



Integrating science into humanitarian and development planning and practice to enhance community resilience

Full guidelines

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Cover photo: Dr Megan French of University College London (UCL) collects samples for water quality analysis in the Bolivian Altiplano with Efrain Blanco Coariti of the Instituto de Investigaciones Químicas, Universidad Mayor de San Andres, Bolivia, a local partner of the Catholic Agency for Overseas Development (CAFOD). The research is coordinated by the UCL-CAFOD partnership. Source: M. French, February 2013.

Purpose of the guidelines

These guidelines are for humanitarian and development practitioners looking to effectively integrate relevant scientific understandings of risk within their humanitarian/development planning and practice, for the purpose of enhancing community resilience. Beginning with an introduction to what science is and how it might be used, followed by a breakdown of the key components for integrating science these guidelines encourage practitioners to think about the types of scientific information and expertise that they may need, how to access and use them, and how to ensure that they are applied in an ethical and accountable manner. Each section concludes with a checklist of key questions practitioners should consider throughout the process.

These guidelines are not exhaustive or prescriptive instead the aim is to enable practitioners to ask useful questions that will ultimately help them to apply science in their planning and operational decision-making. While the authors acknowledge that invaluable knowledge resides in communities at risk, the draft guidelines are about how to utilise scientific and technical expertise from external institutions.

The intended audience is those practitioners looking to integrate science information at any stage of the project cycle. Discussed are the wider scale application of science and some of the organisational challenges in fostering partnerships with scientists, thus this document is also of interest for management and across different departments within an organisation.

The objectives of the guidelines are as follows:

- to describe what science is and how it can be applied to humanitarian and development planning and practice in order to build resilience;
- to provide some initial guidance to NGO practitioners upon how they can access and use science;
- to demonstrate that engagement with scientists is through multi-stakeholder co-production of knowledge;
- to emphasise the need for ethical, credible and mutually beneficial engagement with science and scientists;
- to emphasise the need to monitor and evaluate the impact of integrating science;
- to highlight how to overcome the common pitfalls NGOs face when integrating science into their activities and how to overcome them.

The internalisation of science within NGOs is important; thus it is the recommendation of the authors that to complement the guidelines, NGOs need to incorporate scientific training within the professional development of relevant staff.

The authors acknowledge that a paired document for scientists to better understand how practitioners can receive, understand and influence scientific research is also required.

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Executive summary

There has been an increased emphasis upon the application of science for humanitarian and development planning, decision-making and practice; particularly in the context of understanding, assessing and anticipating risk (e.g. HERR, 2011). However, there remains very little guidance for practitioners on how to integrate sciences they may have had little contact with in the past (e.g. climate). This has led to confusion as to which ‘science’ might be of use and how it would be best utilised. Furthermore, since this integration has stemmed from a need to be more predictive, agencies are struggling with the problems associated with uncertainty and probability.

Whilst a range of expertise is required to build resilience, these guidelines focus solely upon the relevant information, knowledge and perspective which *scientists* can provide, that typically lie outside of current humanitarian and development NGO approaches. However, the process of building resilience involves the communication and co-production of knowledge across a number of stakeholders, including the community knowledge of the risks they face. The process of integration of science should, therefore, be mutually beneficial to all stakeholders.

Integrating science requires an **iterative process of engagement** through the continual revisiting of the components of five activities:

1. Defining the problem to be addressed:

Do you (the practitioner) know what sort of information you require?

Begin by identifying and defining the problem to be addressed. This will help establish an aim and set of objectives to determine what sort of information is necessary and, thus, know what questions to ask of scientists. Knowing what questions to ask is a key enabler in obtaining access to scientists: **it is easier to build a dialogue around an initial set of questions, rather than a vague concept.** Having a clear aim and a set of objectives will also help in monitoring and evaluating the success or failure of the integration of science.

2. Accessing the scientific information, knowledge and expertise:

Do you know where and how to access scientific information?

Science can be accessed both through **open-sources** and directly with **scientists. A particularly effective mechanism of engagement is through partnerships with scientific organisations.** Engagement with local scientists helps to ensure sustainability of this knowledge exchange and the process of integration should aim to be inclusive of all relevant stakeholders and experts. Partnerships take time, commitment and resources to build and they may take time to deliver benefit. However, by **proactively** setting up a partnership that involves **good communication** with scientists, a relationship will exist in advance of immediate needs and, as such, scientists are more likely to be available in the event of a demand for information under short time constraints.

