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A critical assessment of knowledge quality for climate adaptation in Sylhet Division, Bangladesh

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ABSTRACT

There are numerous challenges to mobilising high quality knowledge in support of climate adaptation. Urgent adaptive action often has to be taken on the basis of imperfect information, with the risk of maladaptive consequences. These issues of knowledge quality can be particularly acute in vulnerable developing countries like Bangladesh, where there can be less capacity for producing and using climate knowledge. This paper argues that climate change adaptation in places like Bangladesh would benefit from a more self-conscious critical review of the knowledge systems mobilised in support of action, and suggests that 'knowledge quality assessment' (KQA) tools can structure this review. It presents a desktop assessment of information used for climate change adaptation projects in Sylhet Division in Bangladesh, steered by the six themes of the 'Guidance for Uncertainty Assessment and Communication' KQA tool. The assessment found important differences in approaches to mobilising knowledge, particularly between governmental and non-governmental organisations (NGOs). It demonstrated that *problem framing* has an impact on project success; projects that adopt a narrow techno-scientific framing can lead to significant adverse side effects. Recognising this some projects are *engaging stakeholders* in framing adaptation. It found a lack of national policy Guidance on the use of *indicators* or appraisal of *uncertainty*, seeing government agencies fall back on their risk-based calculations, and NGOs attempt to identify indicators and uncertainties via community engagement, with mixed success. Moreover, the adaptation knowledge base is relatively disintegrated, despite tentative steps toward its *consolidation and appraisal*, potentially related to on-going friction impeding vertical *communication* within government, and horizontal communication between government, NGOs and stakeholders. This all suggests that the Bangladeshi practices at the adaptation science-policy interface can benefit from reflection on KQA criteria; reflection that could concretely be encouraged through revision of the national policy framework.

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1. Introduction

There are on-going debates around the particular challenges to mobilising high quality climate knowledge in support of climate adaptation. Scholars argue for reorganising 'adaptation science' in recognition of the challenges of: (i) framing climate science at a regional or local scale; (ii) addressing significant uncertainties; (iii) navigating contested and corrupted science; (iv) creating the institutional conditions for 'coproducing' information in partnership between the scientific community and other knowledge-holders; (v) making this climate information more useable for adaptation, tailored to particular institutions and users; and (vi) muddling forward with imperfect information (Armitage et al., 2011; Dilling and Lemos, 2011; Hallegate and Mach, 2016; Kerr, 2011; Moss et al., 2013; van Bree and van der Sluijs, 2014; Brammer, 2014b). Together these challenges mean that urgent, high stakes adaptive action often has to be taken on the basis of low quality climate knowledge, which can lead to maladaptive outcomes (Moss et al., 2013). Indeed, these challenges are compounded in the vulnerable developing world, where there may be less expertise and capacity for producing and using adaptation science, and attendantly, where science may be either misused or go unused (Pasgaard et al., 2015). This paper argues alongside others that adaptation actors need to be acutely aware of the (high or low) quality of climate knowledge they use, if adaptation is to be successful.

Problems of knowledge quality have been discussed for more than 40 years by scholars in the philosophy of science (Ravetz, 1971; Funtowicz and Ravetz, 1993), science and technology studies (Clark and Majone, 1985), and environmental governance (Bremer, 2013; Cash et al., 2003). Clark and Majone (1985, p. 6) note that, "Among the many prescriptions offered for the mitigation of such questions (...) the repeated calls for strengthened mechanisms of peer review and critical evaluation stand out". But, as a departure from 'normal' scientific practices of peer review, these scholars argue that science (or knowledge) for policy demands different practices and norms of evaluation. Alternative perspectives on peer review, such as theories of 'post-normal science' (Funtowicz and Ravetz, 1993), propose extending the peer community to include the full diversity of relevant knowledge holders and users, exercising a self-conscious and reflexive review of knowledge quality, according to criteria that are meaningful for a particular context. These theories have also seen the development of a diverse set of 'knowledge quality assessment' (KQA) tools, for supporting such processes of peer review (van der Sluijs et al., 2008; Maxim and van der Sluijs, 2011). These perspectives on the critical peer review of knowledge quality have seen some practical application in the field of climate adaptation (Ford et al., 2013; Risbey et al., 1996; Weichselgartner and Kasperson, 2010), but we argue there is much more scope for their use.

This paper argues that climate change adaptation projects, including in Bangladesh, would benefit from a more self-conscious critical review of the knowledge systems mobilised in support of action, and suggests that concepts of 'quality' and KQA tools offer one feasible framework for structuring this review. From this point of departure, the paper implements a desk-top KQA of the knowledge used in support of climate adaptation projects in Bangladesh, with a particular focus on the Sylhet Division, and steered by the particular KQA tool presented by 'The Guidance for Uncertainty Assessment and Communication' (van der Sluijs et al., 2008). The six themes of knowledge quality in the Guidance are used here as a heuristic for organising reflections on the quality of knowledge mobilised for various adaptation initiatives in Sylhet Division, with regard for the wider Bangladeshi policy context. The study moves from a *description* of knowledge used in support of adaptation, to a systematic *assessment* of knowledge quality, before making *recommendations* on how to improve knowledge quality for adaptation in Bangladesh. In this way the paper aims to both stimulate critical reflection on knowledge quality in Bangladesh, and demonstrate how KQA, including through use of the Guidance, can benefit adaptation practice in other contexts.

The paper begins in Section 2 by presenting some background information on climate adaptation in Bangladesh and Sylhet Division specifically, before Section 3 introduces the Guidance tool and how it was employed in this study. Section 4 presents the results of the knowledge quality assessment, then Section 5 concludes with recommendations.

2. Background: Sylhet's climate adaptation under uncertainty

2.1. Climate vulnerability and adaptation governance in Bangladesh

Bangladesh has been assessed as one the countries most vulnerable to climatic change (Maplecroft, 2010; United Nations, 2011). Geographically it is highly exposed to the physical impacts of climate change, with these impacts exacerbating other on-going environmental, social and economic challenges facing this densely-populated country. At the same time, Bangladesh's capacity to adapt to these impacts has been relatively weak (Ahmed et al., 1999; Mahmud and Prowse, 2012), with Islam et al. (2013, p. 96) noting; "Low economic strength, inadequate infrastructure, a low level of social development, a lack of institutional capacity and a high dependency on the natural resource base make the country more vulnerable". Bangladesh's vulnerability is compounded by significant uncertainties around current climate variability and future climate change, and the extent of the resultant impacts; particularly indirect social and economic impacts.

This has seen Bangladesh take a lead role amongst climate vulnerable developing countries, investing $US10 billion over the past 35 years to reduce its vulnerability, mainly in infrastructure, flood management and climate resilient crops (Islam et al., 2013). It has also led the way in developing national policy, producing the National Adaptation Programme of Action (NAPA) in 2005, and the first nation globally to produce a Climate Change Strategy Action Plan (the Bangladesh CCSAP) in 2009. Under the BCCSAP, a range of government agencies and NGOs are committed to working with climate adaptation

across six thematic areas: (1) food security, social protection and health; (2) comprehensive disaster management; (3) infrastructure; (4) research and knowledge management; (5) mitigation and low carbon management; and (6) capacity building and intuitional strengthening (MoEF, 2009). Finally, we see Bangladesh as having a high general awareness of climate issues, with a recent survey of seven Asian countries finding Bangladeshis to be highly aware of the term "climate change", and the most active in adapting to climatic changes (Mamun et al., 2013). Against this background, some vulnerability indices show that Bangladesh has consistently reduced its vulnerability, to be the 43rd most vulnerable country in 2014 (ND-GAIN, 2016).

