Regional Environmental Change (2019) 19:1533–1547
https://doi.org/10.1007/s10113-019-01479-7

ORIGINAL ARTICLE

Climate change and uncertainty from 'above' and 'below': perspectives from India

Lyla Mehta[1] · Shilpi Srivastava[1] · Hans Nicolai Adam[2,3] · Alankar[4] · Shibaji Bose[5] · Upasona Ghosh[6] · V. Vijay Kumar[7]

Received: 18 September 2017 / Accepted: 15 February 2019 / Published online: 14 June 2019

Abstract

Climate-related uncertainty refers to the inability to predict the scale, intensity, and impact of climate change on human and natural environments. Debates of uncertainty in climate change have emerged as a 'super wicked' problem for scientists and policy makers alike. The article draws on ongoing research in different socio-ecological and cultural settings in India (Kutch, the Sundarbans and Mumbai) and introduces the heuristic of the 'above', 'middle' and 'below' to explore how climate change and uncertainty are understood and experienced by diverse actors. Responses from 'above' (especially by planners and policy makers) tend to be directed towards controlling uncertainty through top-down, techno-managerial solutions whereas scientists tend to rely on quantitative assessments and models based on probabilistic scenarios. These may have little to do with the experiences and lived realities of local people, especially in the global South, who are often at the frontline of climate change. Also at the local level, climate-related uncertainties seldom stand alone, rather they closely interact with other socio-economic drivers of change that create new uncertainties and vulnerabilities, especially for poor and powerless people constraining their adaptation choices. This article demonstrates deep differences in ways different actors understand and experience climate change and uncertainty. It argues that diverse knowledge and approaches need to be deployed to understand and embrace climate related uncertainties in order to facilitate socially just adaptation.

Keywords Uncertainty · Climate change from 'above' and 'below' · Adaptation · Science policy · India

Introduction

Climate shocks and stressors such as cyclones, floods, droughts, changing rainfall patterns and extreme temperatures are some examples of uncertainties that planners and local people in the global South regularly confront. Climate-related uncertainty refers to the inability to predict the scale, intensity and impact of climate change on human and natural environments (Curry and Webster 2011). Uncertainties in climate change projections remain particularly high, and combined with economic and political drivers of change, they make local level effects difficult to predict (IPCC - SREX

✉ Lyla Mehta
l.mehta@ids.ac.uk

Shilpi Srivastava
s.srivastava2@ids.ac.uk

Hans Nicolai Adam
hans.adam@nmbu.no

Alankar
alankarsy@gmail.com

Shibaji Bose
shibbose@gmail.com

Upasona Ghosh
upasonaghosh9@gmail.com

V. Vijay Kumar
vijay196129@gmail.com

1 Institute of Development Studies, Brighton, UK

2 Norwegian University of Life Sciences, As, Norway

3 Norwegian Institute for Water Research (NIVA), Oslo, Norway

4 Centre for the Study of Developing Societies, New Delhi, India

5 Kolkata, India

6 Indian Institute of Health Management Research, Jaipur, India

7 Gujarat Institute of Desert Ecology, Bhuj, India

2012). Uncertainty has emerged as a 'monster' or 'super wicked' problem for scientists and policy makers alike (van der Sluijs 2005, Levin et al. 2012), and its integration in climate change decision-making is disputed (Dessai and Wilby 2011). Despite the limitations of quantitative assessments, which are usually based on probabilities and ecological risk assessment, they remain at the heart of how uncertainty is understood in science and policy domains (Curry and Webster 2011). However, theorising about climate-related uncertainty from 'above' by experts, natural scientists and modellers may have very little to do with how men and women (poor or rich, urban or rural especially in the global South) live with, understand and cope with uncertainty in everyday settings.

We build on social science and qualitative approaches that seek to understand diverse perceptions, impacts and responses to climate change (cf. Wynne 2010; Crate and Nuttall 2009; Jasanoff 2010). Why is this important? A growing number of authors have discussed key differences between how experts (be they policy makers or scientists) and local people view and experience climate change (e.g. Rudiak-Gould 2013; Hulme 2015; Hastrup and Skrydrstup 2013). These authors have attempted to validate the place-based knowledge and agency of local expertise vis-à-vis climate and its changes. Rudiak-Gould (2013), for example, argues that different lenses and experiences of climate change are required to appreciate the diverse dimensions of climate. This article builds on this literature to develop the heuristic of 'above', 'middle' and 'below' to examine differences in understandings, discourses and practices around uncertainty and climate change in three ecologically diverse settings in India, namely dryland Kutch, the Sundarbans delta and urban Mumbai. Specifically, we focus on three different aspects of uncertainty as related to climate change, namely, ecological and epistemic uncertainty, and uncertainty related to political economy (see Mehta et al. 1999).

We demonstrate that while local people are attuned to living, coping and adapting[1] to uncertainties in climate-sensitive marginal environments, climate change presents a radical uncertainty that can push local people to the limits of coping or trigger paths of maladaptation. Furthermore, traditional responses to these uncertainties are increasingly constrained when climatic uncertainties intersect with other socio-economic drivers of change that are multi-scalar in nature (Gajjar et al. 2018). These drivers also limit the adaptive capacity and pathways to address climate-induced uncertainties (Solecki et al. 2017; Tschakert 2007). Attempts from 'above' (especially from planners and policy makers) often tend to be directed towards controlling uncertainty through top-down, techno-managerial solutions, which may ignore local realities and knowledge systems. These can end up creating new uncertainties and vulnerabilities, especially for poor and powerless people constraining their livelihood choices, and also narrowing pathways for socially just adaptation (cf. Pelling 2011; Few et al. 2017). Our core proposition is that investigating and unpacking the gaps in diverse conceptions of uncertainty can facilitate processes that embrace rather than eliminate uncertainty. This is because as Leach et al. (2010) and Stirling et al. (2007) argue, subjective judgements, multiple knowledge and interpretations around uncertainty tend to be the best way forward, instead of a singular value or recommendation. These can ultimately help promote adaptation that is both socially just and responsive to the socio-ecological diversity of contexts.

Our focus is India which has large population groups that are highly vulnerable to the impacts of climate change (IPCC 2014). At the same time, India is also an emerging economy with one of the largest sources of greenhouse gas (GHG) emissions globally whilst also having one of the lowest GHG emissions per capita, reflecting an enormous share of the world's poor (Dubash 2012). The article now turns to presenting the conceptual framework and the heuristic of 'above', 'middle' and 'below', followed by the methodology deployed and a description of the research sites. It then teases out the diverse discourses and practices of uncertainty in the three settings before ending with some concluding thoughts.

Conceptualising uncertainty and climate change from 'above', 'middle' and 'below'

Put simply, uncertainty can refer to 'unknown unknowns', a situation where we do not know what we do not know—or 'known unknowns', where insufficient knowledge limits our understanding of a phenomenon (Rumsfeld, 2002). Uncertainty is thus characterised by indeterminacies where not enough is known about the probabilities of a particular set of outcomes and where they cannot be calculated (cf. Knight 1921). Unlike risk where we know the odds and the scientific proclivity to contain it (cf. Wynne 1992), uncertainty is a situation where one does not know the odds and the probabilities cannot be calculated. It is then about incomplete knowledge or degrees of knowledge (Funtowicz and Ravetz 1993; Stirling et al. 2007). Walker et al. (2003:5) define uncertainty as 'any deviation from the unachievable ideal of completely deterministic knowledge of the relevant system'.

Uncertainties in climate projections are particularly high and the IPCC has moved away from an initial confidence in the ability to deal with uncertainties in the climatic system towards acknowledging, accepting and embracing it (Curry and Webster 2011). There is now a growing acknowledgement that climate science is better at dealing with uncertainties arising due to macro trends such as temperature extremes and sea level rise than understanding the effects at the local level

[1] Coping here relates to more immediate responses over shorter time scales such as emergency responses to droughts whereas adaptation refers to more enduring changes that are broader in nature and cover longer and wider tempo-spatial scales such as changing agricultural patterns or livelihood practices (Smithers and Smit 1997).

due to downscaling challenges and also intersections with other drivers of change (Bhave et al. 2016). These include impacts of land use change, water management trends and socio-political and economic processes, which can increase uncertainties for local people (see Swart et al. 2009). This can be described as the 'envelope of uncertainty' (Wilby and Dessai 2010) that intersects with social, political, economic, cultural and scientific domains.

In this article, we focus on three types of uncertainties: (1) ecological or ontological uncertainties namely, ecological systems characterised by high degree of variability and disequilibrium dynamics thus having unknown effects; (2) knowledge or epistemic uncertainties which refers to indeterminate knowledge about changes and their impacts; and (3) uncertainties linked to larger political economy conditions (unanticipated outcomes due to socio-political interventions and how they are experienced by diverse groups) (Wynne 1992; Mehta et al. 1999; Walker et al. 2003). All these uncertainties are experienced, framed and interpreted differently by different actors and are linked to relations of power that justify different institutional practices and responses (Rein and Schön 1993). Historical understandings of both macro and micro level changes are also critical to conceptualising uncertainty. Furthermore, uncertainty can also often be politicised and manipulated by powerful actors or used as an excuse to do nothing (Mehta et al. 1999; Dessai and van der Sluijs 2007).

