Building capacity for risk management in a changing climate

A synthesis report from the Raising Risk Awareness project

The University of Melbourne · University of Oxford · Koninklijk Nederlands Meteorologisch Instituut, Ministerie van Infrastructuur en Milieu · Climate Central · Red Cross Red Crescent Climate Centre · Climate & Development Knowledge Network

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Introduction

The Raising Risk Awareness (RRA) project uses the latest advances in climate science to understand the role of climate change in the occurrence of extreme events such as flooding, droughts and heatwaves in developing countries. Having a better understanding of whether and how climate change might affect the likelihood and severity of extreme events in a particular location is important when managing future climate risk. The project analyses the role of climate change in recent droughts in Ethiopia and Kenya, and recent flooding and heatwave events in India. In Bangladesh, the project examines the risk of coastal flooding as a result of sea level rise induced by climate change, using the Surging Seas tool. The project also considers how such information is communicated between those who undertake the analyses (scientists), those who disseminate the information (media and communicators) and those who ultimately incorporate this information in decision-making (policy-makers). More detailed information underpinning this summary can be found on the project websites.[1, 2]

Extreme event attribution: Ethiopia, India and Kenya

Climate change is increasing the severity and frequency of some extreme weather events across the world. The Fifth Assessment Report[3] of the Intergovernmental Panel on Climate Change outlined how extreme weather events, such as heatwaves, droughts and floods, are changing in frequency and intensity in a non-uniform way across the globe.

Recent advances in climate science mean that it is now possible to make quantitative statements about how human-induced climate change is impacting certain types of extreme weather events. This is still an evolving science. New methodologies, approaches and tools are being developed to improve our understanding of the impact of climate change on the likelihood and intensity of an individual extreme weather event. This emerging field of climate science is referred to as **extreme event attribution**.

Scientists use peer-reviewed methods and a combination of observational data and climate models to conduct extreme event attribution analyses. Regional and global climate models are used to simulate worlds with and without climate change. These models allow scientists to isolate the climate change effect. Other methods and evidence employed by the RRA project included statistical modelling of observed data, on-the-ground reports and existing literature on the role of climate change in the occurrence of extreme weather events.

Extreme event attribution enables scientists to understand the likelihood of a location-specific and season-specific type of extreme weather event within the context of historical, current and projected climates. Extreme event attribution can even capture changes in extreme events at the state or city level, or focus on the type of event to which a location is particularly vulnerable. However, the level of confidence in attribution results varies with the region and the size and type of event.

Developing countries are particularly vulnerable to the impacts of extreme weather. Such events are eroding decades of development gains and are devastating communities, livelihoods and infrastructure. The Global Climate Risk Index 2017[4] shows that "of the 10 most affected countries (1996–2015), nine were developing countries in the low income or lower–middle income country groups".

Extreme event attribution analyses conducted to date have focused largely on the global north, i.e. on extreme weather events in developed countries. The RRA project is a pilot attribution project that brings the scientific expertise of World Weather Attribution[5] (WWA) together with the developing country expertise of the Climate and Development Knowledge Network[6] (CDKN) to advance extreme event attribution in developing countries. WWA is led by Climate Central and comprises leading scientific partners from the University of Oxford's Environmental Change Institute (ECI), the Royal Netherlands Meteorological Institute (KNMI), the University of Melbourne, and the Red Cross Red Crescent Climate Centre.

Stakeholders are increasingly demanding information about the role of climate change in individual extreme weather events, as evidenced by a rising number of requests for such information coming from governments, non-governmental organisations and the media in the wake of these events. Extreme event attribution questions are amongst those most commonly asked of the International Federation of Red Cross and Red Crescent Societies and the International Research Institute for Climate and Society help desk during major disasters. In recognition of this demand for information, the RRA project sought to raise awareness of and share extreme event attribution analyses with a range of stakeholders across the science, communication and policy communities in Ethiopia, India and Kenya. In many areas of new science, a major challenge relates to the science–communications–policy gap: the challenge of making scientific outputs understandable and actionable for laypersons and policy-makers. Therefore, an important element of the RRA project was to **understand and help address potential science–communications–policy gaps** associated with extreme event attribution and sea level rise risk that may exist in Bangladesh, Ethiopia, India and Kenya.