Bangladesh's national climate adaptation governance represents the sum activities of a complex network of groups, working concurrently in different institutions according to different principles, using different tools, towards different goals (Chowdhury, 2012). A recent review identified an 'institutionally chaotic' network including 37 central government ministries (plus their departments and autonomous bodies), more than 10 Donors on a multi-lateral and bilateral basis, local government, a host of non-governmental organisations (NGOs) (an estimated 19,000–45,000 NGOs and voluntary organisations are active scattered over most villages in Bangladesh; Haider, 2011), private sector enterprises, the research community including universities and research organisations, and individual villages and households (O'Donnell et al., 2013). Overall, Bangladeshi adaptation governance can be characterized as *hierarchal*, led by central government experts and administrators in a top-down way, and shaped by international adaptation agendas and donor bodies, with emphasis on large physical works (Ahmed et al., 1999; O'Donnell et al., 2013; Alam et al., 2013). It is also *horizontally disintegrated*; despite a nationally harmonising policy framework, climate adaptation is, in practice, narrowly implemented within 'development' and 'disaster response' sectors (O'Donnell et al., 2013).

Bangladesh's national adaptation policy is primarily implemented through government-led projects, funded across four main mechanisms. The Bangladesh Climate Change Trust Fund (BCCTF) draws on government revenue streams to fund projects under the thematic areas of the BCCSAP (US$ 226.56 million in almost 200 projects), with parallel support from the donor-financed Bangladesh Climate Change Resilience Fund (BCCRF) (Haque et al., 2013). The Strategic Programme for Climate Resilience (SPCR), instituted by the Asian Development Bank, helps top up major adaptation projects, and includes a loan component (CIF, 2010). Lastly, the donor-financed Comprehensive Disaster Management Programme (CDMP – and later the CDMP II) led by the United Nations Development Programme, works closely with the Ministry of Disaster Management and Relief (MoDMR) to reduce vulnerability to hazards and extreme events.

2.2. The case study: vulnerability and adaptation governance in Sylhet Division

The case study area, Sylhet Division, consists of four districts in the northeast of Bangladesh, including Habiganj, Moulvibazar, Sunamganj and Sylhet (Fig. 1). It occupies an area of almost 13,000 km^2, representing 8.5% of the total area of Bangladesh. The area is dominated by the Surma-Kusiyara floodplain; a levee and basin relief sloping from the north-east towards the west and the south-west, with basin centres marked by extensive permanent and seasonal depressions, which are locally called *haors* (Brammer, 2012). There are more than 6000 *haors* (63 500 ha), almost two thirds of which are permanent, which serve as an important fishing source (Ali, 1999). From June–September the entire depression is inundated with water from the pre-monsoon and monsoon rains. Sylhet Division is also known as the site for most of Bangladesh's tea gardens, in the hill-country.

Sylhet Division has a particular climate that distinguishes it from neighbouring areas, and introduces unique challenges to coping with both climate variability, and indeed long-term change. It is one of the wettest regions in Bangladesh with average annual rainfall of 4080 mm (1980–2009), though this amount can vary greatly from year to year. Annual rainfall total varied between 3280 mm (1980) and 5620 mm (1988) between 1980 and 2009. A study in 2013 (Stiller-Reeve et al., 2015) found that the summer period is particularly important between April and June. Between 1980 and 2009 the total rainfall in May varied between 222 mm (1987) and 1129 (1988). With the rains come regular flooding, with both positive and negative impacts. Flood data from 1988 to 2014 demonstrates that flood levels, in Sunmganj District for example, remain regularly above 'danger levels' set by the Bangladesh water Development Board over the summer and monsoon period. For instance, heavy floods in 1988, 1989, 1993 and 1996 saw waters exceed danger levels for 60, 25, 43 and 18 days respectively, with significant damage to rice and other crops (BWDB, 2014). In 1996 about 75% of rice crops were damaged in Sunamganj (Sumon and Islam, 2013). On the other hand, while heavy flooding can be harmful, lesser flooding is vitally important for the community; irrigating the rice crop, restocking the *haor* with fish, and bring down alluvium for instance.

The livelihood of Sylhet Division's population of around 8 million people is heavily dependant on the rice, fisheries, and tea sectors. Indeed, Sylhet communities have a long experience of coping with rainfall extremes and flooding; they have long learned to live in this highly unpredictable environment. Rice farming has adapted, with many farmers harvesting just one *boro* rice crop each year before the summer rains, while others cultivate transplanted *aman* rice as an important rain-fed rice crop, limited to those areas that escape flooding (BBS, 2011). In this way, through these crop cycles, and early maturing strains of rice (see below), rice production has steadily increased in Sylhet Division, with trends in recent years (from 2004 to 2012) showing an increase in rice cropping land by 10%, and increase in production of 41% (BBS, 2013). Another livelihood strategy is seen in aquaculture, with the area and production of aquaculture in Sylhet Division growing over 200% from 2001–02 to 2013–14 (FRSS, 2001–02–02; FRSS, 2013–14), suggesting an increasing reliance on aquaculture for food fish production. This noted, aquaculture is also vulnerable to climate change in terms of uncertain impacts on hatchery operation, fry nursing and grow-out production (Swaminathan, 2012). Finally, a third particular adaptation strategy of Sylhet

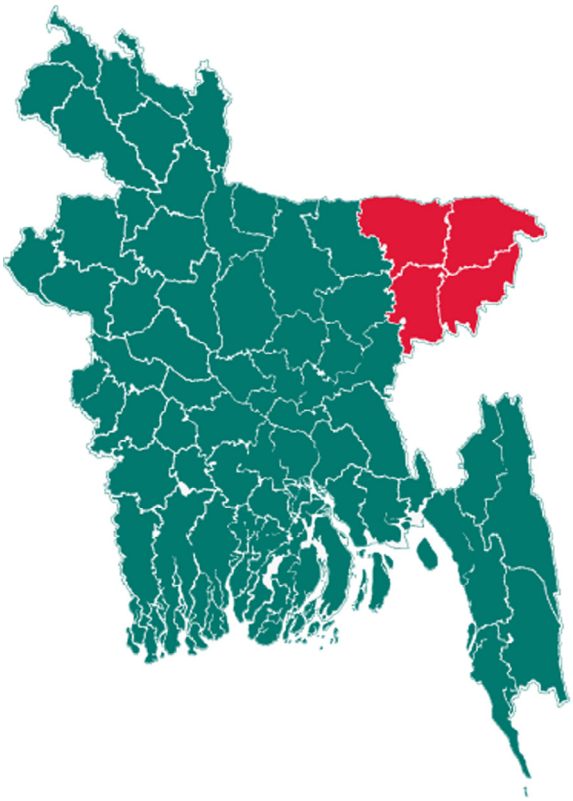

Fig. 1. Map of Bangladesh, Sylhet Division indicated red. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.) *Source:* http://en.wikipedia.org

Division communities is seen in migration to different countries, a sending back remittance to family remaining behind. According to BBS (2016), the average size of remittance being received by households in Sylhet Division per year (BDT 333,125) is the second largest just after Dhaka Division (BDT 359,833).

Notwithstanding the coping strategies of Sylhet communities, studies have highlighted their self-perceived vulnerability in the face of climate variability, and eventual long-term climate change. In a recent survey, Sylhet Division people perceived that climate variability has significant impacts on their lives by changing access to resources; reporting a substantial decrease in the availability of fresh water, in agricultural productivity, and in the availability of electricity and fuel (Mamun et al., 2013). This echoes other research on Sylhet's vulnerability, looking at how changes in flooding regimes affect *haor* biodiversity and fisheries (Ali, 1999), how changes in rainfall patterns impact on tea gardens (Ahmed et al., 1999) or how increased flooding "...can cause deaths and injuries and can be followed by infectious diseases (such as diarrhoea) and malnutrition due to crop damage" (IPCC, 2012, p. 252). There remains contention over whether Sylhet Division is experiencing more long-term climate change; while the surveys show some perceived long-term change in the climate by community-members, other scientific studies are divided on whether Bangladesh is (Nishat and Mukherjee, 2013a) or is not (Brammer, 2014a) experiencing conclusive changes in the climate, including in Sylhet Division.