Uncertainties have differential impacts on local people as they are also are mediated and experienced differently by axes of difference arising due to gender, ethnicity and class thus exacerbating the vulnerabilities of ordinary people (Tschakert 2007; Adger 1999; Lemos et al. 2016). Historically, local communities have developed practices and strategies to plan for and live with ecological uncertainty and variability (Hastrup 2013). These could be seasonal mobility, crop diversification or risk averse behaviours to cope with resource fluctuations. However, climatic change presents a radical rupture with what they have been normally attuned to in the past.

In the policy domain, there is growing recognition that the global, national and sub-national responses to uncertainty have been inadequate (Stirling et al. 2007). Despite this recognition of growing complexity, there remains a constant search for technically driven managerial solutions that—as we demonstrate—can falter in the face of local dynamics and uncertainties or end up harming certain groups, usually the poor (Mehta et al. 1999; Leach et al. 2010). The STS (Science and Technology Studies) literature has elucidated the narrow ways in which uncertainty is often conceptualised by modellers, scientists, and planners (cf. Wynne 1992) and the predominance of an 'intensively scientific primary framing' and 'intensively economistic imagination' (Wynne 2010: 291). A growing literature in the Indian context and beyond has highlighted the importance of local perceptions about climate variability (Panda 2016; Vedwan and Rhoades 2001) and resource scarcity (Mehta 2005) and their impact on coping and adaptation behaviours; the importance of local knowledge in adapting to climate change (e.g. Naess 2013); the wider intersections with local power and social dynamics (Coulthard 2008, Adam et al. 2018); and the impacts on decision-making and adaptation behaviours (Singh et al. 2016).

While these different analytical traditions have traditionally not spoken to each other, in recent years, some gaps are being bridged, especially around efforts to create a 'citizen science' of climate change (Panda 2016) or through transformative scenario planning (Kale and D'Souza 2018; Totin et al. 2018). This article builds on these emerging bridging efforts. We distinguish between uncertainty from 'above' and uncertainty from 'below', recognising that there are overlaps between the two. We also recognise that bridging requires actors and knowledge systems that can speak to both constituencies, hence the notion of the 'middle' in this article.

Uncertainty from 'above' is represented by climate scientists, policy elites and decision makers. This is usually linked to powerful agencies, though we concede that there will be hierarchies within these. Within climate science, uncertainties arise from a variety of different sources and factors, including linguistic imprecision, statistical variation, measurement error, variability, approximation, subjective judgement and disagreement (Schneider and Kuntz-Duriseti 2002). The standard approach for conceptualising uncertainty is to quantify it in terms of probabilities (e.g. Sigel et al. 2010) and statistical models that accommodate sophisticated data with multiple variables across a range of spatial and temporal scales. Computer models remain the most important tool of climate science, which largely tend to distance their efforts from situated contexts (cf. Edwards 2001). Of course, many modellers acknowledge the limits to models and their predictions due to limited understandings of the climate system (Curry and Webster 2011; Hulme 2013). Uncertainty and climate change from 'above' also tends to draw on singular rationalities and may seek out singular ways to understand causality (Hulme 2017). At this larger/global scale, climate is usually seen as abstract and invisible (Rudiak-Gould 2013).

Uncertainty from 'below' concerns the framings of lay and local people as differentiated by gender, class and caste. It is 'experiential' non-official knowledge, not necessarily played out at the verbal or articulated level but instead is a more 'practical' or tacit form of knowledge (cf. Bourdieu 1977). While our concern is largely with marginalised groups and perspectives, this can also be a very heterogeneous group consisting of both rich and poor, powerful and powerless people. A wide literature on anthropological, sociological and complex ecology traditions has demonstrated how local people live with and adapt to uncertainty (e.g. Berkes and Berkes 2009; Mehta 2005; Hastrup 2013). Many indigenous knowledge (IK) systems evolve through adaptive learning based on developing a complex knowledge base of the environment and lessons from past mistakes—a version of

'post-normal' science (cf. Funtowicz and Ravetz 1993). Thus, IK can also complement more macro perspectives by filling in the local scale. A rich body of literature has elucidated how people attach meaning and significance to the world they inhabit, and in turn gain meanings from the natural world to understand and live with change (cf. Hastrup and Skydrstrup 2013). Urban studies have also highlighted how uncertainty is an essential dimension of urban life itself and has been a focal theme of those engaged in planning, building and governing cities (Zeiderman et al. 2015). It is consequently important to capture the everyday realities of those who live at the interface of climate stressors, risks and shocks in urban and rural contexts and how human activities and livelihood practices intersect with climate change in these settings (IPCC 2014). As Puri (2015) argues, climate change responses and impacts at the local level are mediated through holistic experiences of wider ecologies concerning land, water and forests, markets and the economy and institutions and governance across scales.

In anticipation of caveats from a careful reader, we acknowledge that climate change and uncertainty from 'above' and 'below' have different relative strengths, epistemological entry points and a potential for complementarity (Berkes and Berkes 2009). Both are culturally and socially embedded in local institutions, practices and power relations (Hastrup and Skrydstrup 2013). Both, however, approach temporal and spatial concerns differently as we spell out in this article. Uncertainty from 'below' tends to be more engaged with local weather variability (or everyday change) (cf. Hulme 2017) with people drawing on multiple rationalities that interact in different ways. Climate scientists, by contrast, are concerned with long-term climate change and short-term forecasting but usually construct them statistically and not experientially as the 'below'. Policy makers need to work across different scales and rationalities and often uncertainty can be quite politicised. We also recognise some of the limits to local knowledge in the face of large-scale climate change related uncertainties (Marin 2010). Neither scientists nor local people are homogenous, and we do not intend to privilege one form of knowledge over the other. While there are clear power differentials between the two with the 'the above' tending to be more powerful, there is potential space for collaboration and bridging. This dynamic view of the nature of uncertainty from 'below' and 'above' opens up the possibility of acknowledging a multiplicity of approaches and knowledge that could allow for socially just and locally appropriate adaptation.

We thus developed a simple heuristic to study different understandings of uncertainty (see Table 1).

Methodology and sites

In order to capture climate related uncertainties in different socio-ecological settings, we focused on three different sites for this study—Kutch (a dryland), the Sundarbans (a wetland) and the megacity of Mumbai (Fig. 1). The approach pursued was largely qualitative with field research in India from 2013 to 2017. Site-specific literature reviews were conducted to guide the field research and methodological development. These formed the basis for interview guides to ensure consistency in data gathering and analysis across the sites. The interview guides included questions grouped around thematic areas (e.g. climate change impacts, livelihoods, institutions) and were tailored for each heuristic category. Questions on uncertainty were posed keeping in mind the cultural/linguistic and socio-economic context of the respondents.

Fieldwork built on long-term ethnographic engagement of several research members. Methods included participant observation, transect walks, snowballing, key informant interviews and focus group discussions (FGDs). The sampling methodology was purposive in nature and differed in the sites based on the respective socio-ecological setting. Deploying the heuristic categories of 'above', 'middle' and 'below', respondents were included from local, regional and national levels (for details, see Table 2). In Kutch and the Sundarbans, due to proximate impact of climatic changes on livelihoods, 'below' respondents dominantly comprise natural resource dependent communities (agriculturists, fishers) and casual labourers (refer Table 2). In Mumbai's urban setting, 'below' respondents were dominantly drawn from informal settlements, but also from middle/upper middle class residents in flood-affected areas of the city, and fishers residing along hamlets on Mumbai's coast. In all over 400 interviews were conducted across the sites (130 in Kutch, 140 in Mumbai and 150 in the Sundarbans across 'above', 'middle and 'below'). Additionally, 30 focus group discussions were conducted with different social groups, e.g. fishers, farmers, NGOs and casual labourers. The FDGs varied in size between 5 and 10 respondents.

Site description

The Sundarbans is a coastal delta and major climate hotspot located in both Bangladesh and the state of West Bengal in India. In total, it covers an area of about 10,000 km^2, with the Indian Sundarbans comprising 38% of this area. It is home to about 4.5 million people spread across 54 islands (WWF-India 2010). The delta faces significant ecological challenges such as dwindling mangrove forest, islands affected by rising sea levels, erratic rainfall and cyclones. Many residents are considered to be landless due to fluid migration, land erosion and ill-defined property rights and subsist on agriculture, forest produce and fishing. Poverty and deprivation are both high, with migration emerging as a major development issue. Contestations between conservationists, the state and local resource users lead to frequent protests and litigations

Table 1 Heuristics of uncertainty

	Actors	Scale	Types of devices	Uncertainties
Above	Climate scientists, government officials, donors and policy makers	Longer time frame; global and national levels; emerging regional scales	Scientific and 'expert' knowledge; drawing on statistical tools and methods; most powerful of all actors	Studying impacts and dynamics of ecological uncertainty; epistemic uncertainty regarding the scale and impact of change at lower scales; power and knowledge struggles around whose account matters and who has the ears of governments and powerful actors
Middle	Knowledge brokers, intermediaries, street level bureaucrats, activists, non-governmental organisations (NGOs), academics, media	Hybrid/across	Hybrid knowledge (drawing on above and below); not as powerful as the 'above'	Seeks to translate across diverse experiences and perceptions of ecological, epistemic uncertainties. Action and decisions affected by wider political economic conditions
Below	Heterogeneous group of local people, differentiated by gender, class, ethnicity, caste	Immediate and local, everyday encounters; weather and its changes	Experiential and indigenous knowledge; least powerful of all actors	Attuned/accustomed to ecological uncertainty but rising epistemic uncertainty due to radical changes caused by climate change. Amplification of local impacts due to changes in the political economy

(Ghosh et al. 2018). Three villages[2] were chosen across three islands to capture a range of data and insights on issues such as deltaic topography, exposure to climatic shocks and multi-ethnic/caste composition.

