked of the arrival of migratory birds to the haor (B10). But, interviewees did symbolise these ecological rhythms as undergoing long-term changes, which they associated with reduced summer rains and fish spawning.

⁷ A board game.

Challenges to health and well-being

Summer brings a transition from extremes of heat and drought, to rain and floods, and is thus symbolised as a period of illness and discomfort. Hot and dry conditions bring respiratory problems, with one medical practitioner saying that ‘...the air becomes dusty and that makes people sick with asthma, the common cold, and so on’ (A12), while another interviewee described the heat as uncomfortable; ‘I hate hot weather. I feel bad from Falgun (mid-February to mid-March) to Joishtho (mid-May to mid-June) because of hot weather [...] Eating and sleeping are difficult, the children can’t sleep’ (G2). In the same summer months, floods are also very likely, which have other health impacts, with one agricultural worker (F4) saying when the water rises ‘it harms, people suffer from disease’. Floods also cut off communities from medical help. One government official (C19) connected flooding with female hygiene, due to poor sanitation in many houses.

A changing climate

Summer rainfall was discussed according to its long-term changes beyond normal variability, symbolising summer by its departure from ‘normal’ rainfall patterns. Interviewees from all institutions discussed long-term climate changes, and while not unanimous, interviewees’ responses reveal some common experiences (see [How representations are evolving with ways of knowing](#)), particularly around interruptions to typical rhythms of rainfall, and a general reduction in summer rain.

Guiding institutionalised practices by seasonal symbols

We found that while interviewees’ stories drew on a common stock of representations, they deployed them in configurations that inferred meanings for adapting their specific institutionalised routines and practices. Summer is culturally symbolised in diverse ways—e.g. as a season of honey, living on the water, dread storms or fatigue—making for a rich repertoire for interpreting situations in various social spheres, and how to respond or adapt. Symbols were used to anticipate, make sense of and attribute meaning to phenomena and were in turn translated into courses of action. From interviewees’ narratives, we distinguished the use of cultural symbols from other resources guiding decision-making, such as meteorological forecasts, though ways of knowing and symbolising seasons are intertwined (see [How representations are evolving with ways of knowing](#)). Here we present revealing examples of symbols guiding (adaptive) action in four fields of practice:

Summer on the rice farm

For the rice farmers, we spoke to summer could be a *season of plenty*, though much was made of a delicate balance between *summers sun* and rain. By the end of Choitro (mid-April), the intense sun means ‘farmers cannot work in the field’ (B6), and many farms fall into drought; ‘crops fail, insects attack the paddies, and fertilisers don’t work (C26). Those farmers who can, take this cue to adapt and begin pumped irrigation, while others trust in the *onset of the summer rains*. The arrival of the rains—when ‘there is both a lot of sunlight and rain’ (B27)—heralds a period of fertility. ‘Boishakh (mid-April to mid-May) is a month of joy for us. A new year comes and the weather remains pretty good [...] Joishtho (mid-May to mid-June) is a month of crops. We cultivate mango, jackfruit. [...] a little rainfall becomes really helpful for rice crop production’ (A26). The boro rice crop is ready to harvest in this season, and farmers must carefully adapt to the weather to find periods for drying the rice; ‘Paddies are cut down and dried in this time because there is enough sun. But if it rains and these paddies get wet then they cannot be eaten because they rot. There is a smell’ (G5). At the same time, the rains of Boishakh (mid-April to mid-May) are important for germinating the Aus⁸ rice crop, planted around then, and farmers adapt their sowing practices to the rain onset (A12). In addition to being vulnerable to the ratio of sunny and rainy days, rice farmers voiced anxiety about *summer storms*, and the *rising waters* that wash away their crops and property. One farmer (A26) talked about a hailstorm in 2013, where ‘Houses and crops got really damaged [...] My house was completely ruined too’. We see symbols (*in italics*) invoked to explain the cues and scripts of rice farming—how they think, feel and act—such as farmers’ understanding of rainfall onset and frequency and how that affects the timing of practices like sowing and drying, adaptive plans for irrigation and feelings of vulnerability.

Summer in intensive livestock sheds

Interviewees intensively farming poultry and cattle talked about what summer meant for their animals. The *summer’s heat* causes animals to lose their appetite, with one poultry farmer noting, ‘because of the heat, the chickens drink water more than they eat food, and so they lose weight’ (G5). And, the same delicate balance of droughts and *summer rains* that troubled rice farmers was also evoked by livestock farmers, this time relative to animal health. A poultry farmer

⁸ *Aus rice* refers to rice sown in summer (mid-April to mid-June) along with summer rainfall and harvested in autumn (mid-August to mid-October) in Bangladesh.

noted, ‘If it rains a lot in Boishakh (mid-April to mid-May) the poultry feed remains wet and the chickens suffer from a disease and die’ (G6), while a cattle farmer said; ‘...reduced rainfall is harmful for my cattle, because they’re attacked by different types of diseases (D13). Here seasonal representations are connected to animal husbandry and interviewees knowledge of the rhythms of animal growth and health. Symbols are translated into adaptive practices to alleviate animal stress through opening the shutters in the sheds to reduce the heat or taking steps to keep the feed dry.