Climate adaptation governance in Sylhet is top-down and expert-driven in its implementation, mainly by central government agencies and major NGOs (Habiba, 2012; Habiba et al., 2013). Union Parishads (UPs)[1] are charged with implementing the directives of central government and Upazila[2] offices, but have limited power, financial autonomy or capacity to promote climate adaptation (O'Donnell et al., 2013). Most government adaptation efforts take the form of ministry-led infrastructure and agricultural extension projects. This has seen five river infrastructure projects funded by the BCCTF, and a number of Ministry of Disaster Management and Relief (MoDMR) adaptation projects funded by the CDMP. These latter projects focussed on responses to floods and flash-floods in the *haor* area, including; (i) cultivation of early maturing rice varieties; (ii) dyke building with communities; (iii) improving livelihoods of disabled people; (iv) coping mechanisms in water logged areas; (v) protecting homesteads from the wave action; and (vi) the construction of seasonal villages for fishing and agriculture in the dry season (MoFDM, 2009). Later, CDMP II supported the Department of Agriculture Extension (DAE) to promote agricultural adaptation

[1] The Union Parishad (UP) is the most local unit of government, comprising an elected committee led by a chairman, with a small secretariet.

[2] The Upazila is the second most local unit of local government, comprising several UP. The Upazila Parishad comprises an elected committee led by a chairman, and a body of bureaucratic staff led by an Executive officer.

through: (i) flood-tolerant rice varieties; (ii) early maturing rice varieties; (iii) floating vegetable production; and (iv) community-based rice seedbed development (DAE, 2012).

In parallel, NGOs have been active in implementing several physical projects, studies and demonstration activities in Sylhet Division. The Voluntary Association for Rural Development (VARD) conducted a participatory study in 2009 to assess disaster risks in Jamalganj Upazila, identifying the most important impacts as early floods, seasonal floods, hail storms, excessive rainfall, drought and riverbank erosion (VARD, 2009). CARE Bangladesh worked with the Centre for Natural Resource System (CNRS) from 2006 to 2010, to reduce vulnerability to flash floods and improve food security by bringing larger areas of Sunamganj under rice cultivation (CARE, 2010). The project constructed submersible embankments, re-excavated waterways, planted mangroves, and formed community-based organisations to maintain these works. A separate CNRS project from 2006 to 2007 sought to improve agricultural adaptation in Jamalganj through field-testing early maturing rice and other crops that could be harvested a month before flash-floods (CNRS, 2008). In 2010, the International Union for Conservation of Nature (IUCN) Bangladesh carried out a participatory assessment to develop community-based adaptation practices (IUCN, 2011), including: (i) building multipurpose disaster shelters; (ii) constructing roads, submersible embankments, and protection walls; (iii) researching early-harvest rice; (iv) implementing floating gardens; (v) training on integrated pest management; (vi) developing ecotourism; and (vii) installing sanitary latrine and tube wells (IUCN, 2011). A later IUCN initiative sought to develop co-management of the Tanguar *haor* wetland, a Ramsar site (IUCN, 2014).

Research institutions and universities in Sylhet Division have mainly focused on the biological impacts of a changing climate (Ahmed, 2012; Islam, 2014; Rahman, 2015), but some agencies, like the International Resources Group (IRG), have explored community conceptions of climate vulnerabilities, and adaptive responses. The IRG identified floods, drought and storm as major vulnerabilities, to be addressed by constructing embankments and shelters, raising houses and improving public awareness (IRG, 2012).

2.3. Uncertainty compounding vulnerability: introducing KQA

Adaptation in Bangladesh, and Sylhet particularly, remains compromised by significant uncertainties, a lack of a high quality knowledge base for decisions, and a historic weakness in education on climate and weather. In the late 1990s, scholars said that Bangladesh needed "...better information, better tools of analysis, and more comprehensive and better focussed exercises" (Huq and Asaduzzaman, 1999, p. 10). Today, there is a growing availability of climate information in Bangladesh, and efforts to assemble this knowledge in one place. For instance, the International Centre for Climate Change and Development (ICCCAD) has developed the Gobeshona web-based platform for sharing literature of climate research in Bangladesh, which as of February 2016 registered 1017 publications across various categories (Gobeshona, 2016). In parallel, the NAPA introduced modules on climate and climate change in secondary and tertiary educations, accepting the limitations of textbook learning on such pervasive and lived phenomena as the weather. Notwithstanding this growth in research and education, uncertainties persist owing to the inherent uncertainties of complex and dynamic climate systems (Nishat and Mukherjee, 2013b), a dearth of fine-scaled scientific studies of climate in Bangladesh, the fragmented nature of knowledge fit for supporting adaptation (Islam et al., 2013), and challenges to the quality of climate indicator measurement. By way of illustration, Brammer (2014a,b) notes that many temperature measurements across Bangladesh may be skewed because the weather stations are located in towns or airports where temperatures are increased by masonry and tarmac.

In Sylhet Division there remain significant uncertainties about the current rainfall regime and how it may look under future climatic change; what gives rise to rainfall in that area? Why is 'pre-monsoon' rainfall more significant than elsewhere in Bangladesh? Climate science has made limited advances in its understanding of Sylhet's rainfall, in large part because most models have tended to present broad national patterns in Bangladesh's climate, with little regard for local variation. The result is at-times significant disparity between the lived experience of Sylhet communities, and climate science models. For instance, the people of northeast Bangladesh perceive the heavy early summer rainfall as the 'monsoon', however, due to coarse model resolution, this rainfall does not appear in most climate models rendering them poor information sources for adaptation (Stiller-Reeve et al., 2015). Significant uncertainties make it difficult to arrive at a robust explanation of rainfall in Sylhet Division, and gives rise to a plurality of disparate perspectives within the scientific community, *and* within local communities.

This paper systematically assesses the quality of the knowledge used in support of climate adaptation across the science-governance interfaces in Bangladesh, with a particularly focus on Sylhet Division, using the Guidance KQA tool. The study is steered by three open questions:

(a) How is knowledge mobilised in support of climate adaptation projects in Bangladesh and Sylhet Division? (Section 4.1)
(b) To what degree is this knowledge of 'high quality' for supporting adaptation? (Section 4.2)
(c) How could better quality knowledge be mobilised in support of adaptation? (Section 5)

'Climate knowledge' as used here includes knowledge stemming from all different forms of scientific (social, human and natural sciences), local, traditional and other knowledge systems related to climate and its impacts, and how to respond to these impacts. 'Climate adaptation projects' refers to all formal project work undertaken by any organisation or group, to support adaptation to both climate variability and change.

3. Method: systematic assessment of knowledge quality for climate adaptation in Sylhet Division, Bangladesh

3.1. Data collection

The research conducted a desktop study of the climate knowledge used in support of adaptation projects and policy in Sylhet Division, in a Bangladeshi context, using written material collected through a comprehensive review of the published and grey literature, including unpublished material. It covered published journal articles, books, reports, thesis, web documents and government reports. A number of government and non-government organisations[3] working with climate change adaptation were visited to collect additional documents.