Kutch is the largest district in India located in the state of Gujarat but sparsely populated with a population of 2 million people (Government of India 2011a). It is a dryland known for water scarcity, frequent droughts and erratic rainfall (Mehta 2005). More recently, Kutch has become one of Asia's most rapidly industrialising zones. Specifically after the 2001 earthquake, special incentives such as tax holidays, special economic zones, subsidy regimes and investments for reconstruction led to fast paced economic growth. While these have had some positive effects, they have also led to rising inequalities and environmental destruction in the region (Kohli and Menon 2016). Research focused on three villages that represent three major ecosystems of the district, namely agricultural areas, the grasslands and coastal areas.

Mumbai is a coastal city on the western seaboard of India largely reclaimed from the sea and by interconnecting island chains. It is India's largest city and financial capital. Its official population is estimated to be 12 million people in its municipal limits and around 20 million in its metropolitan area (Government of India 2011b). A characteristic feature of the city is the sharp inequality between elites and poor people. The city is likely to be affected by sea level rise and is prone to disasters precipitated by extreme rainfall events, tropical cyclones and heatwaves leaving large parts of the population vulnerable (Hallegatte et al. 2010; TERI 2014). Research focused in Central and suburban Mumbai, namely Bandra (East), Mahim, Kurla, Andheri (East), Worli and Dadar which are prone to flooding. They are also close to sensitive coastlines, the Mithi River (the main natural drainage channel of the city) and comprise large sections of marginalised communities (e.g. fishers and slum-dwellers).

Findings

In all three sites, the perceptions, impacts and evidence related to uncertainties are diverse and need to be situated in their specific contexts. Findings are discussed across three key axes of uncertainty as discussed earlier (Table 2). In all sites, despite tendencies of planners and policy-makers from 'above' to control uncertainty, we find some alternative trajectories emerging that offer better ways of dealing with uncertainties.

The Sundarbans

There is growing evidence of climate change impacts in the Sundarbans. Sea level rise is estimated at 3.14 mm/year which is higher than the global average of 0.5 to 3 mm (Hazra et al. 2010). By 2100, sea level rise is predicted to lie between 0.46 and 1.5 m and could well submerge parts of the delta (Payo et al. 2016). Sea surface temperatures (particularly important for mangrove growth) in the Bay of Bengal have shown a decadal increase of 0.13–0.15 °C/10 in the period from 1961 to 2000 (Jadhav and Munot 2007) leading to changes in cyclone patterns and coastal ecology (Hazra et al. 2010; Jadhav and Munot 2007). While the frequency of storms and cyclones may have been on the decline in the Bay of Bengal over the period from 1970 to 2000, their magnitude has increased (ibid). In 2009, cyclone Aila caused widespread devastation

[2] To respect anonymity, we are not naming the villages in Kutch and the Sundarbans, however due to the sheer scale of Mumbai, we feel comfortable to name the different localities within the city.

Fig. 1 Field sites in India (source: modified Google map)

and loss of lives and livelihoods (International Flood Network 2009). It is however disputed whether Aila was precipitated by climate change or should be viewed as part of regular occurrences of cyclones. Other climate-related impacts include an increase in extreme rainfall patterns and temperature patters (Hazra et al.2010).

Still, there is epistemic uncertainty regarding the degree of climate change impacts amongst the 'above'. While some scientists contend that the islands are in imminent danger due to climate change, others point to several factors causing drastic changes, which include port development and poor drainage in the delta where major Himalayan rivers drain their waters. River scientists say that the Sundarbans is a geologically active delta where tidal waves both form and erode islands. For decades, the river has been eating up portions of several islands or making land uncultivable due to erosion or submergence. Furthermore, silt accumulation due to the Farakka Dam and the draining of major Himalayan rivers (Ganga-Bramhaputra-Meghna) have also led to massive changes to the river ecology and to erosion (see Rudra 2008, Brown and Nicholls 2015). This, combined with sea level rise, has led to rapid land erosion (Rudra 2008; SANDRP 2014) and the depletion of land in 11 islands (Hazra et al. 2010; CSE 2012).

Even though these islands have only been inhabited for about 300 years by humans, different groups of Muslims, Hindus and tribals (alternatively Adivasis) have created a

Table 2 Uncertainty from above, middle and below across sites

		Sundarbans	Kutch	Mumbai
Actors	Above	Various ministries and departments, climate and river scientists, tour operators, conservationists	Various ministries and departments, business actors, climate scientists	Government departments, business actors, climate scientists
	Middle	Non-governmental organisations (NGOs), journalists, academics	NGOs, journalists, academics	NGOs, academics, journalists
	Below	Islanders: fishers, farmers, migrants	Farmers, fishers, pastoralists	Poor, middle class and elite city dwellers
Types of uncertainty	Ecological uncertainty	Cyclone, sea level rise, erratic pattern of rainfall	Erratic rainfall, droughts, cyclones, rising temperature, flooding	Erratic rainfall, flooding, sea level rise, rising temperature
	Epistemic uncertainty	Contestations about the active river delta, cyclones, embankments; knowledge silos between departments	Increasing uncertainty about occurrence of droughts and rainfall pattern; knowledge silos between departments	Increasing uncertainty about the incidence of flooding; contestation around mangroves and urban climatology
	Political economy	Port development and politics of embankments; history of government neglect; conservation and dispossession	Port development and industrialisation; land and water grabs; dispossession from land	Rapid urbanisation; real estate development; socio-economic inequalities

syncretic culture typical to the islands. For example, the goddess Bon Bibi is venerated by all as their protector (Jalais 2010). They have got used to living with uncertainty and precarity because every high tide can become a flood inundating their lands and homes. According to a community worker living on the islands, 'Between May and September every year, we live with our children under four feet of water especially during high tide. We are used to it'. But in recent decades, cyclones, storm surge flooding, land erosion, sea level rise, disappearing islands and extreme rainfall and temperature patterns, have emerged as a form of radical uncertainty in local people's daily experiences of their immediate environment. These have negatively affected traditional livelihoods such as shrimp farming and paddy cultivation and also made daily survival a struggle. The archipelago has more than 3000 km of embankments, which have become particularly controversial after Aila breached them leading to displacement and livelihood loss (see Ghosh et al. 2018). An old man who has lived all his life in one of the research villages said:

> 'There is no doubt that the river level has increased. It now flows over the embankment to inundate our lands. My entire agricultural land and homestead are lost. Due to the approaching river, I've had to move and rebuild my house thrice. Now I am left with nothing'.

After Aila, several male residents (between 16 and 50 years) from the worst hit remote islands migrated to distant parts of India leaving women to fend for their family. These women comprise the most vulnerable and disadvantaged of the 'below' (Ghosh et al. 2018). Depleting livelihood options, the threat to shelter due to erosion and difficulties in accessing food, water, sanitation and health services are issues that intersect with their daily survival. The Sundarbans are only about 100 km away from Kolkata (the state capital) but are considered very 'remote' and 'backward' by the urban elites and policy makers. More recently, tourism and conservation efforts (which are restricting traditional access to fishing and the forest) have contributed to unequal growth patterns in the region with rise in poverty and malnutrition (Ghosh et al. 2018).

Concrete embankments as a way to protect the islands from flooding are a preferred option of several scientists and policy makers from the 'above' but are highly controversial (Mukhopadhyaya 2016). By contrast, local people's IK has enabled them to build bunds by forming informal cooperatives. Our research found that very few experts support these low-tech community-based approaches which the local community leaders, who represent the 'middle', feel are more in sync with the unique ecology of this delta. The river scientists interviewed felt that regardless of climate change, the dynamics of accretion and erosion would continue and the saline water would eventually corrode the base of the existing and proposed concrete embankments, thus resulting in a form of maladaptation. Still despite these uncertainties, many 'above' actors tend to privilege a techno-bureaucratic approach. As embankments corrode and crumble, land must be acquired to replace or reinforce them with concrete ones, leading to controversial displacements. The 'middle', i.e. activists and NGO representatives living on the islands as well as most of the historically disenfranchised 'below' are dissatisfied with how the government has tackled the problem. They feel that in the name of climate change and uncertainty, experts, construction companies and others are promoting expensive concrete embankments and solutions whilst ignoring local knowledge and practices. Yet, it is unclear whether these traditional practices can withstand future climate change shocks and uncertainties.