Summer at school

Teachers interviewed drew on representations for interpreting the rhythms of school attendance and classroom energy levels. Summer introduces extremes that hinder transport and make it difficult for students to get to school. In *drought conditions*, the roads dry out and crack making communication difficult; ‘The villages feel far from each other’ (E5). But, with the onset of the rains and the *rising waters*, families can be similarly isolated, as one teacher (E7) recounted; ‘My grandmother was terribly sick but we could not call a doctor to our house. Heavy rainfall totally broke the communication system so we could not treat her properly and she died’. This introduces another representation of summer, associated with *health and well-being*. Some teachers associated colds, fevers, heat stroke and discomfort to summer’s heat, contributing to lower school attendance but also lower energy and enthusiasm amongst students. These changes to movement and communication are associated with long-held adaptive measures in Sylhet division, where life on the water means moving around by boat for instance.

Summer on the water

For the fishermen and boatmen, we interviewed, summer began with the *onset of the rains* and *rising waters*, which initiates community life on the water. Fishermen discussed the areas phenology and migrations in detail, describing how summer rain, floods and storms are bound to *ecological changes*, and particularly the fish reproduction cycle. They described how fish lay their eggs in Choitro (mid-March to mid-April), how these eggs hatch in summer—prompted by rain and lightning—and how the fish grow in the fast-filling waterways. Their fishing practices follow this rhythm, these natural cues, and thus their livelihood is vulnerable to interruptions to this cycle; ‘When there is no water there are no fish [...] so when there is no rain I cannot pay the rent, and we are short of food’ (C14). Another source of anxiety for fishermen and boatmen comes during *the storms*, when they are fearful of moving around on the water; ‘We face problems when there is lightning. Last year two people died from

lightning strikes’ (E17). For one boatman (G19), this made summer too dangerous to use his boat; ‘We cannot use the boat in this time. We have to tie them up because of excessive rainfall [...] and blowing winds’. Here we see interviewees assembling summer representations in ways that portray intertwined natural and social order; the close links between climate and ecology, and between ecology and fishing practices. This has implications for adaption strategies, according to the timing of their activities, but also fishing practices if it becomes too dangerous to be on the water.

How representations are evolving with ways of knowing

While representations of summer impose stability, they are not static. Our interviews revealed several ways of knowing climate that converge in institutional fields and continuously re-work seasonal symbols, creating ideas of summer rain that are a composite of the traditional and the modern, the pragmatic and the spiritual, the past and the future, the local and the global. An interviewee might simultaneously appeal to traditional calendars, meteorological measurements and God’s will, in representing summer as stormy. This suggests a relationship between how groups choose to know seasons, and how they symbolise or find meaning in them. Here we focus on interpreting how symbolic representations are mutually adapting with systems of knowledge. We grouped interviews into the 11 categories and coded responses to questions about the weather information interviewees’ use and trust, and who they share it with. But, not discerning any meaningful patterns specific to institutions, we discuss knowledge systems in general, rather than by institution.

Religion

We saw Islam and Hindu religions occupy a central place in Sylhet communities’ culture, with an important role in how people think about summer rainfall, and deviation from natural order. Some interviewees talked about summer rainfall according to God’s plan, with one saying ‘Recently the summer rains have not come on time, but this is happening with the permission of God, so me and you have nothing to do in this’ (A01). Attributing rainfall to God’s mysterious will implies, for some, that the climate is inherently uncertain and beyond any attempts to reliably understand it; ‘We cannot believe anyone, everything is God’s decision’ (B19). But others allowed that, while recognising God’s will, some sources of information are nonetheless helpful; ‘I believe in that which Allah has decided for us, and also the newspaper’ (B10).

Traditional calendars and proverbs

We saw traditional seasonal representations remain influential in Sylhet communities. Five interviewees said their symbols of seasons were drawn from the ‘Ponjika’⁹ astronomical almanac. The Ponjika has a long history—‘My forefathers used to trust Ponjika’ (F16)—but some seemed embarrassed to still the almanac in modern times. One teacher (B07) said, ‘You won’t believe that we used to be warned of any natural disaster by reading the Lokonath Ponjika.’¹⁰ But now we watch TV to get weather updates’. Though later in the interview he revealed, ‘In fact, I also trust the Ponjika’. A more commonplace understanding of seasons comes from the standard Bangladeshi calendar, divided into six seasons; spring, summer, monsoon, early autumn, late autumn and winter. Alongside cultural artefacts such as calendars, interviewees draw on traditional proverbs, signs and mnemonics. Some of these are linked to observations of the sky, in the sense of predicting rainfall from observing dots around the moon or a round rainbow around the sun. Others were linked to plants, with some noting that when the mango tree buds prolifically in spring this predicts heavy summer rainfall.