3.2. 'The Guidance' KQA tool

The past 30 years have seen discussions on the 'quality' of science for collective decision-making, with important contributions from the philosophy of science, and the perspective of 'post-normal' science in particular. Faced with the limitations of normal science to cope with societal challenges like climate adaptation, Funtowicz and Ravetz (1993, p. 793) developed post-normal science as an alternative; recognising "assumptions of unpredictability, incomplete control, and a plurality of legitimate perspectives". Faced with uncertainty, "Quality…becomes the organising principle of post-normal science because the old ideal of scientific truth is no longer attainable or relevant for policy" (Funtowicz and Ravetz, 1994). Seen through a post-normal science lens, the study of climate and its impacts requires the engagement of an 'extended peer community', which includes peers from science, policy, the private sector and wider civil society. Each member of the community has a responsibility to contribute their own knowledge, and appraise the quality of the knowledge provided by others. This process of extended peer review evolves through dialogue, with quality appraisal structured by formal criteria or tools agreed on within the community. These criteria of quality extend beyond the narrow criteria of single scientific disciplines to encompass broader notions of what constitutes knowledge quality, including its fitness for *purpose*, the *people* producing it, according to which *process*, and the final knowledge *product* (Funtowicz and Ravetz, 1993). Subsequently there is a significant literature on knowledge quality criteria, including the work of Cash et al. (2003), who discuss knowledge legitimacy, salience and credibility, and a growing list of tools for KQA (van der Sluijs et al., 2008).

For structuring this desktop meta-assessment of adaptation policy and initiatives in Sylhet Division, we selected the '*Guidance for Uncertainty Assessment and Communication*' KQA tool (the Guidance) (Janssen et al., 2005; Petersen et al., 2013), because it is a comprehensive framework that covers both the substantial and the societal dimensions of quality. It is a proven tool that has previously been successfully applied in various contexts and we have in-house expertise on its application and use. The Guidance was developed in 2002 through a partnership between the Netherlands Environmental Assessment Agency and Utrecht University, has become widely used in that Agency. It has reportedly stimulated co-learning processes among scientific advisors and policy makers for a deeper understanding and awareness of uncertainty and its policy implications (van der Sluijs et al., 2008).

The Guidance tool adopts a checklist approach, designed to transparently highlight and communicate uncertainties along a scientific assessment process as a way of structuring informed public and policy debate; whether it be for an Environmental Impact Assessment for a particular project, or a broader assessment of the body of knowledge used to inform a policy programme (see e.g. Janssen et al. (2005), van der Sluijs et al. (2008) and Petersen et al. (2013)). It does not limit its focus to formal, quantitative methods for sensitivity and uncertainty analysis, but extends a regard to the social context of knowledge production, including assumptions and value-loadings. In this way it systematically guides scientists in an exploration of deeper uncertainties that reside in problem framings, expert judgments, and assumed model structures for instance. "*It provides a heuristic that encourages self-evaluative systematic critical reflection in order to become aware of pitfalls in knowledge production and use. It also provides diagnostic help as to where uncertainty may occur and why.*" (van der Sluijs et al., 2008). The Guidance focuses on six elements of knowledge production and use (Table 1).

As a heuristic, the Guidance tool can be employed at all scales for assessing knowledge quality for climate adaptation; from a particular project on riverbank protection for instance, up to an assessment of adaptation policy for a region or country. This paper employs the Guidance to organise an *ex post* meta-assessment of knowledge quality used in support of all explicitly labelled adaptation initiatives initiated in Sylhet Division, with a regard for the wider Bangladeshi adaptation policy context. One main weakness of this approach is that it cannot go into significant detail on any one initiative. On the other hand, a broader perspective allows comparison across initiatives, and consequently, some comment on varied or widespread practices, institutional policies and norms, resources and expertise for instance.

[3] The government organisations visited include: Department of Meteorology, Syllhet; Bangladesh Water Development Board, Dhaka; Upazila Nirbahi (administrative) Office, Barlekha; Upazila Nirbahi (administrative) Office, Sunamganj; Union Parishad Office, Jamalganj; and Bangladesh Tea Research Institute, Maulvibazar. Researchers working with climate change were visited in Sylhet Agricultural University, and Shahjalal Science and Technology University located in Sylhet Division. The offices of local and international non-government organisations visited include: Bangladesh Centre for Advanced Studies (BCAS), Dhaka; Centre for Natural Resources Studies (CNRS), Dhaka, Sunamganj and Jamalganj; IUCN in Sunamganj; CARE head office, Dhaka; International Water Maudling (IWM); Practical Action Office, Dhaka; SAARC Agriculture Centre in Dhaka; CDMP office, Dhaka; OXFAM office, Dhaka; and SHIREE Project Office, Dhaka.

Table 1
Criteria and key issues for knowledge quality in the Guidance (Petersen et al., 2013).

Criteria	Key issues
Problem framing	(i) Existing frames of the problem, other than that of end users; (ii) the interconnections with other problems; (iii) any other relevant aspects of the problem not addressed in the research questions; (iv) the role of the study in the policy process; and (v) the way in which the study connects to previous studies on the subject
Stakeholder involvement	(i) The relevant stakeholders; (ii) their views, roles, stakes and involvement with respect to the problem; and (iii) the aspects of the problem on which they disagree
Indicator/visualization selection	(i) Adequate backing for selection; (ii) alternative indicators; and (iii) support for selection in science, society, and politics
Appraisal of knowledge base	(i) The quality that is required; (ii) the current state of knowledge; and (iii) the gap between these two
Mapping and assessing relevant uncertainties	(i) The relative importance of statistical uncertainty, scenario uncertainty and recognized ignorance with respect to the problem at hand; (ii) the uncertainty sources that are most relevant to the problem; and (iii) the consequences of these uncertainties for the conclusions of this study
Communication of uncertainty information	(i) Context of reporting; (ii) robustness and clarity of main messages; (iii) policy implications of uncertainty; (iv) balanced and consistent representation in progressive disclosure of uncertainty information; and (v) traceability and adequate backing

4. Results

4.1. How is knowledge mobilised in support of climate adaptation projects in Bangladesh and Sylhet Division?

Bangladesh's national climate adaptation policy framework emphasises producing and disseminating 'scientific-quality' knowledge as a sound basis for adaptation. In 2005 the NAPA highlighted 15 priority actions, with three of these promoting climate adaptation research and two others promoting knowledge dissemination. A revised list of adaptation research priorities came with the revised NAPA in 2009 (Islam et al., 2013). Concurrently, the BCCSAP explicitly deals with *'research and knowledge management'* as one of its thematic pillars (MoEF, 2009), promoting the creation of a centre for climate knowledge management and training, together with building modelling capacity, and monitoring on-going climate impacts.

To what extent does this policy manifest itself through nationally funded adaptation research? The BCCTF devoted less than 2% of its resources to *Research and Knowledge Management,* making it the least supported of all the six BCCSAP themes. This noted, the BCCTF also funded research projects under the themes *Food Security, Social Protection and Health* (15 projects), *Comprehensive Disaster Management* (5 projects) and *Capacity Building and Institutional Strengthening* (5 projects). On the other hand, knowledge production and management has been an important focus of CDMP (II). It has promoted strategic 'knowledge gap filling' through coordinated research according to a prioritised *research agenda* around three themes: (a) disaster risks, (b) integrated concepts of resilience, and (c) adaptive livelihoods (Islam and Sumon, 2013). This has manifested in various research efforts, including the work of the DAE to identify, validate, compile and share indigenous adaptive knowledge, options and technologies with farmers (DAE, 2012).

In sum, the national policy framework centres knowledge production on improving capacity in research institutions to carry out scientific studies, particularly around: (i) predictive numerical and empirical scientific models, such as flood forecasting; (ii) agricultural research into tolerant crops; (iii) engineering technologies, mainly for managing flood risks; and (iv) monitoring the on-going impacts of a changing climate (Ahmed et al., 1999; Ali, 1999; Karim and Mimura, 2008; MoEF, 2009). Some attention has been devoted to mobilising indigenous knowledge systems, as promoted in the NAPA 2005, and implemented by the DAE under CDMP (II). Less attention is given to knowledge dissemination and management. The NAPA promotes dissemination through the school curriculum and targeted channelling of information to vulnerable communities, for example. Knowledge management is promoted under the BCCSAP and Centre for Climate Change and Environmental Research (C3ER), and though the proposed 'knowledge management centre' is not yet developed, the Department of Environment has established a Climate Change Knowledge Network (CCC, 2014), and the MoDMR has established an E-library, as a web-based platform for sharing information about disaster management. Parallel efforts are led by research centres like the ICCCAD and the Bangladesh Centre for Advanced Studies (BCAS).