Several NGOs representing the 'middle' told us that poor planning and lack of coordination amongst key departments

have magnified the suffering of the islanders. While there is no dearth of institutions focusing on the development of the Sundarbans (e.g. the Sundarbans Board and Sundarbans Affairs Department), efforts are uncoordinated and not integrated. Local people are cynical about the massive pilferage of funds for embankments and the lack of basic services to the islanders. The notion of climate change catastrophes is being used strategically to justify bureaucratic inaction, regarding the welfare and development concerns of the islanders. Instead, planned exit strategies have been proposed by policy makers and some scientists to deal with climate change impacts. The Sundarbans is a world heritage site due to its rich biodiversity and mangrove forests, and is also home to the endangered Royal Bengal Tiger. There are tensions between efforts on the part of the forest department and conservation NGOs to protect the habitat of the tiger and the forests, on the one hand, and the place attachment and livelihood needs of the poor islanders, on the other. We acknowledge valuable efforts by conservationists to protect ecosystems and biodiversity heritage. However, as indicated in several of our interviews, some of them maintain the primacy of the famous Royal Bengal Tiger to inhabit its natural habitat over that of poor islanders living near the tiger reserve.

Most islanders continue to live on the islands with no intention to leave. And where, indeed, would they go? An elderly resident from one of the study villages said, 'The government hasn't even been able to successfully resettle a few households affected by erosion. How will they resettle 4 million of us?' While this quote might suggest that local people have normalised uncertainty, we feel that this statement instead highlights widespread cynicism amongst the poor and marginalised islanders towards experts and the state.

Despite the overall pessimism of most actors regarding the future of the Sundarbans, some new alliances between NGOs, scientists and local people are attempting to challenge the dominant trajectories that have largely neglected the dynamic nature of the delta and its multi-faceted challenges. Rather than focusing on top-down solutions (such as concrete embankments) that might prove maladaptive in the long run, they are arguing for locally appropriate and sustainable options that can help expand livelihood options for local people while at the same time easing pressure on existing natural resources such as forests and mangroves. For example, hybrid innovations around wetland agriculture and fishing (e.g. salinity resistant paddy cultivation, crab farming, aquaculture) are helping to enhance food and livelihood security (see Hegemann 2013). These initiatives have helped to counter various cascading uncertainties for marginalised groups such as small farmers who lost their lands to land erosion and small fishers who are being involved in new initiatives with the potential to reduce out-migration. This is one example, where 'above', 'middle' and 'below' can create hybrid alliances and solutions to create pro poor and socially just adaptation.

Kutch

The arid to semi-arid district of Kutch has a dynamic ecosystem, ranging from wetlands to grasslands, deserts and a long coast with lush mangrove forests. Studies estimate that coastal areas such as the Gulf of Kutch are likely to be the worst hit by climate change as agricultural lands become susceptible to inundation and salinity ingress (Hiremath and Shiyani 2012). Sea level rise in the Gulf of Kutch is reported to be highest on the west coast, which is also exposed to cyclones and storm surges that are likely to become more frequent with global warming (Noronha et al. 2003). According to a 2015 study, the mean temperature is set to increase by 1.5 °C by 2050 with the increase in minimum winter temperature by 0.6–1 °C, and maximum summer temperatures by 0.1–1.2 °C (Sarkar et al. 2015). Data gathered between 1958 and 2007 showed that the district of Kutch experienced the highest annual variability, i.e. 57% when compared to other regions of Gujarat (Pandey et al. 2009).

Ecological uncertainties by way of droughts and erratic pattern of rainfall have been part and parcel of life in Kutch. As with most drylands, rainfall is highly erratic and variable across the district. Kutch receives an average of 335 mm of rainfall between June and September with peak rainfall traditionally occurring in July. This pattern has shifted with the maximum rainfall now falling in September (GUIDE 2014). Historically, local people have drawn on IK to plan their livelihoods. Across the three villages, we heard of different traditional methods to predict the arrival of the monsoons and the success and failure of crops. These range from observing sea water currents, animal and bird behaviour, the flowering of particular plants and planetary positions in the sky, with many preferring these 'signs of nature' to scientific projections about rainfall. A pastoralist in Banni grassland explains how they draw on these signs to predict the weather:

> 'Good signs include: if the winter and summer arrive in a timely fashion; there is an excess of west-north winds and lightning in north-east direction […] the crows start nesting before the arrival of the month of Jeth (begins 22nd May); and the sheep and goats get up in night and start walking in the direction of wind' (GUIDE 2014).

Scientists from GUIDE (Gujarat Institute of Desert Ecology) found these predictions to be 90–95% accurate in the 1995–2004 period, but after 2004, they acknowledge that local level predictions of monsoon patterns have been more uncertain and difficult to predict for local people (GUIDE 2014). In the official discourse, Kutch is considered to be drought-prone with droughts taking place every 2–3 years (Mehta 2005). However, over the last 10 years, scientists and local people interviewed believe that a new pattern has

emerged in some parts of Kutch. Rainfall has become far more unpredictable with an increase in extreme events, namely intense periods of rainfall, floods or what one farmer referred to as 'receiving one month's rainfall in three days'. While droughts are part of life in Kutch, floods are not. Additionally, the gap between the showers and their intensity has also increased making livelihoods more precarious and local predictions less reliable. These extreme events present a radical uncertainty for the local people and have created multiple challenges for local residents who increasingly find it hard to plan their seasonal calendars. For example, the freak rainfall events have often wiped out crops, leaving farmers impoverished and helpless (GUIDE 2014). Changes in temperature have also disrupted the cropping calendar in these villages.

Animal husbandry has been a traditional and important livelihood option for the people and Kutch is known for having more animals than humans (GUIDE 2014; Mehta 2005). Pastoralism is also well suited to the scarcity and semi- arid conditions of the district. For the traditional pastoralist groups such as the *Rabaris* and *Jats*, seasonal migration with animals in lean periods has been a way of life. However, the negative impacts of *Prosopis juliflora* (an invasive plant), changing drought patterns and a high burden of livestock diseases due to increased temperatures are some of the challenges that herders live with on a daily basis. Furthermore hostile state policies and growing resentment towards pastoralists have also made many give up pastoralism in favour of settled agriculture or migrant labour (Srivastava and Mehta 2017).

Similarly, fishers in the coastal village argue that changes in rainfall patterns have affected fish breeding and report a significant decline in fish catch. They now need to be in the sea for much longer to get a good catch.

The head of the fishers' association explained these challenges:

> 'Warmer temperature has led to a decrease in fish production. In the 1990s, the day temperature used to range between 7 to 10 degrees and night temperature around 2 degrees. But from 1995, heat has increased significantly […. If the rain is late, the fish breeding period also changes accordingly.'

While some local residents attribute these changes to *havamaan* (weather) or perceive them as an 'act of God', others—particularly coastal people—blame rapid industrialisation for the loss of forest cover and the rise in temperature. In the last 15 years, the coastline of Kutch has changed dramatically. Following the 2001 earthquake, industrial zones and ports were set up to 'develop' this hitherto remote district (Kohli and Menon 2016). They have caused changes in land use, biodiversity, resource distribution and have thus exacerbated the effects of climatic uncertainties. Intense groundwater extraction and destruction of mangroves for industrial activities have compounded the problem of salinity ingress. The blocking of the coastline due to port and industrial development has denied small-scale fishers and pastoralists access to coastal resources, key to maintaining their livelihoods.

Thus for the 'below', ecological uncertainties are interlocked with other drivers of change. The accelerated pace of industrial development has constrained other adaptive choices (seasonal migration and reliance on common pool resources) for local people. Both the 'above' and the 'middle' concur that climatic uncertainties by way of erratic patterns of rainfall and rise in temperature have become acute in Kutch in the last two decades (GEC 2011) but their responses vary significantly and there are deep epistemic divides. Scientists interviewed largely agree that climate-related uncertainties are increasing. Many of them are very aware of how these changes will cascade into different arenas of local people's lives. They recognise the limitations of downscaling and are also positive about working with local people. Nevertheless, all of them face challenges communicating their understandings of uncertainty to policy makers who 'demand' more certainty about local level impacts of these climatic events.

State policies, by contrast, are driven by reactive and fire-fighting measures such as setting up fodder camps, providing water tankers and short-term drought relief, rather than long-term drought proofing (Mehta 2005). These strategies are geared towards controlling uncertainty rather than managing it. Official policies have tended to ignore the, experiences and expertise of local communities, especially pastoralists, to deal with scarcity dynamics and denigrated their practices as primitive (Srivastava and Mehta 2017). Authorities in Central Gujarat have limited awareness regarding the specific ecological dynamics of Kutch and the need for a strategic approach to climate change adaptation. Gujarat is one of the first states in India to have a separate climate change department. Yet, its close proximity to the energy department has resulted in a strong focus on green energy and mitigation measures, largely focussed on urban centres rather than on the adaptation needs of poor rural people.