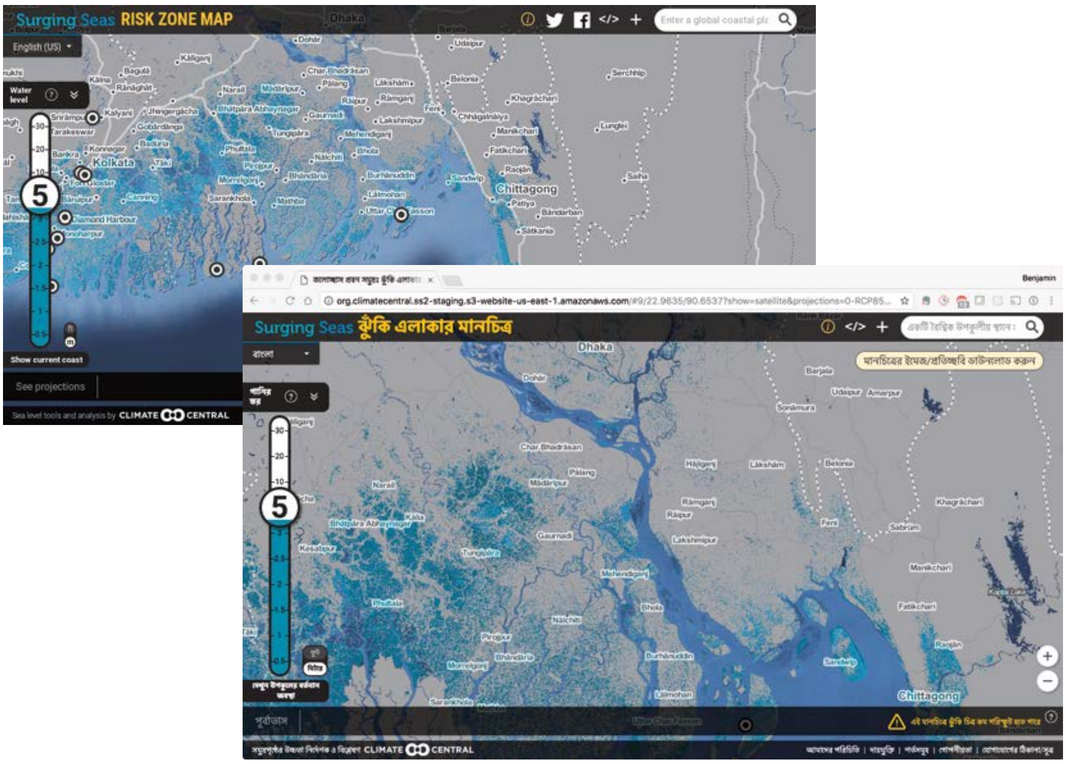
This report provides a summary of the RRA project's results and learning. In summarising both the project's activities and stakeholders' responses, this report may prove useful to scientists, development agencies and civil society-based organisations who wish to build on this foundational work in the future.

Surging Seas tool: Bangladesh

Climate Central has developed the Surging Seas tool[7] to help vulnerable countries and regions improve understanding of their exposure to flooding and rising sea level. The web-based tool comprises the following main components:

- Risk Zone Map, which illustrates local sea level rise and flood risk projections, and shows the likely vulnerable areas
- Risk Finder, which quantifies the vulnerable land area and population, from district to national levels
- Mapping Choices, which visualises the long-term local consequences under different greenhouse gas emissions scenarios.

Bangladesh is one of the countries that are most vulnerable to rising tides. It has mostly flat, low-lying topography, and numerous water bodies and rivers, and over 48% of its population of 163 million people (2016 data)[8] currently lives less than 10 metres above sea level. The RRA project has, therefore, sought to develop and raise awareness and utilisation of the Surging Seas tool in Bangladesh. By providing information relating to future climate risks and the vulnerability and exposure contexts of different areas (in Bengali and English languages), the Surging Seas tool will inform policy planning and disaster risk reduction.



Country summaries

The RRA team developed a range of outputs in various formats in consultation with stakeholders in the pilot countries. These outputs include, but are not limited to:

- extreme event attribution analyses for Ethiopia, India and Kenya
- sea level rise analysis for Bangladesh
- science summaries, which explained the climate modelling results for each extreme weather event in question for technical audiences
- vulnerability and exposure fact sheets, which explained the local vulnerability context and key impacts of the extreme weather events for technical and non-technical audiences
- policy briefs, which were designed to provide policy-makers and communicators with an overview of the scientific findings and key policy recommendations
- infographics and animations, which were designed to explain extreme event attribution to non-technical audiences.

Ethiopia: The drought of 2015

RRA outputs

- Science summary: The drought in Ethiopia, 2015[9]
- Extreme event attribution analysis[10]
- Human impact summary: Extreme drought in Ethiopia stretches drought management systems[11]

Overview

Droughts have plagued Ethiopia for decades and, during the 1970s and 1980s, several droughts resulted in widespread famine. Ethiopian scientists expressed an interest in understanding the role of climate change in the occurrence of specific extreme weather events, such as droughts, but lacked the capacity to undertake such analyses. In response to this, the RRA team engaged Ethiopian scientists in analysis to assess the contribution of

drivers such as climate change and the El Niño Southern Oscillation to the 2015 Ethiopian drought.

Extreme event attribution analysis

The RRA team worked closely with two scientists from the National Meteorology Agency of Ethiopia and Addis Ababa University in undertaking this analysis. The scientists visited ECI at the University of Oxford to gain first-hand experience of using attribution tools and methodologies, participated in the attribution analysis of the 2015 drought and co-authored a journal paper.

Dr Abiy Zegeye of Addis Ababa University shared his experience of the visit to the University of Oxford in 'Sharing knowledge on Ethiopia's extreme weather attribution'.[12] He said the experience was an "excellent entry point and a valuable addition to my own set of skills".

The RRA analysis showed that areas across north and central Ethiopia suffered their worst drought in decades in 2015, a year marked by a strong El Niño. The drought affected nearly 10 million people. RRA scientists found that El Niño exacerbated the drought over the Kiremt, the normal July–September rainy season. A measurable influence of climate change was not detected. However, there was some uncertainty in the final result, such that a small impact of climate change could not be excluded as a possibility.

Ethiopia is one of a number of developing countries already undertaking ambitious climate change action and implementing measures to reduce drought vulnerability, such as the Productive Safety Net Programme that enables the rural poor to increase their long-term resilience to food shortages. The lesser impact of this drought compared with the 1973 and 1984 droughts is a testament to the country's improved resilience to climate shocks and stresses.

The preliminary results from the 2015 drought analysis were presented to a predominantly scientific audience at an RRA workshop in Addis Ababa. This workshop helped to build scientific capacity and attribution science networks. Looking forward, the National Meteorology Agency is well placed to engage with both the press and decision-makers, and therefore will be an important partner for future engagement beyond the science community.