3. Understanding the science and assessing its credibility:

Do you, your partners and the communities you work

Practitioners and other users of science need skills to determine the **credibility and uncertainty** of the science they are using and whether

with understand the science?

or not it is fit for purpose. There are basic measures that can be adopted to ensure the scientific information is **trustworthy and representative of the real world**. Seeking out more than one source of information and appreciating scientific debate are just some of the ways in which the quality and relevance of scientific information can be verified.

4. Applying scientific information and methods:

Do you know how to apply scientific information and methods in an ethical and accountable manner?

Whilst scientists and NGOs are both bound by ethical/accountability frameworks alike, it is important to have an agreed set of values prior to meeting with a community. **Accountability mechanisms should be put in place to protect scientists, NGOs and communities.**

5. Measuring the impact of the science integration:

Do you know how to measure the impact of science integration within your project?

The impact of integrating science can be measured in order to determine whether there has been a positive (or negative) change to a vulnerable communities' situation. This can be achieved throughout the programme cycle but requires the **monitoring of science integration within the project or programme framework from the start.**

Key considerations when integrating and using science:

Managing expectations:

Being aware of the limits of science and scientists will help to facilitate partnerships with scientists, who should also be aware of the expectations of communities, and the constraints upon them that may affect their ability to participate.

Knowing the suitable entry point:

Ideally science (just as with any other relevant knowledge) should be used to inform the analysis for and design of any implementation activity. However there may be instances where it is more appropriate to introduce different types of science later in the project cycle.

Science integration should be a positive and beneficial process for all parties involved:

Using science should not be burdensome if the process of engagement is well managed and a proactive approach to accessing the science is adopted. Practitioners should not be put off by uncertainty as all decisions are based on a degree of uncertainty, which should stimulate debate that leads to improved decision making.

Communities are interested in and can understand science:

If well communicated, communities can deal with a number of scientific concepts and uncertainty and make well informed decisions based on this and their own knowledge and understanding. They can also inform the science and participate in scientific research.

In conclusion being able to evaluate the *credibility* of the information and *co-produce the knowledge to inform decision-making and action* through *partnerships with scientists* and *good communication and understanding* of the science will improve projects and build an evidence base to *inform future research strategies and influence donor funding* for this type of work.

Definitions

Community: a group of people living in the same area or close to the same risks and/or with common interests, values, activities and structures. Communities are, however, complex and not always united. They have socio-economic differentiations, linkages and dynamics that contribute to vulnerability. Communities do not exist in isolation – a level of a community’s resilience is also influenced by capacities outside the community¹. For the purposes of this document, we use the term ‘community’ to refer to ‘community at risk’.

Integrated science: the incorporation of all the relevant, available and credible sources of natural and social scientific information and knowledge deemed essential for solving a humanitarian/development problem and thereby contributing to increased resilience.

Resilience: the capacity of an individual, household, population group or system to anticipate, absorb and recover from shocks and stresses without compromising long term prospects. Resilience is not a fixed end state, but is a dynamic set of conditions and processes².

Science: pursuit and application of knowledge and understanding of the natural and social world following a systematic methodology based on evidence³.

Scientist: a person who works in the advancement of science, either natural or social, typically working within a specific scientific discipline. In the context of this document, a scientist is seen as someone with knowledge and expertise that have potential application to resilience building.

Practitioner: a person who applies their expert knowledge to a certain profession, in these guidelines this refers primarily to the development and humanitarian sector.



Most of the fundamental ideas of science are essentially simple, and may, as a rule, be expressed in a language comprehensible to everyone – Professor Albert Einstein



¹ Modified from Twigg, J. 2007. *Characteristics of a disaster resilient community: A guidance note*. DFID Disaster Risk

² Modified from Turnball et al., 2013. *Towards Resilience*. Emergency Capacity Building Project.

³ Science Council, 2013. *What is science?* Available online: <http://www.sciencecouncil.org/definition>

Introduction: What is science and why is it useful?

Science is the ‘**pursuit of knowledge and understanding of the natural and social world following a systematic methodology based on evidence**’⁴. Natural science is comprised of those branches of science that attempt to understand the rules that govern the natural world, typically through quantitative scientific methods, whilst social science is the study of people and society and typically adopts qualitative as well as quantitative approaches to data collection and analysis (see section 3 for an explanation of qualitative and quantitative data). Through scientific research, theories and models are constantly refined so that they become closer to reality. However, it is important to remember that these will never fully represent the real world and that there will always be uncertainty.