Similar to the concerns raised by the 'below', the proactive 'middle'—which comprises civil society members and NGOs—is critical of the apathy of state authorities who fail to recognise the specific dryland dynamics of Kutch and challenges faced by vulnerable groups. Additionally, they argue that aggressive industrialisation has depleted the health of the ecosystem, making Kutch more vulnerable to climatic uncertainties. The denudation of mangroves, in particular, has seriously affected the livelihood strategies of fishers and pastoralists on the coast (Srivastava and Mehta 2017). Despite their frustrations, creative alliances are now emerging (between local communities, state agencies, civil society, and academics)

that are attempting to bridge these binaries and create hybrid knowledge that marry local perspectives with scientific expertise as ways to deal with climate related uncertainties. These include innovative experiments around revival of indigenous seeds system in the Banni grasslands, revitalising pastoralist livelihoods (Sahjeevan 2016)) and improving groundwater systems (ACTS 2018).[3]

Mumbai

Mumbai is one of the world's most vulnerable cities to climate change (UN-Habitat 2010) and home to the largest population threatened by coastal flooding (IPCC-SREX 2012). At present, it experiences an annual sea level rise of between 2.5 and 3 mm along its coastline (Pramanik 2017). Sea level rise and the disappearance of natural buffer zones (e.g. coastal wetlands) increase the threat from inundation, erosion and flooding of densely populated areas in the city, many of which lie only 2–3 m above mean sea level (Pramanik 2017; TERI 2014). Average sea level rise in the Mumbai region is projected to lie between 30 cm–80 cm until 2100 (TERI 2014) with sea surface temperatures increasing at 0.32 °C per decade from 1985 to 1998 (Khan et al. 2004). Atmospheric temperature rise and fluctuations are expected to have adverse health related impacts, with temperature increases projected between 1.5 and 1.8 °C by 2050 (TERI 2014). Mean temperatures have already registered a rise by 2.4 °C for the period from 1881 to 2015 based on a NASA study for this region (NASA 2015). Threats from extreme rainfall variability (18% rise in minimum and maximum precipitation) and tropical cyclones are added exposures that will become more frequent (TERI 2014; D'monte 2017).

The cataclysmic flooding of 26 July 2005, when 944 mm of rain poured over Mumbai within 24 h leading to hundreds of deaths and extensive economic damage (Revi 2008), was a watershed event. It brought most of city to a grinding halt and caught civic authorities by surprise, resulting in an ad hoc and chaotic response effort (Revi 2008). To date, it has been the most catastrophic incidence of urban flooding in modern India and laid bare the underlying vulnerability of this megacity. Since this key event, not much has changed. Endemic waterlogging and flooding continue to be regular events, particularly during the monsoon season and have negatively affected the livelihoods and well-being of disenfranchised communities residing on low-lying marginal lands such as swamps and flood prone areas (TERI 2014; Hallegatte et al. 2010). Flooding in itself is not perceived as something new by actors from the 'below'. But changes in spatial dispersion and intensity are now variables of growing concern and emblematic of an emerging radical uncertainty—as was the flood of 2005. Many from the 'above' believe that climate change will aggravate flood-related disasters. Still, contestations remain regarding possible ways forward. Mangroves are a good case in point. Most respondents view these ecosystems as providing a natural buffer zone to sea level rise and a measure of flood protection; yet, some influential scientists interviewed disagree and see them as potentially obstructing surface water outflow from the city and increasing flood threats. This has repercussions on the planning for disaster management, since built up infrastructure is often prioritised over the protective functions of ecosystems. Similarly, the role of the urban heat island effect on local weather patterns is disputed and uncertain (Shastri et al. 2015), having implications for the design of localised, downscaled climate models and associated early warning systems.

Local respondents from 'below' mention increasing heat and changes to rainfall intensity as key manifestations of climate related uncertainties. Like Kutch, the *Koli* fishers in Mumbai (the city's oldest community) discuss changes in the seawater temperature, wave strength, wind patterns and sea level rise. As one fisher noted:

> 'Earlier, they [our fathers or grandfathers] would know about fishing seasons and availability of fish in a particular area based on star constellation, wind patterns and lunar position[...]but that knowledge is not relevant anymore and we do not know where and when to catch particular species'.

Fishers in Colaba and Versova informed us that growing pollution, large trawler fishing and urban expansion has also resulted in a loss of predictability for fishing with adverse impacts on livelihoods. Slum dwellers discussed climate change impacts in conjunction with everyday concerns that relate to displacement, migration, shelter, livelihoods and access to water. In particular, women and children are experiencing uncertainty with respect to water availability and quality, floods and related health hazards like vector borne diseases. Elites tend to experience climate change in terms of seawater ingression, shrinking beaches and reduced leisure space and a growing demand for air conditioners to cope with the soaring temperatures. The wealthier sections criticise the failure of urban planning authorities to implement structural and engineering interventions to control flood related disasters such as the Mithi deluge of 2005. They are also able to afford micro-adaptations like building water-barriers and elevated buildings deal with flooding in their housing societies.

Some of the 'above' and 'middle' interviewed, advocated approaches to tackle climate related uncertainties that included technological fixes, zoning, gentrification and the greening and 'sanitising' of the city in terms of removing undesirable settlements. These are considered to be necessary but also 'hard choices', resulting in the forced resettlement of marginalised people already struggling with housing needs,

[3] http://act-india.org/

living mostly on marginal lands especially along the city's main natural drainage channel, the Mithi river. New vulnerabilities and uncertainties for large swathes of people from 'below' are created as a result. While political patronage sometimes protects the slums from evictions, their residents live in a constant state of flux and fear of displacement.

Many environmentalists we interviewed contend that the 2005 flooding changed the city's consciousness towards climate change. Much has been made of the city's 'resilience' and ability to bounce back after flooding events, yet there is still no fundamental change in the city's flood or disaster management planning, which lacks long-term strategic planning and coordination (Adam et al. in review). Even more than a decade later, the 'above' still relies on technological and infrastructural solutions that include the construction of pump stations, retainer walls or storm water drains to control flooding problems. Respondents from the 'below' say that these structures have increased water discharge capacities to a certain degree, but also opened up new areas prone to flooding, thus causing new uncertainties and vulnerabilities (Firstpost 2018). The 'middle'—NGOs, community leaders and activists—have worked hard to highlight these problems and provide other alternatives including the protection of wetlands, restrictions on construction activities, opening up flood plains and improving solid waste treatment but with little avail so far (Gandy 2008; Adam et al. in review). The main natural discharge channel in Mumbai, the Mithi River, still remains hugely polluted, overexploited and encroached by construction activities.

The 'above' backs the 'smart-city' initiative by the central government that emphasises the need to create more livable cities while drawing heavily on techno-managerial solutions (MURD 2015). In an aspirational and upwardly mobile city like Mumbai, there is a marked lack of willingness to shift from a consumption-dominated lifestyle towards one that promotes more environment-friendly and socially just development pathways. While the critical 'middle' stresses these wider concerns, they bemoan the limited willingness of the 'below' and 'above' to change behaviours and attitudes. The state has also invested in infrastructure projects such as a controversial coastal highway project cutting across its sensitive coastline—ignoring cautionary advice by environmentalists (Adam et al. in review). The building of such infrastructure on the fragile coastline of the city not only displaces people but also may cause ecological disruptions to tidal patterns and the coastline. These could end up creating new uncertainties for resource dependent poorer communities living on the shoreline of the city and its periphery.

The focus on mitigation as the foremost priority in state-led discourses on climate change within cities has led to the dominance of market-driven agendas and business ventures, often in the name of energy efficiency and the green economy (e.g. Government of India 2008; MoEFCC 2015) with private bankers seeking opportunities to harness international finance flows for these activities. There is little questioning in public discourse of the unregulated property boom, especially along the coastline which has created fierce conflicts between informal settlers, the state, environmentalists and the aspiring middle class. Activists and NGOs argue that poor people working in the informal sector form the backbone of the city's economy and climatic uncertainties are going to increase their economic hardships. The continuous usurpation of coastal wetlands also robs the city of a valuable buffer against future climatic shocks and threats.

In order to better prepare the city to deal with climate related uncertainties, different approaches challenging the existing status quo are urgently required. Some emerging initiatives include efforts by concerned scientists, activists, ordinary residents and sympathetic state actors, to set up community-based mangrove governance projects (e.g. Versova, Mahim and peri-urban Uran), waste treatment initiatives to improve the water flow of the Mithi and drainage channels and the use of legal avenues to promote coastal wetland preservation. Ultimately, the dominant governance regimes need to be attuned to become more participatory and plural in their outlook with climate change featuring as a key priority in urban planning.

Discussion and conclusion

This article has analysed the perspectives of the 'above', 'middle' and 'below' regarding climate-related uncertainties across three sites in India. It has documented how climate related uncertainties (ecological, epistemic and political economy) are experienced and are increasing with time, as documented by a range of actors. All three sites are ecologically dynamic and uncertainty is writ large on their landscapes. For instance, it is manifested in the ever-changing rhythms of the river that gobbles up and creates new islands in the Sundarbans; the erratic rainfall in Kutch; and the impacts of flooding on marginal, low-lying lands in Mumbai. In all three sites, the 'above', 'middle' and 'below' are constituted by diverse actors and networks. Their framings of and responses to uncertainty are diverse and often contradictory across all sites. In several instances, we found these categories to be internally fragmented and ridden with internal tensions. While experts acknowledge that climate change is occurring in all the research areas, there were significant epistemic uncertainties concerning the impacts, scale, adaptive options and also attribution, i.e. whether changes are due to climate change, natural variations or other anthropogenic causes and effects from development.