Local knowledge of natural signs

Overlapping with traditional knowledge, we saw Sylhet communities exhibit an awareness of local signs that characterise seasons and signal on-coming weather. In predicting rainfall and storms, many interviewees observe the thickening and darkening clouds. Different seasons see clouds gather in different sectors, and winds from different directions, with spring and summer rainfall signalled by clouds in the west and northwest, which can bring ‘Kalboishakhi’ storms. Interviewees also drew on a repertoire of signs of floods including; (i) ants entering houses and climbing trees; (ii) grasshoppers swarming and flying close to the ground; (iii) snakes around the house; (iv) frogs croaking loudly and moving to the roof and (v) dogs becoming restless. As floods approach, interviewees monitor them by observing the flow of water in the rivers.

The media

We saw how meteorological science in the media is coming to mediate how Sylhet communities represent seasons (findings that echo studies in other countries; see, e.g. Schmidt

et al. 2013). Interviewees revealed a reliance on science-based forecasts, with most respondents using television and/or radio forecasts. Most appear to trust in these forecasts as credible and reliable: (i) generated by ‘respected people’, (ii) underpinned by scientific research, (iii) using high technology, (iv) endorsed by the Bangladesh Meteorological Department (BMD) and (v) disseminated widely via public media and used by others in the community. Steadying this trust, some interviewees saw forecasts often came ‘true’—corresponding with their observations—though others recognised the uncertainty underlying forecasts, especially at the local Upazila scale; ‘all of the information are just predictions, it could be wrong anytime’ (A26).

School

We saw the school as an important institution in Sylhet communities, shaping how they interpret the weather and seasons. Schools balance and integrate certain cultural representations—such as the traditional Bengali calendar—with the scientific meteorological curriculum they teach. Importantly, global climate change is now a part of the school curriculum, and we saw how this was mediating students’ experience of local climate variability. Students were the only interviewees that explicitly appealed to climate change as a cause for perceived weather. One student discussed a perceived warming of summer; ‘Summer feels warmer. Carbon dioxide increases. The weather of the earth becomes warmer’ (B3).

Informal institutions; community knowledge and norms

We saw weather and seasons are a frequent topic of discussion within Sylhet communities, with almost all interviewees saying that the regularly swapped weather information within their networks. Such sharing could also account for the common stock of seasonal symbols drawn on. Most of this sharing was via informal communication with neighbours and others in the community and in common areas such as at the bazaar¹¹ or tea stall. As one interviewee said, ‘We get weather information from the radio and the TV and then we discuss. By sharing the news with each other, everyone gets the news’ (G09). This communication is shaped by local cultural norms, as when interviewees say that they speak with people of the same age group.

Formal institutions: governmental and non-governmental organisations

We saw formal institutions influencing the way people understand and live by summer rainfall. Some interviewees

⁹ The Panjika is the Hindu religion’s astronomical almanac where dates; lunar days; auspicious and inauspicious times; positions of the sun, moon, planets and stars; horoscope; days of various festivals and religious occasions, etc., are published.

¹⁰ Lokonath Ponjika refers to the Panjika printed by the Lokenath Book Agency.

¹¹ Local market place.

said they drew directly on weather information from governmental or non-governmental organisations, most notably the BMD forecasts or loud-speaker warnings from the municipalities to warn of impending storms. There was also evidence of (semi-)formalised networks for sharing weather information amongst organisations and groups. For example, boatmen and fish-mongers maintained a network of warnings of bad weather on the haors; ‘When I’m in my boat I get called by friends and colleagues, so then I can get prepared and tie up the boat in case of rainfall and storm’ (G19).

Lived experience of climatic change

Most interviewees said they had observed reduced summer rainfall and storms. For them, the timing of summer rains is increasingly irregular and unpredictable; ‘It used to rain in the past, but now we cannot say much about this rain; it may or may not rain’ (C10). Many interviewees also felt summers are getting warmer, though there were mixed perceptions of temperature, with some experiencing cooler summers. The increasingly warm and dry summers are often linked to reduced flooding and water levels in the waterways. This is affecting the haor ecology, through reduced fish stocks and migratory birds, and agriculture. Some saw reduced flooding as positive since the floods damage property and infrastructure.

Interestingly, many interviewees saw changes in summer rainfall as part of a general change in seasonal rhythms; ‘It seems that the seasons will totally change over the next 20–30 years. Now we notice only three seasons, when there used to be six. In the past, we used to call Boishakh (mid-April to mid-May) the month of hazards. Now it is dry’ (A27). The consistency with which actors told this story of seasonal loss reveals it as an important ‘public narrative’ of climate change, which is shared and recited as a social fact. Actors claim that they distinguished between the traditional six seasons by the natural phenomena that accompanied them, but that these signs are disappearing with climatic and other changes to their natural environment like deforestation; ‘In the present nothing happens according to season, now we can’t feel the seasonal change’ (G05).