The RRA project equipped two Ethiopian scientists with the knowledge they need to understand, undertake and interpret extreme event attribution. These two individuals have since become extreme event attribution advocates and are exploring ways to share their newly acquired knowledge with other scientists and students at Addis Ababa University. They have also expressed an interest in collaborating with local institutions, such as the Ethiopian Red Cross Society, to take this work forward.

India: Extreme precipitation (2015) and heatwave (2016)

Extreme precipitation event: RRA outputs

- Science summary: The heavy precipitation event in Chennai, India, 1 December 2015[13]
- Extreme event attribution analysis[14]
- Human impact summary: Rapidly growing Chennai submerged by rare extreme rainfall event[15]

Overview

On 1 December 2015, record 24-hour rainfall led to catastrophic flooding in Chennai. The downpour occurred during the rainy season, coinciding with a strong El Niño, record warm global surface temperatures and high Indian Ocean temperatures. No measurable influence of climate change was detected in the extreme one-day rainfall event, possibly due to the masking effects of aerosol pollution. (See 'Aerosols – How they affect atmospheric warming'[16] for an explanation.) Very high levels of aerosol pollution exist over much of India, including the area around Chennai, which counteract the more extreme heat and rainfall events associated with greenhouse gas emissions.

Heatwave event: RRA outputs

- Science summary: Heatwave in Phalodi, India, 19 May 2016[17]
- Extreme event attribution analysis[18]

Overview

Heatwaves in parts of India are becoming more frequent and more intense, although this is not the case for most of the country. On 19 May 2016, the city of Phalodi in Rajasthan set an all-time record of 51°C. RRA scientists used peer-reviewed methods to estimate whether and to what extent climate change is affecting the risk of record heat like the Phalodi event and a similar one-day heat event in Andhra Pradesh in May 2015. The analysis did not find that human-induced climate change played a role in these individual heatwaves. Analysis of the observed temperature records revealed that a climate change impact cannot be found over large parts of the country, including Phalodi, despite that fact that all model simulations show an increase in the risk of record heat events. This discrepancy could result from the fact that climate models do not allow for the high levels of aerosol pollution observed in many parts of South Asia, which can mask the effect of warming on extreme

temperatures, but exacerbate the health impacts of extreme heat. Another possible explanation for the discrepancy between observations and models could be the use of irrigation, which affects local temperatures, but is not represented in climate models.

Extreme event attribution analysis

While there is broad understanding of the impacts of climate change across India, awareness and understanding of extreme event attribution, and how it can be used to manage future climate risk, is limited. India is highly vulnerable to extreme weather events, but it has largely relied on weather forecasting to inform its early warning and preparedness responses.

The RRA team worked closely with local scientists and experts from the India Meteorological Department, Ministry of Earth Sciences, the Department of Science and Technology in the Ministry of Science and Technology, and the Indian Institute of Technology to deliver two attribution studies: the 2015 flood in Chennai and the 2016 heatwave in Phalodi.

The RRA team engaged a range of Indian stakeholders, including scientists, media, communicators and policy-makers, in the analysis of these two past extreme events. Through in-country meetings, the RRA team learned that these stakeholders tend to work in silos and, when they are required to work together, find effective communication between scientific experts and non-experts to be challenging. The facilitation of networking across different stakeholder groups through the co-development workshop and final workshop saw close discussions between scientists, media representatives and policy-makers. In engaging this network, the RRA project not only helped to broker necessary links among experts, but also highlighted the importance of effective communication of extreme event attribution information to catalysing action, influencing policy and ultimately bridging the communications gap between disciplines.

Following the publication of the two attribution studies, a scientist from the Indian Institutes of Technology visited ECI at Oxford to gain first-hand experience of extreme event attribution techniques. These project outputs pave the way for future scientific studies, and the creation of new networks provides a potential communications pathway between scientists and policy.

> ***"What a marvellous opportunity has come across to India to use its data, to use its scientists, and to use the case studies that have come out, to be at the forefront of attribution science. Some of the first few studies were on the heatwave in India and on the floods in Chennai, and that's very exciting. These two studies will set the trend."***
>
> Mihir Bhatt, CDKN Country Engagement Leader for India

Kenya: The drought of 2016–2017

RRA outputs

- Science summary: The drought in Kenya, 2016–2017[19]
- Extreme event attribution analysis[20]

Overview

Kenya is currently experiencing a prolonged drought and, in February 2017, the country's President declared it to be a national disaster. The RRA team worked closely with scientists from the Kenya Meteorological Department to investigate the role of climate change in the ongoing drought. Through this collaboration, the Kenyan scientists developed their understanding of extreme event attribution. The decision to focus on an ongoing extreme weather event resulted in good engagement from a number of Kenyan stakeholders.

Extreme event attribution analysis

Kenyan scientists participated in the analysis, co-authored a journal paper and co-presented the analysis to senior Kenyan stakeholders at a policy briefing event hosted by Kenya Red Cross in Nairobi on 23 March 2017. The analysis showed that areas with the lowest rainfall were located in the northwest and southeast of the country. Trends indicated that the higher than usual temperatures could be the result of human-induced climate change, but that climate change did not have a strong influence on the lack of rainfall. This close engagement between RRA and Kenyan scientists, and the delivery of the results by trusted local scientists and climate experts, were received positively by the Kenyan Government.