The article also documented how spatio-temporal scales about climate change differ across actors and shape their understanding and responses to uncertainty. While local people experience climate change in terms of everyday change or the vagaries of the weather, climate scientists look at both weather and climate, and their focus on climate relates to a long term scale. They are concerned with changes that manifest themselves at least over a 30-year span and futuristic scenarios and projections regarding the climate. By contrast, policymakers and planners tend to

operate on a shorter time-scale dictated by other demands, including market forces and shorter term interventions. This could often frustrate the work of scientists and local people and also impede financial investments in long-term adaptation.

For many local people, uncertainty is not a new phenomenon and has been part of life for many generations. Still, climate change and its intersection with other drivers of change present a radical uncertainty that can push local people to the limits of coping or trigger paths of maladaptation. This has led to a sense of powerlessness for those whose lives and survival are at the frontline of climate change and uncertainty (Hulme, personal communication, 2014). For example, in our sites, marginalised people are confronted by climate-related uncertainties and the threat of displacement (Mumbai and Sundarbans), difficulties in sustaining livelihoods (Kutch, Mumbai and Sundarbans) and the impacts of neo-liberal and unequal growth patterns. For example, in urban Mumbai, poor people who live in flood-prone areas whose lives and livelihoods are entrenched in informality lack rights to housing and basic services, increasing their vulnerability to climatic events. In Kutch, pastoralists need to deal with changes in rainfall and a declining grass cover alongside hostile government policies and rapid industrialisation that leads to dispossession from the commons. Thus for the 'below' in Kutch, Mumbai and the Sundarbans, climate change as a cause for change is often used to signify concerns around shifts in their cultural, physical, social and economic worlds (cf. Hulme 2017).

It is also striking to note that the existing regional climate action plans do not adequately deal with uncertainty due to a variety of reasons. These include a lack of data, time, funding, capacity or even particular mindsets that prioritise short-term over long-term priorities (Gaurav 2015). At the national level, India's key strategy papers on climate change (e.g. Government of India 2008) and more recently the Intended Nationally Determined Contributions (INDCs) (see MOEFCC 2015) acknowledge the impacts of climate change on natural resources, and people's livelihoods. However, they continue to place disproportionate emphasis on mitigation and issues of equity, redistribution and access to natural resources remain neglected (Bidwai 2012; Venkatesh 2018). While bureaucrats discuss adaptation and climate friendly initiatives, often there is very little concrete action and dedicated financial allocation for adaptation. This reflects a national trend wherein adaptation funds remain underutilised or diverted for different purposes (Venkatesh 2018). India's ambitious INDCs are also closely linked to a 'green economy' discourse that has been criticised for its focus on business and market-friendly principles, technological optimism and neglect of issues concerning power and resource distribution, (Unmüßig et al. 2012). In this context, it is important that India's present approach and policies need to prioritise and engage with the multifaceted nature of climate-related uncertainties in its marginal environments and expanding cities.

In all three sites, dominant pathways to deal with uncertainty and climate change range between capitalist and growth-driven trajectories (Mumbai and Kutch) to apathy and neglect of the vulnerabilities of poor people (Sundarbans). Through our case studies, we showed how the attempts from 'above' tend to be directed towards controlling uncertainty through techno-managerial solutions For example, in the Sundarbans, despite tremendous ecological and epistemic uncertainties regarding the various changes taking place in the delta and how much of it can be attributed to climate change, dominant pathways focus on top-down engineering solutions (e.g. embankments) despite their controversies and problems. Uncertainty can also become an excuse to do nothing (cf. Dessai and van der Sluijs 2007) as exemplified by the government neglect of the Sundarbans. It can also be manufactured to meet certain political ends (cf. Mehta 2005). A good case in point is the evictions of poor people (in Mumbai) from the coastal fringe and flood prone areas in the name of climate adaptation and flood protection. However, ironically, much of these disputed lands are then acquired by developers and sold to elites. Local people are being left disempowered when options such as 'planned exit' (Sundarbans), forced displacement (Mumbai) or deliberate livelihood transition (discouraging pastoralism in Kutch) are projected as realistic adaptation options. These 'decontextualised' top-down policies can often hamper efforts to support locally appropriate and socially just adaptation. Such attempts to control uncertainty (Zeiderman et al. 2015) also fail to address the complexity and numerous intersecting uncertainties that require a range of adaptive options to be considered and implemented across scales.

While the repertoire of local people is rich and diverse with respect to ecological uncertainties which is also experienced in cultural terms (e.g. Bon Bibi in the Sundarbans), this is being challenged in multiple ways. In Kutch and Sundarbans, IK is used to adapt to and cope with climate related uncertainties (e.g. embankments made with local materials in the Sundarbans and the rainfall predictions in Kutch). But in both cases, there are limits to adapting and coping with uncertainties caused by climate change. Still as demonstrated in this article, hybrid alliances from the 'above', 'middle' and 'below' are responding to the various climate-related uncertainties by offering alternative pathways that are attempting to bridge perspectives and experiences across the domains. Here, the role of the 'middle' as interlocutors is key. On the one hand, the 'middle' can struggle to translate messages from 'below' to the 'above'; on the other hand, it often plays a critical role in bridging gaps between 'place-based' experiences and expertise on climate change and the most detached expert assessments and solutions (cf. Rudiak-Gould 2013), thus playing a crucial role in facilitating small but emerging alternatives to deal with uncertainties that can enable socially just adaptation. Critical here are the power imbalances across 'above', 'middle' and 'below.' Usually, the perspectives from the 'above' and their solutions prevail. Governments

also tend to ignore the more place-based experiences and assessments and the more critical voices from the 'middle'. But it is important that these power imbalances are addressed because the 'above', 'middle' and 'below' are all required to help each other see different aspects of climate change (ibid).

As Rudiak-Gould (2013: 129) argues, 'Sensory experience on the ground breathes life and urgency into dessicated expert assessments, while scientists' generality serves to unite disparate communities around the travelable concept of climate change'. Thus, there is promise in combining perspectives of the 'above', 'middle' and 'below', through approaches such as multiple evidence bases (Tengo et al. 2014) that combine a range of perspectives to inform adaptation choices and assessments at multiple scales in a context of climate uncertainty (Nakashima et al. 2012). Resilience and adaptive capacities of local people can be strengthened drawing on IK because it is applicable at much finer scales not captured in models, draws on generations of knowledge and can also expand the repertoire of options available to vulnerable people at low cost (Nakashima et al. 2012). Similarly, stakeholder dialogues and roundtables that seek to breakdown disciplinary and other divides can provide diverse actors the opportunities to engage with and learn from diverse perspectives (Bhatt et al. 2018). Such emerging dialogues stress the importance of bringing to the fore hidden and alternative perspectives and solutions whilst highlighting the need to address the power imbalances that prevent alternatives ways of valuation and epistemic diversity, so urgently required to address growing climate related uncertainties.

Acknowledgements The article presents findings from two projects, 'Climate Change, Uncertainty and Transformation' (project number: 235449) and 'Uncertainty from Above and Below' (project number: ES/I021620/1). We thank the Research Council of Norway and the ESRC STEPS Centre for their generous support. We are grateful to two anonymous reviewers, the journal editor, Suraje Dessai, Espen Sjaastad and Lars Otto Naess for their helpful comments. We are grateful to our colleague Rohan D'Souza for suggesting the use of the term 'radical uncertainty. We thank all research participants for their time and valuable insights. The usual disclaimers apply.

References

Adam HN, Kjosavik DJ, Shanmugaratnam N (2018) Adaptation trajectories and challenges in the Western Ghats: a case study of Attappady, south India. J Rural Stud 61:1–11. https://doi.org/10.1016/j.jrurstud.2018.05.002

Adger WN (1999) Social vulnerability to climate change and extremes in coastal Vietnam. World Dev 27(2):249–269. https://doi.org/10.1016/S0305-750X(98)00136-3

Berkes F, Berkes M (2009) Ecological complexity, fuzzy logic, and holism in indigenous knowledge. Futures 41(1):6–12. https://doi.org/10.1016/j.futures.2008.07.003

Bhatt MR, Mehta L, Bose S, Adam HN, Srivastava S, Ghosh U, Movik S, Narayanan NC, Naess LO, Parthasarathy D, Wilson C, Pathak V (2018) Bridging the gaps in understandings ofuncertainty and climate change - round table reports, experience learning series 76. All India Disaster Mitigation Institute, Ahmedabad

Bhave AG, Conway D, Dessai S, Stainforth DA (2016) Barriers and opportunities for robust decision making approaches to support climate change adaptation in the developing world. Clim Risk Manag 14:1–10. https://doi.org/10.1016/j.crm.2016.09.004

Bidwai P (2012) The politics of climate change and the global crisis. Mortgaging our future. Orient Black Swan, New Delhi