Co-creating seasonal representations: the cognitive maps

We ran two workshops with project scientists and participants from the pool of interviewees, divided into four mixed groups in each workshop (see [Co-creating new representations of rainfall: cognitive maps and analysis](#)), with each group co-creating a cognitive map; yielding eight cognitive maps (see Section 3 of Supplementary material). Making the cognitive maps was a way to explicitly recreate the processes by which people (consciously and unconsciously) assemble

seasonal symbols in making sense of complexity, inferring meaning and justifying their everyday practices (Papageorgiou & Salmeron 2012). The maps complemented interviewees’ narratives in offering an alternative means of studying how symbolic representations are assembled in forming an adaptive strategy in institutionalised settings, a cultural toolbox (Swidler 1986; Sewell 1992). As importantly, it was a reflexive exercise where participants could see how others represented summer, and as a group critically appraise the elements on the map—e.g. which representations hold true, or are useful, for whom?—and identify gaps in how they represent summer (Funtowicz & Ravetz 1993; Meisch et al. 2022). Figure 2 shows two cognitive maps compiled from across the group work.

All maps depicted summer rainfall, though groups focused on different types of rainfall—e.g. storms or seasonal rain—making each map unique. This underlined the rich resource of cultural symbols, which are configured in multiple ways by groups interpreting different situations. It showed that there is no conventional way of representing what happens before, during and after the summer rains. Representations were influenced by group composition and the standpoints of participants active in varied social spheres, calling on their sets of experiences and knowledge of the rains.

Notwithstanding their unique configurations, the maps shared many of the same elements (see Fig. 2). In particular, we saw the same stock of eight symbolic representations from the interviews ([A common stock of summer rainfall representations](#)) reappear on the maps, e.g. summer as stormy and rising waters. While some maps omitted one or two of these common symbols, no new symbols arose. It is mainly in the purple boxes of what happens after the rains that groups depicted what the rains mean for their communities: the rains’ significance for their lives and livelihoods. Here too, we glimpse how symbols shape the way people feel, think and adapt in different spheres: peoples discomfort, the things they pay attention to like snakes or their harvest practices for instance. We also saw interviewees’ ways of knowing the rain appear on the maps, usually in orange boxes as predictors or causes of the rain. We see meteorological science of depressions over the sea, local knowledge of clouds, wind and insects or traditional knowledge of proverbs. It was revealing to see knowledge of rain and its significance depicted on the same representation: the before-during-after format depicting foreknowledge and meaningful impacts. It suggests a relationship between knowing and attributing meaning to seasons, and adaptive action. Overall, the maps verified our analysis of the interviews discussed in the [‘A common stock of summer rainfall representations, Guiding institutionalised practices by seasonal symbols and How representations are evolving with ways of knowing’](#) sections.