The extreme event attribution analysis was also reported by local and international media, including Kenya Red Cross[21] and Climate Home.[22]

> "***Study released on Thursday shows a 2016 drought was made worse by climate change – but with March rains predicted to fail, the Met Office has warned of worse to come.***"
>
> "***Analysis released on Thursday by the World Weather Attribution (WWA) network – which searches for human fingerprints on individual weather events – found the drought of the past year had been exacerbated by human-induced climate change.***"
>
> "***Scientists found that the lack of rainfall was not linked to warming, but higher temperatures experienced in parts of the country that were hardest hit by drought had been made worse by climate change.***"
>
> Hadra Ahmed, Climate Home, 23 March 2017


MTUKUFU ILA
MOYO WANGU

The RRA project raised awareness of extreme event attribution with scientists, the media and policy-makers in Kenya predominantly through three events held in Nairobi. These were a co-development workshop that introduced the project to Kenyan stakeholders; a learning event that brought together international stakeholders; and a policy briefing event aimed at Kenyan policy-makers. The co-development workshop included both Kenyan and Ethiopian stakeholders. This provided an important foundation for initial engagement and was used to assess the needs and demands of Kenyan stakeholders. Learnings from this workshop and a similar co-development workshop held in India were used to develop multiple communications products, including infographics[23] and an animation[24], to raise awareness of extreme event attribution among different stakeholders.

"This is a great initiative to make decisions in the future on issues relating to hazards and improve governments, communicators and development agencies."

"Why is it important? It ensures that the information reaches the right audiences with correct language."

Anonymous feedback, Nairobi co-development workshop

The final workshop held in Nairobi at the end of March 2017 was an important milestone for the project. It provided an opportunity for key RRA stakeholders from Ethiopia, India, Kenya and elsewhere to share their learning and discuss next steps for extreme event attribution. The event helped to build a global extreme event attribution network. Moreover, three Kenyan scientists from the Kenya Meteorological Department and the University of Nairobi visited ECI at Oxford following the 23 March 2017 policy briefing to apply attribution techniques first hand and to consolidate and continue to build their attribution capacity.

"I truly gained greatly from [the Oxford team's] experience with regard to extreme event attribution... I am now able to understand what the science of attribution is and explain it with confidence."

"Dr Sarah Sparrow and Dr Friederike Otto took us through the tools and scripts required in undertaking attribution analysis. What remains is for us to internalise these tools and apply them for our region."

"The meeting in Oxford gave us an opportunity to develop networks with the scientists working at ECI."

Dr Christopher Oludhe, Senior Lecturer, University of Nairobi, Kenya

As a result of the RRA project, Kenyan scientists, communicators and senior government officials have engaged with each other on extreme event attribution. The development of understanding of the science and building of attribution networks in Kenya represents tangible progress since the start of the project.

Bangladesh: Flood disaster risk management

While rising tides are a threat to all coastal countries, Bangladesh is one of the most vulnerable, since it has predominantly flat, low-lying topography, and numerous water bodies and rivers, and over 48% of the population currently lives less than 10 metres above sea level. In order for disaster risk reduction plans to be effective in the long term, such plans need to take into account not just the current risks posed by natural hazards, but also how those risks will evolve with a changing climate. According to CDKN's country advisor for Bangladesh, Dr Munjurul Hannan Khan, the Surging Seas tool would add value to the existing work being done in Bangladesh regarding disaster risk reduction. "The Government of Bangladesh has taken a number of initiatives for fighting adverse impacts of the changing climate," underscores Dr Khan, "making synergies with the existing knowledge and projections from the toolkits is very useful for formulating better policies regarding climate change and disaster management issues."

The RRA project engaged in the following activities to develop and raise awareness of the Surging Seas tool with stakeholders in Bangladesh. These stakeholders included experts in sea level rise, flooding and disaster management, together with climate scientists and policy officials.

- The Surging Seas tool[25] was adapted for Bangladesh, which included translating elements of the tool into Bengali to make it more accessible. The project also developed a technique to improve the accuracy of coastal elevation modelling in Bangladesh and other data-poor regions, which will be integrated into the tool and related analyses once published in the peer-reviewed scientific literature.

- A workshop held in Dhaka brought together a wide range of local stakeholders as well as the team behind the Surging Seas tool, who led the workshop and trained the attendees. The meeting provided an opportunity to share learning and knowledge, strengthen local capacity to use the toolkit, and identify priority areas of interest for future development of the tool.

- An exposure report complements results from the Surging Seas tool, estimating land and population at risk of inundation under best- and worst-case greenhouse gas emissions scenarios due to sea level rise alone, and sea level rise integrated with chronic flooding, for the years 2050 and 2100.

Throughout the project, links have been forged among the Climate Central team and local Bangladeshi experts in sea level rise, floods and disaster management, such as those at the Institute of Water Modelling. Climate Central is now looking into additional partnership opportunities and will continue to tailor the tool to the Bangladesh context. By collaborating with in-country counterparts, the organisation aims to incorporate expertise from Bangladeshi scientists and practitioners, and ensure the tool is complementary to local disaster risk reduction efforts.

The quality and granularity of data is a challenge that will need to be addressed before the tool can be fully taken up by policy-makers. Some coastal scientists in Bangladesh have access to high-quality, non-public elevation and levee data. The architecture of the Surging Seas tool is designed to allow inclusion of improved data over time. The next step for gaining confidence and use by policy-makers is to acquire and implement better local data. The partnerships begun through RRA have laid good foundations to help overcome this challenge.