Focussing on Sylhet Division, a number of initiatives are being implemented to safeguard communities against the current risks that accompany climate variability, and in so doing, build adaptive capacity against future climate change. The way through which knowledge is produced and mobilised in support of climate adaptation varies according to the design and leadership of the project. The five river infrastructure projects funded by the BCCTF were led by experts at the Bangladesh Water Development Board (BWDB). These projects privileged a narrow framing of flooding and erosion according to in-house hydrological science and modelling, which was directly translated into action through civil-engineered works. By framing adaptation as a technical challenge, these BWDB projects omitted other social, environmental or economic considerations, and avoided participation of local communities or other government agencies. Similarly some of the CDMP-funded projects, with government agencies developing climate-resilient rice, also framed adaptation as a technical challenge. This technical framing, often endorsed by government agencies, tends toward techno-scientific information that is easily 'transformed' into practical works across a 'closed' science-governance interface. Moreover, the top-down authoritarian behaviour

of government officers hinders the implementation of development projects that in turn results in gaining poor quality knowledge by the people, and persisting poverty at the grassroots level (Maloney, 1986).

Many of the NGO-led projects have adopted a more 'open' approach to mobilising knowledge for adaptation, including (a) the participatory risk assessment of VARD; (b) the co-management of Tanguar *haor* initiated by IUCN; or (c) the participatory research of the IRG of climate variability and adaptive responses. VARD applied participatory rural appraisal tools to engage diverse stakeholders in focus groups, disaster mapping, and key informant interviews (VARD, 2009). IUCN assembled a co-management committee, comprising government officers and locally-elected community leaders, which was charged with jointly developing and implementing a strategy action plan for the Tanguar *haor* wetland. This saw the committee working together to identify climate impacts facing the wetland, and investigate steps to address these impacts (IUCN, 2014). The IRG research developed a flipchart as a tool for eliciting local climate knowledge through group discussions (IRG, 2012). Arguably, the open science-governance interface initiated by NGO projects enables a broader perspective on adaptation that looks beyond one technological 'solution' to consider a suite of adaptation strategies. Indeed, some NGO efforts resemble research projects in that they raise awareness of climate adaptation options within communities.

Lastly, the Bangladesh Meteorological Department (BMD) has traditionally taken a lead in providing information about climate variability in Sylhet Division, including addressing uncertainties of naturally variable climate and floods. However, the BMD has been hindered in this role by insufficient weather stations, with limited technology in variable seasonality; reducing their ability to provide accurate fine-scaled and short-term forecasts. In response, some donor-funded projects are trying to improve the technical and operational capacity of these weather stations (BMD, 2013). Another BMD initiative, providing weather information to farmers, is being implemented in Sunamganj, where automatic weather stations are collecting real time data (BMD, 2013).

4.2. To what degree is this knowledge of 'high quality' for supporting adaptation?

Applying the six elements of the Guidance (Table 1) a critical appraisal was conducted of knowledge mobilised across the science-governance interfaces in support of adaptation in Sylhet Division, with an appreciation for the wider national Bangladesh framework.

4.2.1. Problem framing

Problem framing refers to the way in which a problem is defined (e.g. narrow or broad), as the first step to organising our understanding of that issue; drawing boundaries around which knowledge is salient and credible for the issue, and limiting our range of possible actions in response.

The policy *process* has influenced the framing of climate adaptation in Bangladesh's national policy framework. The NAPA was developed according to the parallel input from multi-disciplinary expert communities, and a long series of regional consultation workshops with communities across Bangladesh, including in Sylhet Division (Islam et al., 2013). However, the final form of the NAPA was significantly shaped by its international obligations and dominant framings of adaptation in international policy, including the guidance of the UNFCCC COP7 and the guidelines of the Least Developed Country (LDC) Expert Group (see e.g. Fig. 8, page 44, MoEF, 2005). Unlike the long NAPA policy process, the BCCSAP was developed and instituted within just six months, and was accordingly framed by a specialist driven process at the national level (Raihan et al., 2010). Therefore, despite efforts to consider framings of adaptation in the regions, overall the NAPA and the BCCSAP largely endorse framings of climate adaptation from the international policy community, interpreted by national scientists and policy experts.

In Sylhet Division, some of the most financially significant adaptation projects were led by the BWDB for river excavation and embankment construction to reduce flooding. The BWDB has a traditional focus on applied hydrological science, engineered infrastructure and irrigation to support the agriculture sector, resulting in a narrow framing of adaptation as scientific and technical solutions to physically defined problems; in this case the over-topping of the river-banks (Ahmad, 2003). This oversimplified framing neglects the role of water in other sectors, and any consideration for social or environmental implications of their engineered interventions. While addressing some of the impacts of flooding, the river embankments constructed in Sylhet, brought significant adverse impacts, including: (a) the displacement of local communities and reduction of agriculture land; (b) increased river erosion; (c) obstructing the movement of fish to the floodplain; (d) water-logging behind the stopbanks; (e) changes in aquatic ecosystems and water quality in some areas; and (f) increased local disparity, by being designed to benefit locally powerful actors (Ahmed and Islam, 2013). Indeed, the embankment works were met with local opposition, leading to unauthorised work to cut sections out of the embankments (ADB, 2014; Ahmed and Islam, 2013; Choudhury et al., 2004; Sarwar and Islam, 2013).

The projects developing climate-resilient strains of rice, in order to safeguard food security, can similarly be criticised for adopting a narrow technical problem frame. They framed adaptation as a biotechnological challenge to be solved in the laboratory. However, both the governmental MoFDM-led and non-governmental CNRS-led projects excluded particular local conditions and community concerns. Consequently, neither projects' crop was viable, and the projects did not fulfil their objective. In the former project the crop was vulnerable to winter cold snaps and in the latter it was less productive (MoFDM, 2009; DAE, 2012; Sumon and Islam, 2013). To be more fit for function, such research needs to be better integrated into a broader context, with wider problem framings that recognise the interconnectedness and complexity of adaptation problems.

Some of the NGO initiatives were designed to explore a greater diversity of problem frames according to their participatory design, grounded in the experiences of communities facing the impacts of a changing climate. For example, VARD assessed different framings of climate disaster risks through their rapid rural appraisal techniques (VARD, 2009), while IRG used flip charts to elicit different problem framings, and the IUCN encouraged dialogue about different problem framings within a process of co-management. Moreover, these initiatives acted to ensure that these alternative problem framings were considered alongside 'expert' framings within local governance processes and institutions. The VARD initiative saw participants learn about scientific framings of disaster risk, the responsibilities of local government, and disaster risk management, so that they could participate further in local disaster governance. The IUCN used community problem framings to steer co-management committees (IUCN, 2014). This is important, because there is a danger that participatory initiatives focusing on 'lay' framings of climate adaptation can exclude an appreciation for 'expert' framings; effectively swapping an expert bias for a community bias.

4.2.2. Stakeholder involvement

Extending the peer community beyond the domain of scientific and expert community can improve the quality of climate knowledge along three dimensions: (i) *substantively* wider participation accesses a greater array of perspectives and a more comprehensive understanding of adaptation; (ii) *normatively,* participation lends a voice to those stakeholders affected by climatic change, and any adaptation action and (iii) *instrumentally* stakeholders are more likely to regard adaptation projects as legitimate where their perspective has been considered (Fiorino, 1990; Kloprogge and van der Sluijs, 2006).