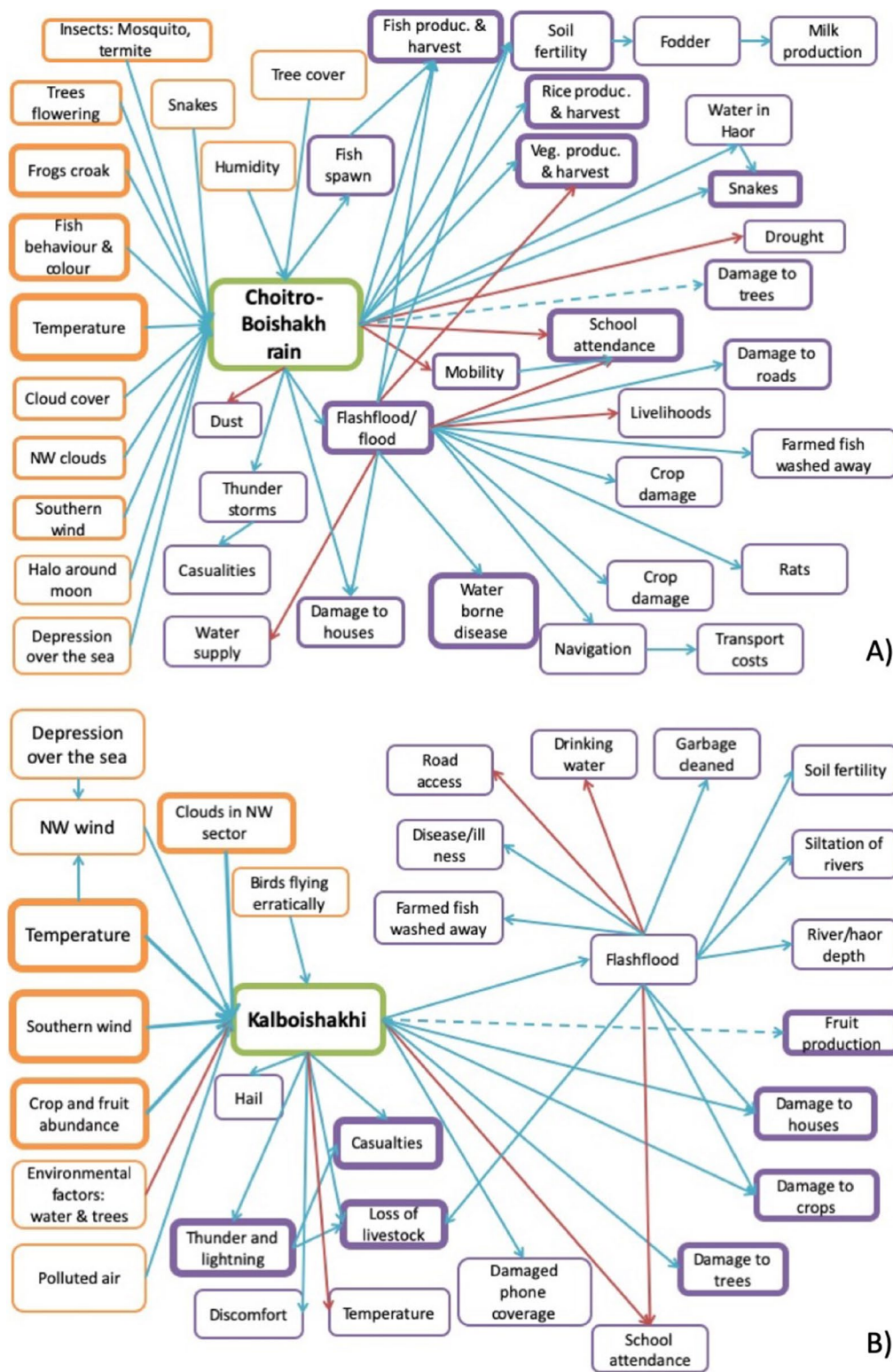


Fig.2 Compiled cognitive maps from **A** Barlakha and **B** Sunamganj workshops. Even though the different groups highlighted different types of summer rainfall, here we include the most prevalent types, which were ‘Choitro-Boishakh rain’ in Barlekha and ‘Kalboishakhi’ in Sunamganj, and associated elements. The thicker borders around variables shows those that appeared most across the groups in each workshop. The orange boxes are what happens before (predictors and causes)

and the purple what happens after (impacts) this summer rainfall. The arrows represent the relationships between different elements of the system; blue arrows show a positive relationship (an increase in one factor leads to an increase in another factor), while red arrows show a negative relationship (an increase in one factor leads to a decrease in another and vice versa). The dashed arrow indicates that some groups saw this as a positive relationship, and others as negative

There were, however, some elements from interviewees' stories absent from the maps. Religious ways of knowing were widespread in the interviews, but only one group included religious elements in their map; a group containing two religious leaders. Also, while showing relational variability, the maps do not well show long-term change, such as climate change. Representation of changing summer rainfall was largely omitted, though (see Fig. 2B) groups in Sunamganj seem to allude to climate change in showing polluted air as causing norwester storms.

Another difference from the interviews was in the complexity of representations. The maps let groups assemble their subjective understandings to build a more comprehensive picture than afforded from each individual perspective. While individuals assembled four or five symbols relative to their fishing or farming practices, the groups usually drew on seven or more symbols, relative to an array of fields of practice—from schools to aquaculture—and unpacked multiple links between them. In this sense, the mapping exercise created complexity, but it also reflected the complexity and interconnectivity between elements of seasonality. For example, Fig. 3 shows a map with just 26 variables (boxes), but which is complex with regards to its connections. Each variable has 1.58 connections to it, meaning that the group saw more than one relationship per variable that they discussed. In this complexity, the maps demonstrate the relationality between how participants from different social spheres attribute significance to summer rain. The maps (Fig. 2) show flash floods, for example as meaning both destruction and isolation, but also the awaited fishing season and increasing soil fertility. We see how the same phenomena has different meanings for people from different standpoints, and how these meanings translate into adaptation strategies, e.g. by moving from agriculture to fishing.

While validating the interview findings, the map making enabled groups to critically interrogate ways of representing summer. Before an element was added to a map, the group had to agree it was salient, credible, legitimate and useful for living with the rains. This often saw religious beliefs omitted as a different category to other elements on the maps; God's will encompasses the whole map. This also enabled debate around relationality, e.g. (see Fig. 2B) do abundant crops predict or cause rainfall? This process suggests that everything represented on the maps was agreed on and trusted by group participants that they adhere to these shared knowledge and beliefs and continue to use these symbols as a cultural resource for adaptation. At the same time, groups used these maps to identify multiple elements worthy of closer interrogation, or perhaps, revision, as part of a citizen science study. This indicates (as did the interviews—How representations are evolving with ways of knowing), that representations are changing with changing climatic experience, narratives and knowledge.