In terms of building resilience ‘science’ and ‘technology’ are very much complementary, but they are not the same; technology (along with engineering) refers more to the application of scientific knowledge⁵.

Science is often used indiscriminately to refer to data, information, knowledge, expertise and research. **Data** are the observations made (raw facts) that are of little usable value, until the actor inserts meaning⁶ and refines the data into **information**, which is ultimately transformed (through individual experience and values) into **knowledge**, by trading and evaluating information through dialogue⁷.

The aspiration of science integration should be the co-production and co-application of knowledge for the purposes of building resilience:

‘Seeing information and knowledge as components of adaptive capacity would encourage actors to put more emphasis on giving people a wider range of information, appropriate to a much wider range of circumstances and future scenarios; giving people the tools to find information for themselves; and turning information into knowledge by supporting people’s ability to use the information for decision-making.’ (Levine et al., 2011: viii).

In order to be useful scientific information must be based upon rigorous **methodologies and research principles**, so as to ensure the credible collection and robust analysis and reporting of data. These principles include making sound observations and conducting experiments, so that one researcher could replicate the experiment and findings of another. Furthermore, scientists continually challenge and ask questions of existing theories in order to improve and progress scientific understanding.

In terms of humanitarian and development planning and practice and decision-making, scientific information and methods can help inform decision-making in many ways:

⁴ Science Council, 2013. What is science? Available online: <http://www.sciencecouncil.org/definition>

⁵ Conway, G. and Waage, J., 2010. Science and Innovation for Development. UK Collaborative on Development Sciences.

⁶ Davenport, T. H. and Prusak, L., 1998. Working Knowledge. Harvard Business School Press, Boston, Massachusetts.

⁷ International Federation of Red Cross and Red Crescent Societies (IFRC), 2005. World Disaster Report, 2005. Focus on information in disasters.

- scientists use theories and techniques for modelling (creating visual representation of situations or scenarios) and extrapolation (making conclusions when there no data);
- models can be used to build scenarios and make predictions in order to anticipate risk, as well as explain environmental change and human behaviour, within varying degrees of certainty;
- science can be used to support or validate other sources of knowledge (e.g. local knowledge) and the two can inform each other;
- scientific information and understanding can help to interpret processes at many scales, from local level flooding to global climate change that may affect communities;
- the scientific approach encompasses a set of methods that can help to ensure the credible and accountable collection, analysis and reporting of data, as well as rigorous methods with which to tackle a problem (e.g. hypothesis testing).

In terms of project cycle management (PCM)⁸, scientific information and knowledge can be of great assistance during the analysis phase, helping to shape the project design and intervention strategy. In the long-run, this will save time, resources and reduce the possibility of oversights. Where possible, science should therefore be included from the outset of the PCM process with engagement continuing throughout the duration of the project. The impact of science integration should, therefore, be continuously monitored and reviewed throughout the project or programme, with methods for monitoring established from the outset.