The Bangladesh adaptation policy-making process enabled the involvement of various categories of stakeholders. The NAPA resulted from three tiers of nested dialogue, including; (a) a national steering committee comprised of policy-makers and scientific experts, (b) a set of multi-disciplinary expert working groups; and (c) regional consultation workshops with local communities (Islam et al., 2013; MoEF, 2005). However, stakeholder involvement was not equal across these three tiers. The on-going dialogue with scientific and expert communities afforded them a significantly greater influence, compared to the 'consultation' with local communities. Looking to the BCCSAP, we see that its rapid development meant that stakeholder involvement was limited to scientific experts and national-level policy-makers. The BCCSAP process was criticised by campaign groups, the media and politicians alike (Alam et al., 2013); arguing it excluded knowledgeable stakeholders from vulnerable regions who could have made substantive contributions, and undermining the 'justice-based framework' it sought to give effect to (Alam et al., 2013).

In Sylhet, a general comparison can be drawn between the limited stakeholder involvement in government-led projects, and the more participatory NGO-led or research projects. The large-scale infrastructure works led by the BWDB were largely conceived, planned and implemented internally by scientists, modellers and engineers, with little participation from local stakeholders or coordination with government agencies (Ahmed and Islam, 2013). In contrast, many of the NGO-led initiatives, and some of the research community projects, were more participatory in mobilising knowledge for adaptation. The IRG initiative, for instance, was informed by community discussions, with the findings disseminated through 'field-days' that ensured mass participation on climate knowledge sharing, adaptation measures and policy planning (IRG, 2012). The CARE and CNRS project, reducing vulnerability to flash floods, developed community-based organisations for the local construction of flood protection. The IUCN initiative gave effect to stakeholder participation in mobilising climate knowledge for adaptation action through a genuine attempt at co-management; engaging stakeholders in assessing disaster risks, formulating adaptation measures, preparing guidelines, initiating community-based organisations, and applying adaptation measures using their own funds.

The work developing climate resilient crop varieties provides two revealing examples of how limiting stakeholder participation can limit the knowledge useful for informing initiatives. On one hand, local stakeholders can provide important input to the effective design of research studies. The CDMP-funded work of the DAE developed options for agricultural adaptation but failed to engage village actors in designing the field studies; those who possess a sophisticated body of local cropping knowledge (DAE, 2011). On the other hand, participation provides an appreciation for the social context within which technical innovations are introduced. The CNRS conducted research into winter rice, vegetable and spice crops, which improved farmers' yields and allowed them to harvest before the onset of flash floods. However, there was little work done to sensitize farmers to shifting from traditional practice to the new varieties, or study of the obstacles farmers may face in this transition (CNRS, 2008; Islam, 2014).

4.2.3. Indicator selection

Indicators have an important role in steering the production of knowledge for adaptation; determining those things that we choose to measure to illuminate the complex issues of climate adaptation (Bours et al., 2014). As such, the selection of an indicator can itself be a highly political process, equally defined by values and political stakes as the state of knowledge. Climate adaptation demands both indicators that provide information on the impacts of a changing climate, and indicators as to the impact of an adaptation initiative itself, including the quality of climate knowledge mobilised.

The Bangladesh adaptation policy framework does not have a strong regard for indicators. The NAPA does include some criteria for prioritizing adaptation projects, but offers no indicators for assess performance of an adaptation initiative, or indicators of climate change impacts (MoEF, 2005). Indeed, the BCCSAP does not have any apparent consideration for indicators (MoEF, 2009). Some commentators have argued that Bangladesh climate adaptation needs a greater emphasis on indicators

to measure the impacts of natural hazards, public health risks, and other socio-economic impacts associated with changes in temperature, rainfall and floods (Rashid et al., 2013).

In the Sylhet Division, we find variable attention to indicators related to the agency leading the initiative, and its funding mechanism. Government agencies tended to limit indicators according to their more narrow problem framing, and their in-house expertise and technology. For instance, in planning and measuring the efficacy of their flood protection works, BWDB showed a strong reliance on the water level measurements (BWDB, 2014), while in developing climate-resilient agriculture, the DAE focussed on measures of crop productivity as the main indicator of performance (Sumon and Islam, 2013). At the same time, funding mechanisms impose their own portfolio of indicators. The CDMP has developed a suite of indicators for evaluating the results and impacts of the projects it funds; including changes in disaster governance such as the number of agencies implementing risk reduction programmes, and the outcomes of this governance in terms of the number of people affected by disasters, or Bangladesh's position in the world risk index (CDMP, 2008). Looking across those government-led projects funded under the BCCTP and CDMP, we see a reliance on quantitative and numerical indicators, largely framed within a risk-based framework, and linked to national policy documents.

Alternatively, many of the NGO-led adaptation projects have worked to elicit indicators more meaningful to locally affected communities, founded in their context-specific understandings of climate impacts, and their desired outcomes of adaptation. VARD worked with communities to highlight indicators of the climate risks they faced, including incidence of seasonal floods, damage from flash floods, waterlogging, damage from extreme rainfall, and damage from storms (VARD, 2009). The IUCN initiative in Tangaor *haor* developed biodiversity indicators related to the abundance and behaviour of key plant and animal species, based in scientific and local observations (Alam et al., 2012). CNRS, in developing climate-resilient crops, tried to go beyond a sole focus on productivity, with a regard for the percentage of rice harvested ahead of flash floods, and income (BDT/ha) for instance (CCC, 2009). CARE, in addressing vulnerability to flash floods, measured diverse indicators, including the area protected from flood, crop production, food consumption, income per household, and survival of planted saplings (CARE, 2010). These portfolios of indicators are largely developed using approaches from social science, most notably techniques in Participatory Rural Appraisal, with varying degrees of robustness. Some NGOs lack the technical expertise to engage properly with indicator development.

4.2.4. Appraisal of the knowledge base

Ideally, adaptation governance would be based on the best quality knowledge available, demanding a transparent and critical appraisal of the current state of knowledge salient to adaptation in a particular place. This implies the threefold task of (i) assembling a broad knowledge base via a robust review process; (ii) appraising its quality as a basis for adaptation, according to criteria like salience, credibility and legitimacy; and (iii) identifying areas for more research, or where the current state of knowledge is of insufficient quality. It supports an analysis of uncertainties, and can steer knowledge production.

The preparation of the NAPA included an explicit review of the knowledge base of climate and adaptation in Bangladesh via six sectoral expert working groups (Islam et al., 2013; MoEF, 2005). It is however not clear to what extent this process enabled a critical appraisal of knowledge quality. Indeed, some commentators have criticised the NAPA process, arguing that it should have founded its review on more robust scientific studies of climate such as General Circulation Models (GCM) (Abedin and Shaw, 2013). On the other hand, the 23 GCMs listed by IPCC vary widely in their projections of climate change in southern Asia (Randall et al., 2007). Some commentators argue that GCMs have significant shortcomings relative to their predictive power for the Indian subcontinent to the extent that they are more useful for multidecade contingency planning than for practical use in mitigation and adaptation measures (Brammer, 2014a,b). Later, the BCCSAP was developed on the foundation built by the NAPA, drawing heavily on the knowledge base established in that process. Looking beyond the policy framework, various national initiatives have assembled published material (ranging from scientific papers to government reports) in integrated and open databases, including the MoE's Climate Change Knowledge Network, the MoDMR's E-Library or ICCCAD's 'Gobeshona' database.

We see fewer concerted attempts to systematically compile and appraise a scientific knowledge base for adaptation in Sylhet Division. In part this is because, despite important efforts in local government agencies and universities, there are as yet relatively few *explicit*[4], published scientific studies relevant to local adaptation in Sylhet Division, compared to other more studied areas of Bangladesh, along the coastline for example (Akhter et al., 2013; BCAS, 2008). In part it is because of a lack of incentives or capacity for government agencies using these scientific studies to assemble them into database specific to Sylhet Division. As a result, many government-led adaptation initiatives appear to be undertaken in an *ad hoc* manner, drawing on the limited knowledge base available.