It is important to note that the maps were also influenced by the facilitation, interaction and local power structures within each group. We tried to bracket power—through mixed groups and active facilitation. All participants did provide elements for maps, but socio-cultural and power structures remained nonetheless (Peterson et al. 2010). For example, structuring activities around a graphical exercise and seeding groups with climate scientists likely brought forward certain knowledge—such as rainfall's relationship to depressions over the sea—but excluded others.

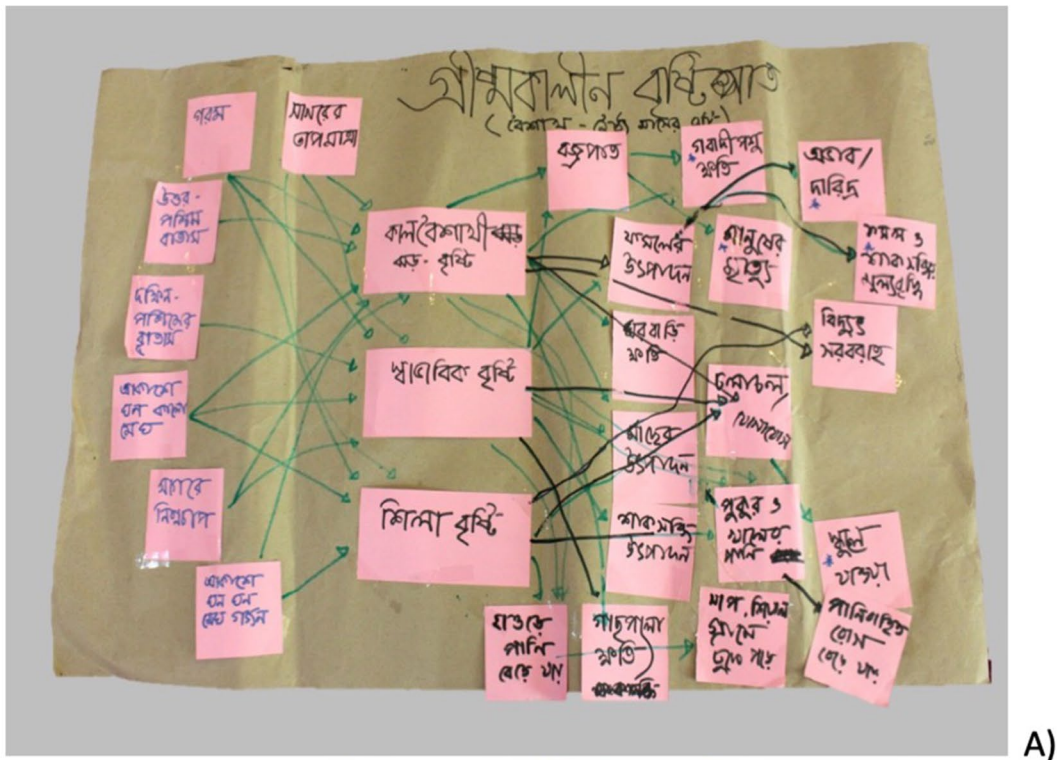
Discussion: relevance for adaptation research and practice

This study asserted that seasonal frameworks of symbols are an important cultural repertoire availing Sylhet communities to adapt their practices to seasonal variability and change, and set out to (i) access the symbols of summer rainfall used in local institutions; (ii) comment on how these symbols are changing and (iii) facilitate a process for critically reflecting on these changing symbols. Our work contributes to scholarship on climate adaptation governance with its focus on social structures—or institutions—as culturally conveying seasonal patterns of thought, feeling and action guiding adaptation in various fields of activity (Sewell 1992).

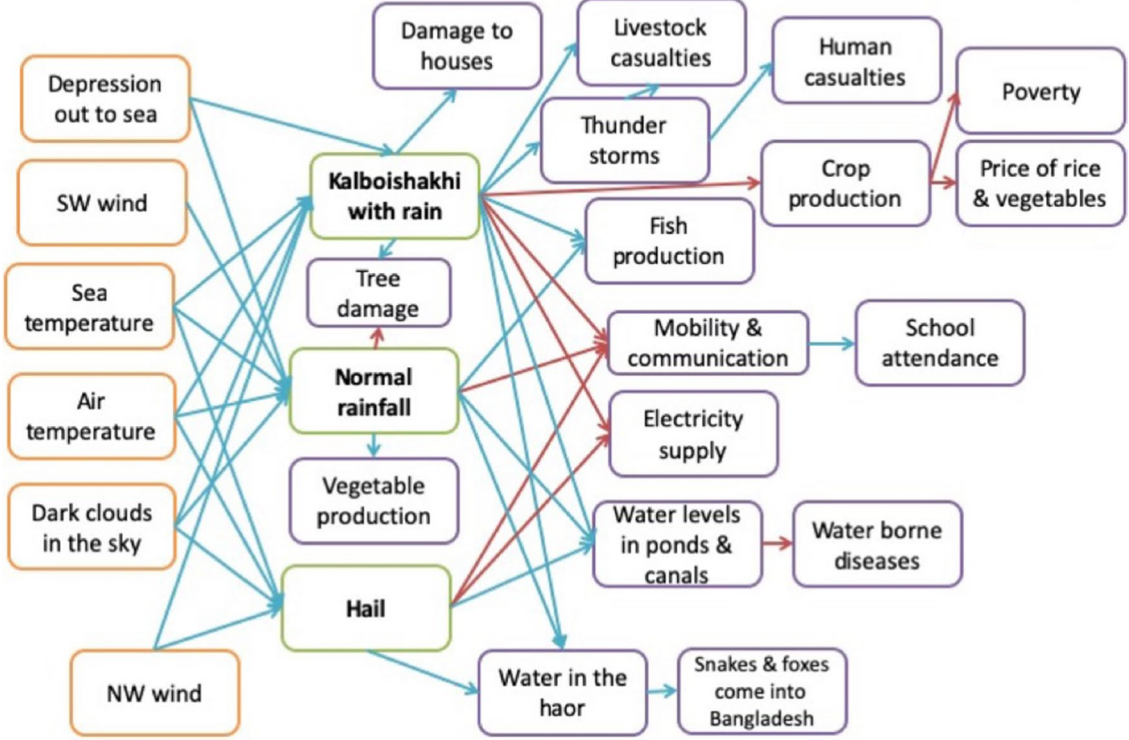
The influence of seasonal symbols on institutionalised patterns of thought and action