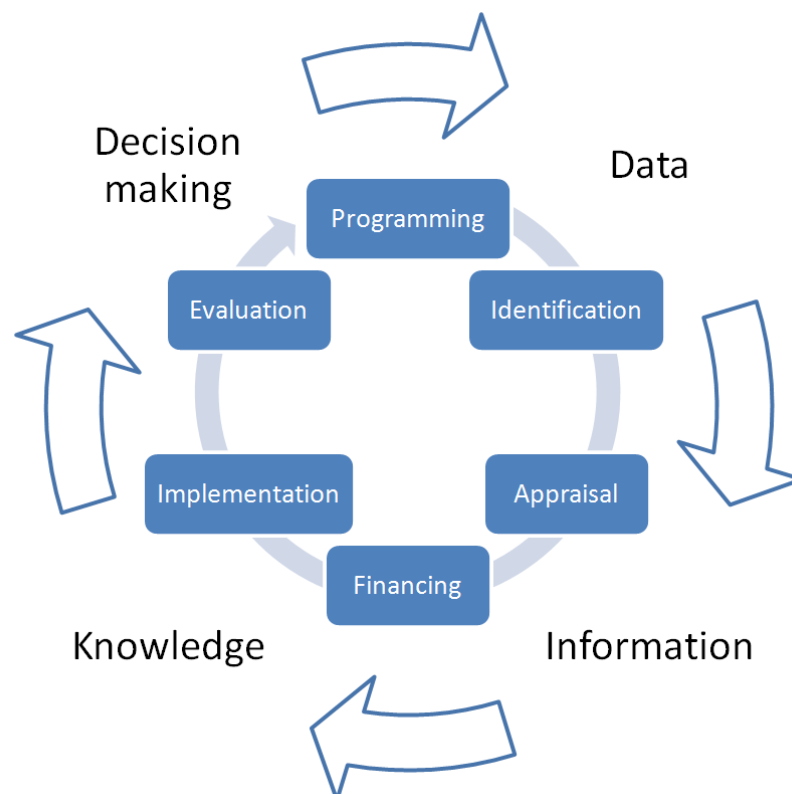


Figure 1: The inner circle represents the PCM stages, whilst the outer circle represents the stages of science production. Source: adapted from the EC manual: project cycle management 2001

⁸ Turnball et al., 2013. Towards Resilience. Emergency Capacity Building Project.

Science integration

For the purpose of these guidelines, we define science integration as the **incorporation of all the relevant, available and credible sources of natural and social scientific information and knowledge deemed essential for solving a humanitarian/development problem and thereby contributing to increased resilience**. Science can be applied at a number of scales, even within a single project or activity. Reflections from a knowledge-exchange partnership project in Bangladesh demonstrate some of these multi-scale opportunities for engaging with science (see case study 1).

Case study 1: Integrating science at different scales – reflections from Bangladesh

In terms of building resilience, Bangladesh faces many challenges, not least because of the range of hazards, both natural and man-made, to which it is exposed; a single community could be exposed to arsenic contamination, cyclones, flooding and earthquakes. Although Bangladesh is particularly known for its exposure to weather- and water-related hazards, it also has a history of very large earthquakes – some as large as magnitude 8; however, there have been no earthquakes greater than magnitude 7 since the 1930s, and there is no community memory of such events.

For practitioners, this is where integrating science into projects can be extremely valuable and supplement the community understanding of risk (here, for raising community awareness of the threat in general and for informing operational decisions for a particular scenario). Other examples include using scientific understanding of arsenic contamination to identify safe water sources. One of the challenges here is to build resilience to hazards with different annual probabilities (i.e. cyclones happen relatively frequently but large earthquakes are comparatively more rare).

Scientific information is available at the international, national, sub-national and community scale and research and monitoring are being undertaken by local and international scientists, often working together. However, available information is often fragmented, and may not be easily accessed or found in peer-reviewed journals (because the research has been commissioned specifically for a particular purpose).

	National	Sub-national	Local
Risk assessment: understanding the source and nature of the problem and anticipating disasters with confidence.	National and international scientists are involved in developing information to inform the national Comprehensive Disaster Management Programme	National and international scientists have developed earthquake scenarios for Dhaka, Sylhet and Chittagong and there are plans to extend this to other cities	Provision of daily/seasonal weather forecasts to farmers; locally relevant data; basic earthquake information is available from the Meteorological Department
Awareness raising and education			Education about disasters from unsafe drinking water to what to do during an earthquake
Technology		Developing low-cost sanitation techniques applicable to context	ICTs to provide market information to local farmers to inform decision-making
Communication	Knowledge dissemination to policy-makers.		

Table 1: Examples of the integration of science for different purposes and scales in Bangladesh



Figure 2: caritas Bangladesh worked with the Bangladesh University of Engineering and Technology to survey salinity levels in the soil and test a solar powered water purification system. This has created a new long term relationship between scientists and practitioner, in addition to enabling new innovations and ideas to improve the health of families such as Kakoli and her son Ruhan pictured here. Source: Kate Crowley, CAFOD.

Where is the entry point for integrating science?

Any project, programme or strategy should be informed by a rigorous analysis of the problem using all available relevant information and data, and yet there is a tendency to bring in science at the end of this analysis (or not at all). Ideally, integrating science should occur throughout a NGO's way of working; however this requires strategic decision-making and even a degree of organisational change. A natural existing entry/starting point for integrating science is via projects. Evidence of impact through integrating science within projects can be used to inform management about the benefits and limits of integrating science, which could shape strategic planning⁹. Similarly, through engagement with NGOs, communities and other users of science, scientists can gain a better understanding of what research is required and, therefore, help to better inform future research strategies.