Key achievements and findings

Extreme event attribution understanding and capacity varied across the project's four pilot countries. Through a series of workshops and meetings with key stakeholders from the scientific, communications and policy communities, the RRA team obtained insights into stakeholders' familiarity with and understanding of extreme event attribution, and identified how the project could develop and build their capacity. While conditions varied in each country, several important overarching achievements and findings emerged through the delivery of the project. These are outlined below and will inform future efforts.

Why extreme event attribution is important for managing climate risk

The RRA project sought to improve understanding on whether and how climate change is affecting the likelihood and severity of extreme weather events in Bangladesh, Ethiopia, India and Kenya, to inform efforts for managing future climate risk. A lack of robust information on and awareness of how climate change may be affecting the likelihood and magnitude of extreme weather events can lead to poor decision-making. Decisions based on inaccurate climate information can lead to reconstruction of community infrastructure that is not resilient to future extreme weather events. Conversely, those who point to climate change as the cause of an extreme weather event without relying on an objective scientific analysis may overplay the connection. In doing so, they risk undermining the debate on climate change, misguiding investment in reconstruction (i.e. maladaptation) and failing to identify the non-climate factors (e.g. vulnerability and exposure) that may have contributed to the scale and nature of the impact of the event.

Extreme event attribution is a new and rapidly growing method within a suite of tools available to help the world prepare for and adapt to the impacts of climate change. The RRA project focused on bringing extreme event attribution into the policy space, with the recognition that it complements other important tools and information, such as forecasting, long-term projections and agro-services. But just as extreme event attribution is an emerging science, so, too, is our understanding of for whom such information would be useful, how it adds value and how to integrate this information into decision-making.

Extreme event attribution can provide a compelling argument for governments in international climate negotiations to secure greater and faster action to curb greenhouse gas emissions, and to secure support for building resilience. Extreme event attribution assesses the changing nature of climate risk, information that is highly pertinent to policy-makers and the insurance industry. The RRA project has commissioned research to identify the end users of attribution information. This research is mapping the existing users of attribution information and will investigate how attribution outputs could be used by decision-makers in the future. The findings could be used to tailor and target future communications about extreme weather event attribution, and, therefore, could provide important information for future phases of the RRA project.

Policy-making remains an important objective for the application of extreme event attribution. Immediately after an extreme weather event, there is a window of opportunity during which decision-makers are more likely to understand the value of extreme event attribution, have opportunities to act on the information in recovery and rebuilding planning, and elevate climate risk as a policy priority.

Experience suggests that extreme event attribution analysis and supporting information, such as factors driving vulnerability and exposure, should be integrated into longer-term policy design and delivery processes to ensure the development of policy that is resilient to the future climate. The design and implementation of such policies often takes place after disaster relief and rescue efforts have been delivered following an extreme event. However, there may be instances when these two processes run in parallel, as a number of decisions are taken at the point at which the extreme event is taking place or immediately after, which may have longer-term implications for the future resilience of a country, region or community. All stakeholders should be involved throughout the policy design and delivery process. This includes the scientists who have undertaken extreme event attribution, organisations and institutions, such national meteorological agencies that play a role in sharing this information with policy-makers, and those responsible for implementing the policies.

The policy-making process varies from country to country, and is very context-specific. In Ethiopia, policy-making is highly centralised. In India, individual states have a greater degree of autonomy, and policy design and delivery takes place at the sub-national level. In Kenya, there are two levels of government: national and county. The national government is mandated to formulate climate change policy, while various functions are assigned to the county governments to fulfil actions required to address climate change. It is, therefore, important to tailor extreme event attribution analysis and supporting information to the policy process it is trying to influence. For example, more granular information would be required in India to inform sub-national policy planning.

Understanding and applying extreme event attribution results

An individual extreme event attribution analysis will have four possible results; that anthropogenic climate change has: i) made an event more likely; ii) made an event less likely; iii) had no impact on the likelihood of an event; or iv) with current understanding and available data it is not possible to determine what impact climate change had on the event in question.

Communicating the case when climate change has **not** played a role in the occurrence and severity of an extreme event (i.e., none or only a very weak anthropogenic climate change signal detected) is equally as important as communicating an event in which anthropogenic climate change **has** played a role (i.e., climate signal detected). Firstly, it suggests that other vulnerability and exposure factors may have contributed to the scale and nature of the impacts felt. Secondly, communicating when a climate change signal has not been detected (as well as when it has) demonstrates integrity and builds the credibility of the scientific community and its attribution analyses.

When relaying whether or not an anthropogenic climate change signal has been detected, it should be made clear that the result applies only to the particular extreme weather event under analysis. This will avoid unfounded generalisations. For example, when an extreme event attribution analysis finds that an event has become more frequent due to anthropogenic climate change, it cannot be inferred that the same event in other locations is also being made more frequent by climate change, or that all future extreme weather events in the location in question will become more frequent due to climate change. Similarly, in instances when no signal is detected, it is important to provide detailed information on why the signal was not detected (perhaps factors counteracting a signal, such as aerosols, could have played a role) and whether other factors may have been important. In all cases, it is important to consider and provide information on the broader climate trends and vulnerability of the region to extreme weather events.

As a case in point, while no measurable climate change signal was detected in the flooding in Chennai in 2015 (possibly due to the masking effects of aerosols), this extreme rainfall occurrence was a one-in-600- to one-in-2500-year event that would have overwhelmed flood prevention measures in any city. Further investigation into the factors that led to the scale of such devastation has concluded that the impact of the extreme rainfall event was exacerbated by a lack of timely desilting, inadequate flood zone planning and large-scale settlements in low-lying areas in the mega coastal city of 8.2 million people.