Our interviews and cognitive mapping workshops revealed that people in Sylhet communities do divide up the year by cultural categories of seasons and that the season they called summer was distinguished—made meaningful—by a common set of eight symbols, which also acted as temporal reference points for this period. In telling stories about their summer activities, interviewees (consciously or unconsciously) oriented themselves by these taken-for-granted symbols, revealing underlying cultural assumptions and presuppositions of conditions and conduct over the season (Orlove 2003). Seasonal categories of symbols are markers that pattern Sylhet social lives (Crane 1994; Douglas 1986; Sewell 1992; 2004; Swidler 1986).

We were surprised to find that the same stock of seasonal symbols was invoked by interviewees across a range of institutionalised fields of practice. This suggested that seasonal cultures and calendars in Sylhet are less specific to institutions, and better studied at the aggregated unit of the population. It might be that seasonal symbols are cultural infrastructure for the whole community, organising and synchronising activities across various social spheres according to a common semiotic template or set of reference points. But, this may have been influenced by how the interviews



A)



Summer rainfall (Boishakh-Joishtho) (Barlekha- Grp C Naznin) B)

Fig. 3 Cognitive map from group C in the Barlekha workshop; original (A) and digitised (B)

were run or that interviewees pass through multiple institutional fields, e.g. moving from farmer to fisher with the rains.

However, while interviewees drew on the same resource of seasonal symbols, they were often seen to reconfigure them into schemas that specifically enabled their practices (Sewell 1992); cultural symbols in action. They drew on seasonal frameworks like a toolkit of, ‘symbols, stories, rituals and worldviews that people use [...] to solve problems and organise their activities over time’ (Swidler 1986). Symbols were an adaptive resource for interpreting summer situations, particularly anomalous situations, and devising and justifying strategies of action (Vaisey 2009). Symbols were fitted to cultural scripts guiding activities, providing situational cues for farming and fishing routines, or linked to animal husbandry or school commutes. And in acting according to templates of practice, interviewees reinforce or reproduce the cultural frameworks of symbols (DiMaggio & Powell 1991).

Symbols informed people’s understandings of natural and social order, as when the flood introduces community life on the water, redefining living spaces, social relations, modes of communication, livelihood strategies and gendered activities (see Bourdieu’s 1977 study). The maps effectively showed the relationality between interviewees’ representations of rainfall, determined by their standpoints. They showed how symbols relate to each other and were in some cases mutually constitutive, as where flooding is simultaneously symbolised as destruction and renewal.

Altogether our findings emphasise the significant influence of ‘common-sensical’ cultural frameworks of seasons on people’s patterns of behaviour, and how they strategise adaptation to seasonal change. This is important because the majority of research on adaptation has tended to overlook cultural impact in favour of policy-making, infrastructure and mobilising scientific and technological advances in support of decisions (Bremer et al. 2021). Without downplaying the importance of this technical work, it does espouse a narrow view of decision-making that poorly accounts for the cultural toolkits that arguably play as large a role in motivating and justifying behaviour (Vaisey 2009). We argue that adaptation research and practice should, in parallel with technical work, provide opportunities for communities to revisit their cultural frameworks and critically assess whether symbols and routines still hold (Meisch et al. 2022). Communities are re-drawing their calendars because seasonal frameworks are not static; they are rapidly changing.