Still, there is a sophisticated body of local and traditional climate knowledge in Sylhet Division, deeply rooted in the social, cultural and natural history of the area, and *tacit* to the knowledge-holders who draw on it to support their adaptation. Local NGO initiatives have tried to unpack this tacit knowledge alongside the explicit scientific research, using various participatory approaches. CNRS used drama and folk songs to elicit knowledge from local baul singers (mystic poets or folk singers) useful for conserving swamp forest and using swamp plants to protect against erosion (Ghani, 2012). The IUCN took an

[4] See Polanyi's (1967) distinction between explicit and tacit knowledge, where explicit knowledge has been produced, recorded and communicated in an explicit according to some formal process and norms, while tacit knowledge is inherent to knowledge holders.

ecosystems approach to access tacit knowledge related to *haor* biodiversity and its importance for crop production, fish production and disaster risk management (IUCN, 2014). IRG compiled an indigenous knowledge base for developing adaptation strategies, such as improving irrigation systems for crops in dry seasons (IRG, 2012). However, it is important to note that NGO initiatives have themselves been undertaken in a relatively *ad hoc* fashion, isolated from parallel efforts of other NGOs. And that these NGO projects show a general lack of critical appraisal, largely failing to question the quality of the tacit information they collect, or the robustness of the scientific process of collection. Not all NGOs are well trained in social science approaches and methods.

4.2.5. Mapping and assessing relevant uncertainties

Mapping and assessing uncertainties is to highlight areas where this knowledge is uncertain, the degree of uncertainty, and the implications of this uncertainty for the quality of the knowledge as a basis for climate adaptation. The Guidance defines an *uncertainty matrix* that distinguishes between the level of uncertainty (statistical uncertainty, scenario uncertainty or recognized ignorance), nature of uncertainty (knowledge related or variability related) and location of uncertainty (e.g. in data, model, expert judgement, or context) (van der Sluijs et al., 2008).

The NAPA and BCCSAP policy-making processes failed to include any deliberate attempt to map and assess uncertainties. Nor do they offer guidelines for uncertainty assessment as part of adaptation projects. With this lack of national guidance, it is unsurprising that there is a relatively weak culture of assessing uncertainty in Bangladeshi adaptation projects.

The BWDB infrastructure projects in Sylhet Division conducted a 'risk' assessment in accordance with their standardised engineering best practice, considering the risk of flooding from the available historical data in designing the height of embankments. However, risk is different to uncertainty in that it purports to be calculable by knowing the probability of defined outcomes multiplied by the damages caused by these outcomes. Risk assessments can be inappropriate where uncertainties are significant and probabilities unknown. The infrastructure projects in Sylhet were characterised by significant uncertainties related to complexities and unforeseen environmental, social and economic impacts (see Section 5.1). Similarly, the research on climate resilient rice varieties raised significant uncertainties, which were marginalised in the design of field-tests, but which later emerged in discussions with farmers; ranging from the specific climatic conditions in the location of the field-tests, to the social and economic context into which they released these new technologies (MoFDM, 2009). Indeed, the research design itself seemed unreflexive of the significant uncertainty associated with testing the performance of a crop over just one season.

NGO initiatives employed some methods to identify the uncertainties in the knowledge underpinning their projects, and threatened their adaptation efforts. IUCN assessed the uncertainties to realising ecological restoration and livelihoods development in the Tanguar *haor*, noting the main uncertainty to be the future flows in the major river, which may change under different scenarios (IUCN, 2014). IRG identified uncertainties that adaptive agriculture needed to respond to; notably less predictable farming seasons, a degraded water supply, and the incidence of floods and cyclones (IRG, 2012). Interestingly, CARE and its partner CNRS assessed the main uncertainties to implementing their project as not climatic, but the exploitation of resources by local elites to the exclusion of the poor. This uncertainty relates to the complex relationship between elite landowners and tenant farmers, based in part on a dependence of tenant farmers on aid from the more resilient elite (in food or seed) following natural disasters for instance, as a form of local adaptive practice (Maloney, 1986). Unlike the attempts to quantify uncertainty within government departments, NGO initiatives draw on participatory rural appraisal techniques to elicit qualitative scales of uncertainty from the communities they worked with, and from monitoring their on-going action research.

In terms of the uncertainty matrix of the Guidance, we see that uncertainties are 'located' relative to the understanding of context (assumptions of ecological, technical, economic, social and political systems and their boundaries), the expert judgements of professionals (see e.g. the judgement of BWDB engineers), the data used to support decisions (a paucity of measured data), and the outcomes of adaptation projects (whether they will be hijacked by local elites). The 'nature' of these uncertainties relates both to the quality of knowledge drawn upon, and the variability inherent to a changeable climate, environment and communities; thus ranging in 'level' from scenario uncertainty (about which future scenarios we may face) to recognized ignorance.

4.2.6. Communication of knowledge and uncertainty

The quality of knowledge for adaptation is also linked to how well its strengths and limitations are communicated to the target audiences. This demands the clear and transparent communication of both what is known and what is not known, and how this knowledge can be used for supporting adaptation in particular contexts of use. Moreover, the ownership of all research and knowledge, from scientific research to local or traditional knowledge, ought to be acknowledged and communicated with the users (Rashid and Khan, 2013).

The communication of the NAPA has been highlighted as particularly effective for increasing awareness of national adaptation priorities, and improving communication between different agencies working on adaptation (Islam et al., 2013). The BCCSAP also emphasises the importance of clear communication, with the fourth theme emphasising the importance of regional and national knowledge networks, which have seen realised in various initiatives to assemble published material in integrated and open databases. Notwithstanding the ambitious goals of the adaptation policy framework, some scholars (Abedin and Shaw, 2013; Stott and Huq, 2014) observed frictions impeding communication of the knowledge produced by the research community to the development agencies (donors and NGOs) that use it. Others lament persistently weak

'vertical' communication from the line-ministry level on to departments, autonomous bodies and local government (ICCCAD, 2014).

In Sylhet Division a sharp difference can be observed between government-led and NGO-led projects. For instance, the construction projects initiated by BWBD and other agencies follow their own internal institutional lines of communication between knowledge 'producers' and 'users'. This communication of climate adaptation knowledge adheres to institutions' own internal rationale of what constitutes high quality communication, though external communication is arguably of a much lower quality, poorly tailored to other knowledge users.

Looking to NGO initiatives, we see greater attention to how knowledge can be mobilised and communicated with communities, in support of local adaptation strategies. The VARD initiative engaged local people in participatory assessment exercises to collectively explore risks of climate change and disaster. The discussions culminated in a detailed report in Bengali, which was made available in the relevant UP offices, and supplemented by billboards that were distributed at the community level. Similarly the CNRS initiatives were seen to employ diverse mediums for communicating the findings of their research to local communities, including leaflets, booklets, billboards, folksongs, and folk drama for instance. The IUCN project established the Tanguar Haor Information Centre (THIC) in Sunamganj to attract students and researchers interested in the Tanguar *haor* ecosystem, and produce other materials, such as leaflets, booklets, and an interactive web portal, to communicate with a wider audience (IUCN, 2014). The IRG convened training programmes that built skills in community facilitation, adult education, ecosystem conservation, and climate change risks assessment and action planning, to support local people in adaptation governance.

5. Discussion, conclusions and recommendations

5.1. How could better quality knowledge be mobilised in support of adaptation?

The systematic analysis of knowledge quality using the Guidance, enables some targeted recommendations for improving knowledge quality, framed according to its six themes.