The RRA project has made an important contribution to the evidence base around extreme event attribution in Ethiopia, India and Kenya, which was limited prior to the project. Documenting methodologies and sharing best practices will improve the foundation of attribution analyses in the future. For example, defining the extreme weather event is one of the most important and difficult parts of an attribution analysis. Event definition requires decisions to be made about the area and duration, as well as relevant event variables, such as temperature, rainfall etc. These decisions can significantly alter the results. Event definition should be relevant to those who will use the results. For example, if the attribution analysis of a heatwave event will be used to reduce the number of people affected by future heatwaves, it is best to define the event so that it captures the correct time period and defines the area that had the maximum heatwave-related mortality.

Researchers from Columbia University have examined how public health influences the vulnerability and exposure of populations to heatwave events (based on information from Bangladesh).[26] This research provided a knowledge base that can be used to inform heatwave-related disaster risk reduction policies.

'Rapid attribution'[27] is where an extreme event attribution analysis is conducted during, or in the days and weeks immediately following, an event. Further standardisation and optimisation of attribution methodologies, but most importantly increasing the number of scientists working in the area, will make rapid attribution more feasible. Rapid attribution can catalyse policy action, since in the immediate aftermath of an extreme event, policy-makers may be granted licence to pursue climate resilient policies and investments if climate change is shown to have been a contributing factor. However, rapid attribution analysis and communication of the results of the attribution to policy-makers is currently challenging in both developed and developing countries. While attribution methods exist, a larger network of scientists is required to react and provide such analyses in a timely manner, and this critical mass does not yet exist in developing countries.

How to communicate extreme event attribution effectively

To raise awareness, encourage behavioural change and/or promote action, communication needs to be tailored to the target audience. Practical Action Consulting was commissioned to investigate the most effective methods, phrases and tools to communicate climate change extreme event attribution information, considering comprehension, ease of understanding and willingness to take action by a range of different actors. (See their report: Communicating extreme weather event attribution – Research from India and Kenya.[28])

A few observations from the research:

- Preferences differed between and within stakeholder groups (media, public and policy-makers) and between countries with regard to how to effectively communicate the probability, frequency, intensity and uncertainty of extreme event attribution. For example, decision-makers and the media in Kenya showed a preference for the use of percentages to describe probability, but the public tended to be confused by this concept.

- There was a range of responses from stakeholders relating to their understanding of 'frequency'. In India, the statement 'frequency… twice in a lifetime' was considered by the public as the easiest to understand. However, understanding 'frequency' was generally challenging in India due partly to difficulty in translating this term into Hindi. It is recommended that probability information presented using the term 'chance' may be preferable for this stakeholder group. In Kenya, high-level decision-makers and media participants preferred to use the phrase 'twice as often', while the public exhibited some confusion. Simplifying the message to 'drought occurs more often because of climate change' was suggested. The use of 'lifetime' was heavily criticised by stakeholders in Kenya because a lifetime varies between people, with poorer people having a much shorter lifespan.

- Research found that graphical depictions are a useful presentation tool for web-based displays, and can be accompanied by explanatory information to help users interpret complex information such as uncertainty. Similarly, icons can be useful for a quick pictorial image on television or web pages. Intended audiences should be consulted on the development of such graphics and icons to ensure they can be interpreted easily, they are appropriate to the situation, and the language and colours are suitable for the local context.

Several RRA outputs have been translated into local languages, including Amharic, Bengali and Hindi, to secure maximum outreach. However, care should be exercised when translating scientific information. Translations should involve input from local native speakers and experts, as often there is no direct translation for specific scientific and technical terms, and it is important to identify the terms and phrases that are understood within the local context. Only one extreme event attribution native scientist was available for the RRA project (Professor Krishna AchutaRao from the Indian Institutes of Technology). This meant that there was some difficulty in validating translations, and care needed to be exercised when translating outputs in all pilot countries where no native speakers were included in the project team. The RRA project showed that it can often take a number of iterations to ensure that a translation is accurate and resonates with its audience.

Extreme event attribution results have the potential to inform a wide variety of people through spokespersons from multiple disciplines communicating to different audiences. The person delivering the extreme event attribution result often dictates whether it is received as legitimate, and can then convey its credibility through the support of other scientists involved in the RRA project (see box). Local communicators also bring salience by tailoring their communication of extreme event attribution results and associated recommendations to ensure relevance to a particular stakeholder. For example, a national meteorological service may be best positioned to communicate extreme event attribution findings to government officials with whom they have already established a strong relationship.

Legitimacy refers to whether an actor perceives the process in a system as unbiased and meeting standards of political and procedural fairness.

Credibility refers to whether an actor perceives information as meeting standards of scientific plausibility and technical adequacy.

Salience refers to the relevance of information for an actor's decision choices, or for the choices that affect a given stakeholder.

Source: Cash et al. (2002)[29]

In many areas of new science, the science–communications–policy gap presents a major challenge. This relates to the difficulty of making scientific outputs understandable and actionable for laypersons and policy-makers. It is, therefore, important to connect communicators with attribution stakeholders in-country before attribution analyses are publicised and, equally importantly if the communicators are not the scientists, to connect communicators directly with scientists and allow enough time and space for a true understanding of the science and barriers to be developed. Policy impact is something the RRA project may achieve over timeframes beyond the pilot phase. However, the important first step was taken and policy-makers were involved in the conversation and exposed to attribution analyses, providing groundwork for future engagement.