Bourdieu P (1977) Outline of a theory of practice. Cambridge University Press, Cambridge

Brown S, Nicholls RJ (2015) Subsidence and human influences in mega deltas: the case of the Ganges–Brahmaputra–Meghna. Sci Total Environ 527-528:362–374. https://doi.org/10.1016/j.scitotenv.2015.04.124

Crate SA, Nuttall M (2009) Epilogue: anthropology, science, and climate change policy. Anthropology & climate change. From encounters to actions. Left Coast Press, Inc, Walnut Creek, CA

Centre for Science and Environment (CSE) (2012) Living with changing climate: impact, vulnerability and adaptation challenges in Indian Sundarbans *Living with changing climate*. New Delhi, CSE

Coulthard S (2008) Adapting to environmental change in artisanal fisheries—insights from a south Indian lagoon. Glob Environ Chang 18(3):479–489. https://doi.org/10.1016/j.gloenvcha.2008.04.003

Curry JA, Webster PJ (2011) Climate science and the uncertainty monster. Bull Am Meteorol Soc 92(12):1667–1682. https://doi.org/10.1175/2011BAMS3139.1

Dessai S, Wilby R (2011) How can developing country decision makers incorporate uncertainty about climate risks into existing planning and policymaking processes. World resources report uncertainty series. Washington, DC, World Resources Institute

d'Monte D (2017) Cyclones will cause more cyclones in Arabian Sea. India Climate Dialogue. http://indiaclimatedialogue.net/2017/12/20/climate-change-will-cause-more-cyclones-on-arabian-sea/. Accessed 9 June 2018

Dubash NK (ed) (2012) Handbook of climate change and India: development, politics and governance. Routledge, London

Edwards P (2001) Representing the global atmosphere: computer models, data and knowledge about climate change. In: Miller,C., Edwards,P. (eds.) Changing the atmosphere: expert knowledge and environmental governance, 1st edn., MIT Press, MA

Few R, Morchain D, Spear D, Mensah A, Bendapudi R (2017) Transformation, adaptation and development: relating concepts to practice. Palgrave Communications 3. https://doi.org/10.1057/palcomms.2017.92

Funtowicz SO, Ravetz JR (1993) Science for the post normal age. Futures 25(7):739–755. https://doi.org/10.1016/0016-3287(93)90022-L

Firstpost (2018) Mumbai rains: four days of torrential downpour derailed city's infrastructure, killed 10; BMC says new flood points emerge. Firstpost. https://www.firstpost.com/india/mumbai-rains-four-days-of-torrential-downpour-derailed-citys-civic-infrastructure-killed-10-bmc-says-new-flood-points-are-emerging-4720621.html. Accessed 18 Jul. 2018

Gajjar SP, Singh C, Deshpande T (2018) Tracing back to move ahead: a review of development pathways that constrain adaptation futures. Climate and Development.1-15. https://doi.org/10.1080/17565529.2018.1442793

Gaurav JK (2015) Decision making under uncertainty for adaptation planning at state level in West Bengal. University of Sussex, MA Dissertation

Gandy M (2008) Landscapes of disaster: water, modernity, and urban fragmentation in Mumbai. Environ Plan A 40(1):108–130. https://doi.org/10.1068/a3994

GEC (2011) Trends of changing climate and effects on eco-environment of Kachchh District, Gujarat. GEC, Gandhinagar

Ghosh U, Bose S, Bramhachari R (2018) Living on the edge: climate change and uncertainty in the Indian Sundarbans. STEPS working paper 101. IDS Sussex, Sussex

Government of India (2011a) Kachchh (Kutch) District: Census 2011 data. https://www.census2011.co.in/census/district/182-kachchh.html. Accessed 17 May 2018

Government of India (2011b) Slums in India: a statistical compendium, Ministry of Housing and Urban Poverty. Alleviation, National Buildings Organisation

Government of India (2008) National Action Plan on climate change (NAPCC). New Delhi, PMO

GUIDE (2014) Climate change and its uncertainty: dryland scenario. Unpublished paper, Bhuj, GUIDE

Hallegatte S, Henriet F, Patwardhan A, Narayanan K, Ghosh S, Karmakar S, Patnaik U, Abhayankar A, Pohit S, Corfee-Morlot J, Herweijer C (2010) Flood risks, climate change impacts and adaptation benefits in Mumbai: an initial assessment of socio-economic consequences of present and climate change induced flood risks and of possible adaptation options. OECD Environment Working Papers, No. 27. https://doi.org/10.1787/19970900

Hastrup K (2013) Anticipating nature: the productive uncertainty of climate models. In: Hastrup K, Skrydstrup M (eds) The social life of climate change models: anticipating nature. Routledge, London

Hastrup K, Skrydstrup M (2013) (Eds.) The social life of climate change models: anticipating nature. Routledge, London

Hazra S, Samanta K, Mukhopadhyay A, Akhand A (2010) Temporal change detection (2001–2008): study of Sundarban. School of Oceanographic Studies, Jadavpur University, Kolkata

Hegemann N (2013) Deluge impact https://www.dandc.eu/en/article/k-ghosh-salt-resistant-landraces-inspire-hope-after-sea-flooded-fields accessed 12 June 2018

Hiremath D, Shiyani R (2012) Adapting Gujarat to climatic vulnerabilities: the road ahead. Res J Recent Sci 1(5):38–45

Hulme M (2013) How climate models gain and exercise authority. In: Hastrup K, Skrydstrup M (eds) The social life of climate change models: anticipating nature. Routledge, London

Hulme M (2015) Climate and its changes: a cultural appraisal. Geo: Geography and Environment 2(1):1–11. https://doi.org/10.1002/geo2.5

Hulme M (2017) Weathered: cultures of climate. Sage, London

International Flood Network (2009) Report: cyclone AILA, may 2009. IFNet. http://www.internationalfloodnetwork.org/aila.htm. Accessed 10 August 2017

Intergovernmental Panel on Climate Change IPCC-SREX (2012) Managing the risks of extreme events and disasters to advance climate change adaptation. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. In: Field, C.B., V. Barros, T.F.Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.) (pp. 1–582). Cambridge, United Kingdom and New York, USA: Cambridge University Press

Intergovernmental Panel on Climate Change IPCC (2014) Climate change 2014: a synthesis report, Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. https://www.ipcc.ch/report/ar5/syr/. Accessed 19 January 2017

Jadhav SK, Munot AA (2007) Increase in SST of Bay of Bengal and its consequences on the formation of low pressure systems over the Indian region during summer monsoon season. Mausam 58:391–396

Jalais A (2010) Forest of tigers: people, politics and environment in the Sundarbans. Routledge, London

Jasanoff S (2010) A new climate for society. Theory, Culture & Society 27(2-3):233–253. https://doi.org/10.1177/0263276409361497

Kale E, D'Souza M (2018) Planning to think critically about the future of water in rural Jalna, India Second TSP Report http://wwwassaructacza/news/using-transformative-scenario-planning-think-critically-about-future-water-rural-jalna-india-0 Accessed 20 July 2018

Khan TM, Quadir DA, Murty TS, Sarker MA (2004) Seasonal and inter-annual sea surface temperature variability in the coastal cities of Arabian Sea and Bay of Bengal. Nat Hazards 31(2):549–560. https://doi.org/10.1023/B:NHAZ.0000023367.66009.1d

Kohli K, Menon M (2016) The tactics of persuasion: environmental negotiations over a corporate coal project in coastal India. Energy Policy 99:270–276. https://doi.org/10.1016/j.enpol.2016.05.027

Knight FH (1921) Risk, uncertainty and profit. Chicago University Press, Chicago

Leach M, Scoones I, Stirling A (2010) Dynamic sustainabilities: technology, environment, social justice. Earthscan, London

Lemos MC, Lo Y-J, Nelson DR, Eakin H, Bedran-Martins AM (2016) Linking development to climate adaptation: leveraging generic and specific capacities to reduce vulnerability to drought in NE Brazil. Glob Environ Chang 39:170–179. https://doi.org/10.1016/j.gloenvcha.2016.05.001

Levin K, Cashore B, Bernstein S, Auld G (2012) Overcoming the tragedy of super wicked problems: constraining our future selves to ameliorate global climate change. Policy Sci 45(2):123–152. https://doi.org/10.1007/s11077-012-9151-0

Marin A (2010) Riders under storms: contributions of nomadic herders observations to analysing climate change in Mongolia. Glob Environ Chang 20:162–176. https://doi.org/10.1016/j.gloenvcha.2009.10.004

Mehta L (2005) The politics and poetics of water: Naturalising scarcity in Western India. Orient Longman, New Delhi

Mehta L, Leach M, Newell P, Scoones I, Sivaramakrishnan K, Way SA (1999) Exploring understandings of institutions and uncertainty: new directions in natural resource management. Exploring Understandings of Institutions and Uncertainty, IDS Discussion Paper 372, Brighton

MoEFCC. (2015) India's intended nationally determined contribution: working towards climate justice. New Delhi. http://www.moef.gov.in/sites/default/files/INDIA%20INDC%20TO%20UNFCCC.pdf Accessed 10 August 2017