Changing ways of knowing and frameworks of meaning

The narratives and cognitive maps revealed a relationship between ways of knowing and ways of symbolising

seasonality, and in this way, seasonal categories and symbols evolve. Traditional calendars and almanacs prescribe symbols to certain periods, while readings of local signs—clouds or insects—likewise populate seasonal frameworks with symbols, and meteorological averages come to scientifically signify ‘climate’. Our analysis showed that interviewees were confronted, in different social spheres, with diverse ways of knowing that they had to reconcile in interpreting what the rains mean for them.

Most significantly, we observed that climate and meteorological science is stabilising as the most trusted ways of knowing weather and seasons, and other pieces of knowledge are marginalised. Interviewees emphasised TV and radio forecasts as most ‘authentic’, even if the forecasts were unreliable for their locality. Some actors seemed ashamed that they still used traditional knowledge. In schools the curriculum about global climate change is mediating how students talk about summer rainfall. One implication is that certain symbols—such as proverbs about dots around the moon—are falling into obscurity, to be replaced by scientific explanations.

At the same time, interviewees commented that certain symbolic representations are being undermined by climatic change. Many appealed to a public narrative that the traditionally discernible six seasons are disappearing, and local signs no longer hold. Interviewees talked about a warming and drying of summer, and irregular timing of the rains; a perception in keeping with meteorological data (Hasan & Kumar 2019; 2020) though not so neatly in NE Bangladesh (Bashar et al. 2017). Interviewees themselves acknowledged that these changes are not only due to changes in seasonality and meteorological phenomena, but also social and environmental changes, such as milling of the forests. It may be that some cultural symbols of summer are becoming defunct as an adaptive resource.

Conclusion: adapting in a cultural interregnum

Our study highlighted a problem that is repeated worldwide (e.g. Lazrus 2015; Leonard et al. 2013; Sheridan 2012; Strauss 2016). Sylhet communities sense that the seasonal symbols they draw on each day, as a cultural script for their daily practices, are being destabilised. Their long-held traditional and local significations are increasingly marginalised in the processes of modernising institutions, or no longer hold for rapidly changing seasonal patterns, in highly modified environments. These sentiments were expressed in interviewees’ stories and in their critical cognitive mapping exercises. At the same time, interviewees highlighted the multi-faceted uncertainties attached to scientific information in the region (Haque et al. 2017). While improving, there is not the

climate and meteorological scientific capacity to make up for the loss of these cultural symbols with locally accurate forecasts (see, e.g. Findlater et al. 2021; and an assessment of Sylhet's climate adaptation knowledge quality by Haque et al. 2017). Communities find themselves in an interregnum, where extant cultural representations become defunct, but new scientific representations cannot yet be brought to bear. Faced with this uncertainty, interviewees said they fall back on informal networks, knowledge, norms and cues, even as they know their flaws. The cognitive maps faithfully represented long-held summer rhythms—such as the onset of the rains—though they perceived these rains as dwindling.

In following increasingly defunct cultural frameworks, Sylhet communities risk being led down dangerously maladaptive pathways, where their patterns of activity are mismatched with seasonal rhythms. Yet given the limitations of science alone for guiding decision-making, culture will always remain an important influence on behaviour. Climate adaptation scholarship and practice in northeast Bangladesh, but also globally, cannot overlook the influence of seasonal cultures; they need to address technical and cultural capacities in parallel. This means communities revisiting their seasonal frameworks with a critical and reflexive attitude and a creative view to recalibrating the seasonality of their practices. There is inertia and path-dependency to cultures and institutions, but if we consider that social structures evolve through individuals' agency, then communities can consciously alter their seasonal frameworks for contemporary conditions. There is a small but growing experience with this important cultural work, ranging from initiatives in the UK to institute new seasonal festivals (Parkes-Nield 2022), to traditional communities in the USA (Chisholm Hatfield et al. 2018) and Australia (McKemey et al. 2020) revising their calendars with consideration for climatic change and the technologies available, or Canadian engineers calendrically mapping the shifting seasonal pressures on their water infrastructure (Penn et al. 2016). For our part, we saw how a collaboration between research organisations and local government did nurture such reflections in Sylhet division using cognitive maps.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s10113-023-02057-8>.

Acknowledgements The authors warmly thank the other members of the TRACKS project consortium for their collaboration, and the Sylhet participants and citizen scientists that were so enthusiastic to work with us to re-learn their climate.

Author contribution Bremer, Stiller-Reeve, Mamnun and Lazrus contributed to conceptualising, analysing and writing up the paper. Bremer, Stiller-Reeve and Mamnun carried out the empirical work.

Funding Open access funding provided by University of Bergen (incl Haukeland University Hospital) This work was part of the TRACKS project supported by the Research Council of Norway (grant number 235613). Bremer was supported in conducting the analysis and writing

of this paper by the European Research Council CALENDARS project (grant number 804150).

Data Availability The datasets generated during and/or analysed during the current study are not publicly available due to privacy considerations, but some sources of data may be available from the corresponding author on reasonable request.

Declarations

Ethics approval Ethics approval was obtained from the Norwegian Centre for Research Data.

Conflict of interest The authors declare no competing interests.

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