It is important to involve communicators from the beginning of any scientific analysis, to avoid a situation where scientists are working independently of the individuals who will use and share the analysis. Tension may arise when ensuring the science is represented accurately with the appropriate caveats, while also making sure it is meaningful to end users. Confidence intervals, uncertainty and return times communicated only in scientific terms can become meaningless for end users. Therefore, by working together, scientists and communicators can help to strike a balance between scientific precision and effective messaging.

Vulnerability and exposure analyses bring a human element to extreme event attribution, and have proven to be a particularly effective approach for those stakeholders wishing to engage the media, decision-makers and the public in extreme event attribution. This approach quickly gets to the heart of why extreme event attribution is relevant and useful, and engages the target audience.

Media and journalists play a vital role in sharing climate information with the public. Extreme weather events grab headlines and journalists are particularly interested in rapid extreme event attribution analyses to inform their stories during and in the immediate aftermath of a disaster. Extreme event attribution analyses can sometimes be difficult to interpret for non-technical readers. Therefore, providing journalists with a series of clear statements articulating the findings of the extreme event attribution analyses conducted and signposting when (dates and times) such information will be made available to them can increase the likelihood that the analyses will be picked up swiftly by news outlets, communicated accurately, and reach a wide, global audience. In addition, this process allows for two-way communication between journalists and scientists, which improves understanding and fosters trust.

Analysis on how mainstream media are making links between extreme weather events and climate change found that the connection between climate and extreme weather is often missing in media coverage. However, it also found that attribution information can serve as an effective tool to ensure inclusion of climate change information in extreme weather event reporting.

Discussions with Indian stakeholders highlighted that the interests of policy officials are driven largely by media reports. In India, the issues reported by the media quickly gain the attention of politicians and policy-makers. Therefore, engagement of policy officials in extreme event attribution relied on the involvement of the media. In light of this, the RRA team established connections with Indian journalists and their networks, such as the Third Pole.[30] The project also invited scientists, journalists and policy-makers to the two workshops in India. In addition to connecting scientists with journalists, this placed extreme event attribution on the radar of policy officials. In Kenya and Ethiopia, government institutions, such as the Kenya Meteorological Department and the National Meteorology Agency of Ethiopia, were able to use their connections with scientists and the media, and those among scientists and policy-makers. These pre-existing networks provided initial pathways for attribution communication.

Communicators are increasingly reaching their audiences through a range of different platforms, such as Twitter and other social media. For example, For example, BBC Media Action used Facebook to engage the public in Bangladesh on the risks from heatwaves. BBC Media Action's work was intended to raise awareness of heatwave impacts now and in the future, and was used to start important conversations about how to prepare for and respond to heatwaves.

Twitter analysis was carried out to assess the frequency and nature of tweets relating to the 2016–2017 East African drought. This research provided lessons on how to tailor communications about extreme weather events more effectively in the future. There is also an opportunity for this work to feed into broader social media campaigns to support disaster risk reduction. For example, social media have been used to communicate weather warnings,[31] track disaster events as they unfold,[32] track disaster victims,[33] and as a disaster relief tool.[34]

Building extreme event attribution capacity

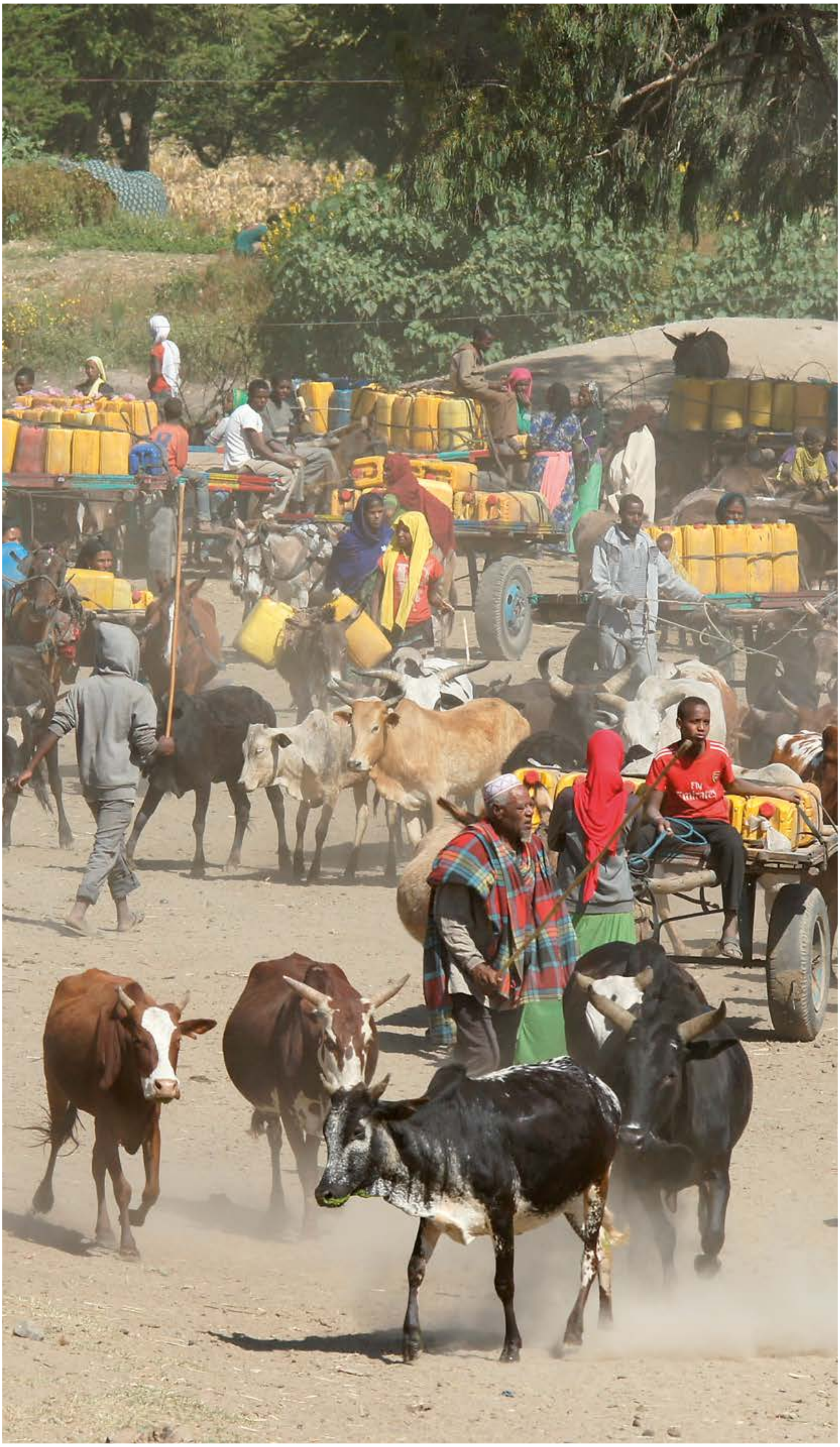
Prior to the RRA project, most stakeholders in the pilot countries – including scientists, communicators and policy-makers – had little or no understanding of extreme weather attribution analysis. The RRA project sought to build capacity for extreme event attribution across its pilot countries. Building such capacity is important for a number of reasons.