Ministry of Urban Development (MURD) (2015) Smart cities mission statement & guidelines. New Delhi: MOUD http://smartcitiesgovin/upload/uploadfiles/files/SmartCityGuidelines(1)pdf Accessed 2 September 2016

Mukhopadhyaya A (2016) Living with disasters: communities and development in the Indian Sundarbans. Cambridge University Press, New Delhi

Nakashima DJ, Galloway McLean K, Thulstrup HD, Ramos Castillo A, Rubis JT (2012) Weathering uncertainty: traditional knowledge for climate change assessment and adaptation. Paris, UNESCO, and Darwin, UNU, pp 120

NASA (2015) GISS surface temperature analysis. https://data.giss.nasa.gov/gistemp/station_data/. Accessed 23 July 2017

Naess LO (2013) The role of local knowledge in adaptation to climate change. WIREs Climate Change 4:99–106. https://doi.org/10.1002/wcc.204

Noronha L, Choudhri BS, Nairy KS (2003) Relative vulnerability of districts to a potential sea level rise along the coastline of India. In: TERI. 2003. Environmental threats, vulnerability and adaptation: case studies from India. TERI, New Delhi, pp 121–142

Panda A (2016) Exploring climate change perceptions, rainfall trends and perceived barriers to adaptation in a drought affected region in India. Nat Hazards 84(2):777–796. https://doi.org/10.1007/s11069-016-2456-0

Pandey V, Patel H, Karande B (2009) Impact analysis of climate change on different crops in Gujarat, India. ISPRS Archives. 38(8):W3 Workshop, At SAC, Ahmedabad, pp 118-123

Payo A, Mukhopadhyay A, Hazra S, Ghosh T, Ghosh S, Brown S, Nicholls RJ, Bricheno L, Wolf J, Kay S, Lázár AN (2016) Projected changes in area of the Sundarban mangrove forest in Bangladesh due to SLR by 2100. Clim Chang 139(2):279–291. https://doi.org/10.1007/s10584-016-1769-z

Pelling M (2011) Adaptation to climate change: from resilience to transformation. Routledge, Oxon

Pramanik MK (2017) Impacts of predicted sea level rise on land use/land cover categories of the adjacent coastal areas of Mumbai megacity, India. Environ Dev Sustain 19(4):1343–1366. https://doi.org/10.1007/s10668-016-9804-9

Puri R (2015) The uniqueness of the everyday: herders and invasive species in India. In: Barnes J, Dove MR (eds) Climate cultures: anthropological perspectives on climate change. Yale University Press, New Haven, pp 249–273

Rein M, Schön D (1993) Reframing policy discourse. In: Fischer FJ, Forester J (eds) The argumentative turn in policy analysis and planning. Duke University Press, Durham and London

Revi A (2008) Climate change risk: an adaptation and mitigation agenda for Indian cities. Environ Urban 20(1):207–229. https://doi.org/10.1177/0956247808089157

Rudiak-Gould P (2013) We have seen it with our own eyes": why we disagree about climate change visibility. Weather, Climate, and Society 5(2):120–132. https://doi.org/10.1175/WCAS-D-12-00034.1

Rudra K (2008) The encroaching ganga and social conflicts: the case of West Bengal. Habra S.C. Mahavidyalaya College, India, West Bengal

Rumsfeld D (2002) Defense.gov news transcript. http://archive.defense.gov/Transcripts/Transcript.aspx? TranscriptID=2636

SANDRP (2014) Sinking and shrinking deltas: major role of dams in abetting delta subsidence and effective sea level rise, blog, South Asia Network on Dams, Rivers and People (SANDRP), http://bit.ly/2FamMOH. Accessed 25 January 2018

Sahjeevan (2016) Center for pastoralism. http://www.sahjeevan.org/pages/center_for_pastoralism.aspx. Accessed 23 July 2017

Sarkar J, Chicholikar J, Rathore L (2015) Predicting future changes in temperature and precipitation in arid climate of Kutch, Gujarat: analyses based on LARS-WG model. Curr Sci 109(11):2084–2093. https://doi.org/10.18520/v109/i11/2084-2093

Schneider SH, Kuntz-Duriseti K (2002) Uncertainty and climate change policy. In: Schneider SH, Rosencranz A, Niles JO (eds) Climate change policy: a survey. Island Press, Washington DC, pp 53–87

Shastri H, Paul S, Ghosh S, Karmakar S (2015) Impacts of urbanization on Indian summer monsoon rainfall extremes. J Geophys Res Atmos 120(2):496–516. https://doi.org/10.1002/2014jd022061

Sigel K, Klauer B, Pahl-Wostl C (2010) Conceptualising uncertainty in environmental decision-making: the example of the EU water framework directive. Ecol Econ 69(3):502–510. https://doi.org/10.1016/j.ecolecon.2009.11.012

Singh C, Dorward P, Osbahr H (2016) Developing a holistic approach to the analysis of farmer decision-making: implications for adaptation policy and practice in developing countries. Land Use Policy 59:329–343. https://doi.org/10.1016/j.landusepol.2016.06.041

Smithers J, Smit B (1997) Human adaptation to climatic variability and change. Glob Environ Chang 7(2):129–146. https://doi.org/10.1016/S0959-3780(97)00003-4

Solecki W, Pelling M, Garschagen M (2017) Transitions between risk management regimes in cities. Ecol Soc 22(2):38. https://doi.org/10.5751/ES-09102-220238

Srivastava S, Mehta L (2017) The social life of mangroves: market-driven enclosures, resource complexes and contestations on the industrial coastline of Kutch, India. STEPS working paper 99, STEPS Centre, Brighton

Stirling A, Leach M, Mehta L, Scoones I, Smith A, Stagl S, Thompson J (2007) Empowering designs: towards more progressive appraisal of sustainability. STEPS working paper 3, STEPS Centre, Brighton

Swart R, Bernstein L, Ha-Duong M, Petersen A (2009) Agreeing to disagree: uncertainty management in assessing climate change, impacts and responses by the IPCC. Clim Chang 92(1-2):1–29. https://doi.org/10.1007/s10584-008-9444-7

Tengö M, Brondizio ES, Elmqvist T, Malmer P, Spierenburg M (2014) Connecting diverse knowledge systems for enhanced ecosystem governance: the multiple evidence base approach. Ambio 43(5):579–591. https://doi.org/10.1007/s13280-014-0501-3

TERI (The Energy Research Institute) (2014) Assessing climate change vulnerability and adaptation strategies for Maharashtra: Maharashtra State Adaptation Action Plan on Climate Change (MSAAPC) New Delhi: The Energy and Resources Institute

Totin E, Butler JR, Sidibé A, Partey S, Thornton PK, Tabo R (2018) Can scenario planning catalyse transformational change? Evaluating a climate change policy case study in Mali. Futures 96:44–56. https://doi.org/10.1016/j.futures.2017.11.005

Tschakert P (2007) Views from the vulnerable: understanding climatic and other stressors in the Sahel. Glob Environ Chang 17(3–4):381–396. https://doi.org/10.1016/j.gloenvcha.2006.11.008

UN-HABITAT (2010) State of the world's cities 2010/2011: bridging the urban divide. Earthscan, London

Unmüßig B, Sachs W, Fatheuer T (2012) Critique of the green economy. Towards social and environmental equity. Heinrich Böll Foundation, Berlin

Van Der Sluijs J (2005) Uncertainty as a monster in the science–policy interface: four coping strategies. Water Sci Technol 52(6):87–92. https://doi.org/10.2166/wst.2005.0155

Vedwan N, Rhoades RE (2001) Climate change in the Western Himalayas of India: a study of local perception and response. Clim Res 19(2):109–117. https://doi.org/10.3354/cr019109

Venkatesh, S (2018) Union budget 2018: climate action funds lying unused is a concern. Down to Earth. https://www.downtoearth.org.in/news/union-budget-2018-concerns-over-funds-for-climate-action-lying-unused-59518. Accessed 12 July 2018

Wilby RL, Dessai S (2010) Robust adaptation to climate change. Weather 65(7):180–185. https://doi.org/10.1002/wea.543

Walker WE, Harremoës P, Rotmans J, van der Sluijs J, van Asselt MB, Janssen P, Krayer von Krauss MP (2003) Defining uncertainty: a conceptual basis for uncertainty management in model-based decision support. Integr Assess 4(1):5–17. https://doi.org/10.1076/iaij.4.1.5.16466

WWF-India (2010) Sundarbans: future imperfect, climate adaptation report. http://awsassetswwfindiaorg/downloads/sundarbans_future_imperfect__climate_adaptation_report_1pdf Accessed 8 May 2017

Wynne B (2010) Strange weather, again: climate science as political art. Theory, Culture & Society 27(2/3):289–305. https://doi.org/10.1177/0263276410361499

Wynne B (1992) Uncertainty and environmental learning: reconceiving science and policy in the preventive paradigm. Glob Environ Chang 2(2):111–127. https://doi.org/10.1016/0959-3780(92)90017-2

Zeiderman A, Kaker SA, Silver J, Wood A (2015) Uncertainty and urban life. Publ Cult 27(2 (76)):281–304. https://doi.org/10.1215/08992363-2841868