5.1.1. Problem-farming and stakeholder involvement

Overall, Bangladesh adaptation policy is heavily influenced by dominant 'framings' of adaptation in the international policy community. This policy framework is implemented through different government adaptation projects, each framed according to the lead-agency's own narrow statutory and technical imperatives. The narrow framing of adaptation associated with a hierarchal and fragmented governance system has resulted in projects that are poorly designed for their particular context, triggering at times harmful impacts and civil unrest (e.g. the flood protection works of BWDB). Government initiatives (from national to the Divisional scale) undertook limited consultation with adaptation stakeholders outside of their tight networks of scientific and policy experts, with the result that they often omitted important knowledge perspectives, and undermined the legitimacy of their work. These findings suggest that government agencies need to make more meaningful efforts to engage with diverse stakeholders as part of the framing, design, implementation and evaluation of adaptation; whether as part of the process of revising the BCCSAP or in planning particular projects with affected communities.

In contrast, the analysis found that most NGO-led projects sought to begin from community-framings of adaptation, and involve community stakeholders at different junctures; contributing their ideas, knowledge, expertise, resources and technologies. While such initiatives do access a rich body of local and traditional knowledge, they are not without their own challenges; including (i) traps of plurality and relativism, (ii) the variable quality of community perspectives (not all perspectives are equally robust, useful, or indeed trustworthy), (iii) connecting community perspectives with the expert perspectives in governance infrastructures, if they are not to be marginalised, and (iv) a lack of relevant technical knowledge within NGOs, including in social science approaches to eliciting local and traditional knowledge. This recommends attention to the robustness of the social science methods used by NGOs, and to connect initiatives with existing governance processes and institutions.

5.1.2. Indicators

Bangladesh adaptation policy offers little guidance on selecting, preparing and using indicators for guiding adaptation. As a result, government agencies tend to fall back on their own limited sets of indicators, or those imposed by international donors. While giving a sense of numerical robustness, these quantifiable risk-based indicators offer a narrow vision of the impacts of climatic change, or the effectiveness of adaptive responses. Many NGO initiatives have elicited more diverse portfolios of indicators, grounded in what affected communities consider important for adaptation. However, these indicators are not always collected in a robust manner, or field tested, and are of variable quality. Together this recommends clear national guidelines on indicators, perhaps through a revised BCCSAP, and developed in coordination between NGOs and government agencies, drawing on their different monitoring and evaluation efforts. Guidelines could be based on efforts in other countries. On one hand they could highlight key indicators of climate variability (e.g. temperature, precipitation) and impacts (e.g. flood height and frequency, crop productivity, illness, road access etc.) like the US Environmental Protection Agency (2016). On the other hand they could outline indicators of successful adaptation initiatives, relative to inputs (resources available),

processes (institutional arrangements and processes running), outputs (works completed) and outcomes (increases in adaptive capacity – food security, income, exposure to hazards) to cite the logical framework approach endorsed by the European Climate Adaptation Platform (ADEME, 2013). The guidelines should be particular to Bangladeshi adaptation, and therefore produced collaboratively with diverse governmental and non-governmental actors.

5.1.3. Appraising the existing knowledge base

Despite some critique of the NAPA development process, Bangladesh adaptation policy recognises the importance of a robust knowledge base for adaptation, and has helped guide national initiatives for assembling scientific literature in online catalogues. However, these initiatives are limited to explicit forms of knowledge, are less suited to under-studied divisions like Sylhet, and largely fail to critically appraise knowledge quality. At the same time we see NGO initiatives have sought to elicit the tacit local and traditional knowledge base in specific places, with varying degrees of scientific robustness, and largely in an *ad hoc* manner. The result, at the divisional scale, is a disintegrated knowledge base that is rarely subjected to any critical knowledge quality appraisal, such that initiatives are themselves disintegrated and poorly informed on the state of knowledge. This finding leads to the recommendation that the government augment the on-going national-scale programmes for assembling knowledge to: (i) make them relevant to each division, (ii) include both explicit and tacit knowledge bases, while (iii) subjecting this combined knowledge base to a high level of systematic critical appraisal.

5.1.4. Assessing uncertainty

The expert-led development process of the NAPA and BCCSAP frameworks excluded the important step of assessing uncertainties. Government-led adaptation projects limit their consideration to risk-based frameworks, and are time-bound; tending to report the positive outcomes of a project, while ignoring the uncertainties that appear after a project's implementation. NGO-led projects in Sylhet division assessed uncertainties within their project life and they have taken initiatives to address these. This leads to the recommendation that climate change adaptation projects, both at national and local level, need a robust framework to assess uncertainties within and the end of the projects to produce quality knowledge that can be replicated in other areas at low cost.

5.1.5. Communicating climate knowledge for adaptation

Though Bangladesh adaptation policy emphasises the importance of communication, there remains friction that impedes *vertical* communication within government, from ministries to departments and local government, and *horizontal* communication between government, NGOs and stakeholders. In Sylhet Division, government-led projects tend to limit communication of knowledge within their own agency or tight network of experts, according to their own systems and norms, making this knowledge poorly accessible to other adaptation stakeholders. NGO initiatives, on the other hand, place a special emphasis on knowledge communication to all stakeholders within an affected community, employing a range of creative means of communication. Considering the wealth of climate knowledge siloed within each government agency, this finding leads to recommend building capacity and institutions across these organisations for coordinating the collection and sharing of information, learning from the practices of NGOs. Again, this is an element that could be incorporated in a revised BCCSAP.

5.2. Employing KQA for climate adaptation

Scholars and practitioners alike agree that climate adaptation should be based on the best quality knowledge available. But in countries like Bangladesh that are vulnerable to current variability in the climate, let alone the prospect of future climate change, the urgency to respond means communities have to act on the basis of imperfect knowledge. Without careful attention to how this knowledge is mobilised for decision-making, adaptation initiatives risk giving rise to unintended maladaptive consequences. For instance, this review of Bangladesh demonstrated how a narrow techno-scientific framing of adaptation can lead to significant adverse side-effects, while the careless (mis)use of social science methods to access broader community understandings of adaptation can be equally harmful. This risk is compounded for governance organisations that have poor capacity for producing or using climate knowledge.

This paper demonstrates the importance of a deliberate effort to critically and systematically assess the quality of information used for supporting climate adaptation. Particularly, we demonstrated how the Guidance tool can organise KQA for Bangladeshi adaptation initiatives, and argue for its more widespread use by adaptation organisations in Bangladesh; at the project level, and at the level of national policy. Further, we assert that incorporating the Guidance is in keeping with BCCSAP commitments to adopting cutting edge science and technologies for improving Bangladesh's adaptation strategy.

Looking beyond Bangladesh, we argue that KQA is an important pre-requisite for climate adaptation in other contexts too; in developing or developed countries. This does not imply that information needs to be perfect for it to be useful, but that it should be of a quality fit for the function of steering urgent adaptive action, as measured along multiple dimensions. Such a reflexive pause can help ensure that adaptive action is based on the best quality knowledge available, used in a way that is appropriate and responsible, toward adaptation that is salient, credible and legitimate. Again, we assert that the Guidance can be one important technology for organising this reflexive step.

To what extent is the Guidance, originally developed in a European context, useful or credible for judging quality in the context of Bangladesh, or elsewhere in the world? First, while the Guidance was developed in the Netherlands, it deliberately took a broad and malleable form in highlighting fundamental questions of knowledge quality, which could be shaped accord-

ing to any particular assessment. For more than a decade, it has been applied toward many different environmental issues in different national contexts (Petersen et al., 2013). Secondly, while the Bangladeshi context is undeniably unique, it is also networked into a broader 'globalised' climate science and adaptation community. To this extent, climate adaptation in Bangladesh (and elsewhere in the world) is, while shaped by local conditions, also largely framed by international scholarship and practice, legitimating the use of international tools. The analysis presented in this paper demonstrated that the Guidance is a useful tool for structuring KQA. Climate adaptation can benefit from wider use of such KQA approaches.

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