- Stakeholders are more likely to engage with and respond to extreme event attribution analyses when they are undertaken and communicated by local and trusted scientific experts and institutions, as opposed to non-native experts.

- Local scientists and institutions provide important contextual information, expertise and access to data, and add legitimacy to extreme event attribution results. Local climate communicators – those sharing attribution and broader climate information with decision-makers – who are already known and trusted by policy-makers also play an important communication role.

Building strong relationships with local scientists was critical to achieving the aims of the RRA project. Such relationships were built through workshops, events, and face-to-face meetings in each country. New relationships were formed in all the pilot countries, and the process was particularly successful in India due to an existing connection with a climate scientist at the Indian Institutes of Technology, which facilitated access to a broader network of Indian scientists, communicators and policy-makers. The scientific analyses also progressed more rapidly in India than in Ethiopia and Kenya. Partnerships between RRA and local scientists now exist in Ethiopia and Kenya as a result of the RRA project and will be important when taking forward extreme event attribution in the future.

Science exchanges took place at ECI at Oxford, where developed country attribution experts shared their skills, knowledge, tools and experience with six scientists from Ethiopia, India and Kenya. These exchanges were used to establish relationships and build capacity.



Conclusion

The RRA project sought to improve understanding of whether and how climate change is affecting the likelihood and severity of extreme weather events in Bangladesh, Ethiopia, India and Kenya. The aim was to inform efforts to manage future climate risk. The project focused on delivering the following outcomes:

- assessing whether climate change played a role in the likelihood and strength of specific extreme events in Ethiopia, India and Kenya
- understanding the risk of coastal flooding in Bangladesh as a result of human-induced climate change to inform disaster risk management and resilience efforts
- building the scientific capacity of individuals and institutions to undertake, interpret and use extreme event attribution analysis
- raising awareness of extreme event attribution and the changing nature of climate risk with a range of stakeholders, including communicators and policy-makers
- understanding how to communicate extreme event attribution and climate risk effectively among different stakeholders
- identifying how extreme event attribution analysis can be used and by whom to inform the design and delivery of policies designed to build resilience to future climate risks.

The RRA project has made progress against these outcomes. At the outset, there was limited capacity for extreme event attribution analysis in Ethiopia, India and Kenya. Scientists in these countries have now been introduced to techniques for conducting extreme event attribution; communications experts have been engaged on how to use extreme event attribution information to raise awareness of climate risk; and policy officials have been exposed to the potential use of this information in decision-making. The level of engagement with these stakeholders varied significantly across Ethiopia, India and Kenya. For instance, in Ethiopia the project focused on enhancing local scientific capacity, while in Kenya and India there was a good level of engagement with scientists, communications experts and policy officials. In Bangladesh, experts in sea level rise, flood and disaster management, and climate scientists and policy officials were engaged to build climate resilience through the Surging Seas tool, which incorporated Bangladesh-specific data.

While the project has taken steps towards achieving its ultimate aim, Ethiopia, India and Kenya are currently not at a stage where extreme event attribution analysis is readily available and integrated into decision-making. Greater in-country extreme event attribution capacity is required for these countries to conduct their own independent analyses. This would necessitate training additional scientists in extreme event attribution techniques and developing robust methodologies and practices. Additionally, further work is needed to identify and understand the needs of policy-makers and other end-users of extreme event attribution information. Similarly, access to quality local data is required to improve the accuracy and uptake of the Surging Seas tool in Bangladesh.

This synthesis report highlights the achievements of the RRA project and shares the emerging lessons on how to effectively build extreme event attribution capacity, awareness and use in developing countries. It is hoped the findings of this report will be useful in informing future efforts in this area.

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