Consulting with scientists from the very outset can help to ensure that the range of risk is fully considered. In reality, however, some expertise or information may only be recognised as necessary further down the line. Close consideration of the entry point for science is necessary in order to manage expectations of all stakeholders as well as, in the case of community participation, ensuring empowerment of and co-ownership of the process by the community.

⁹ See ELRHA case study 3: *A research and knowledge sharing partnership between UCL and CAFOD*

Integrating science is not simply about the application of science but, through the process of engaging with science, the learning that is acquired and the integration of all relevant information in order to co-produce knowledge between stakeholders (e.g. scientists, NGOs and communities) of the risks communities face and what they must do to address these.

For the purpose of these guidelines, the integration of science should be considered as an iterative process within a cycle that can be subdivided into five components:

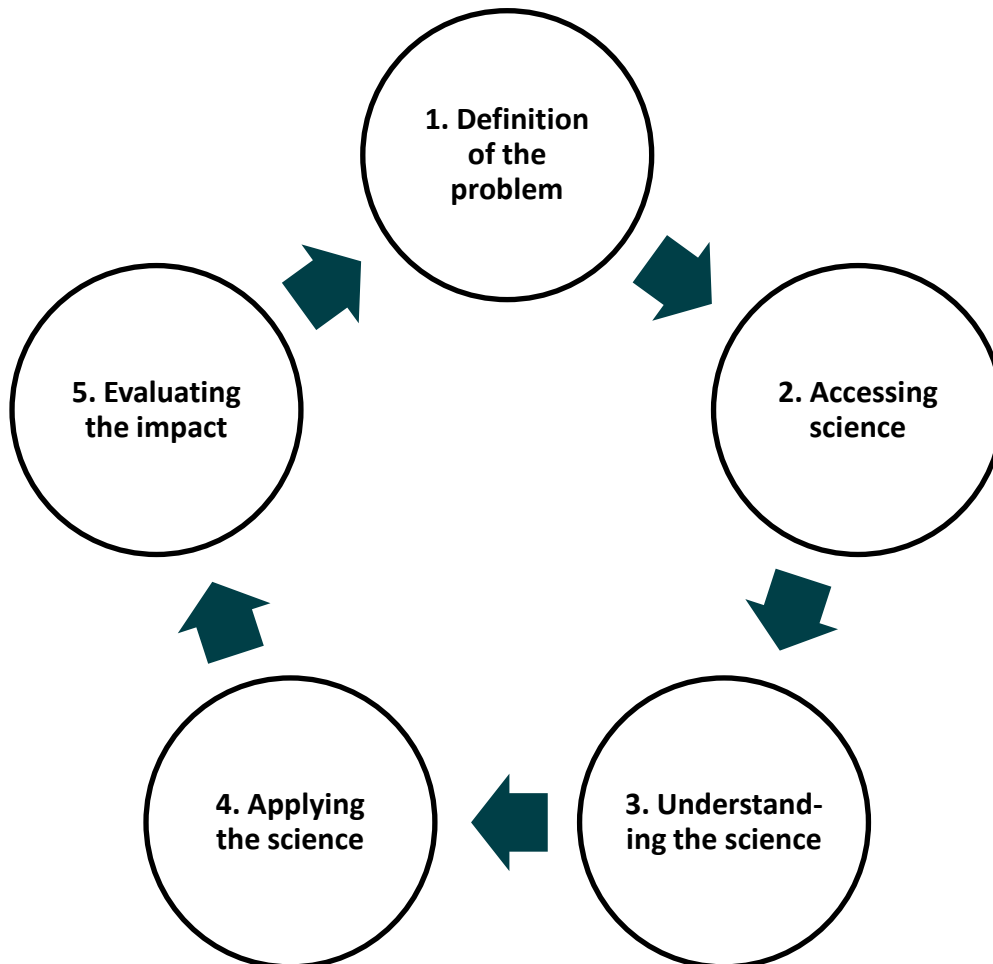


Figure 3: The five components of integrating science.

In the cycle, the implementation of one activity may necessitate going round this cycle several times as the scientific information changes and is updated. For example, you may feel that the problem has been identified from the outset, however it may only become apparent on engaging with scientists and trying to apply the science what the true or underlying problem really is. The purpose of describing the process of integrating science as a series of components is simply to frame the main areas for consideration and demonstrate how to address them with evidence from existing case studies in Bangladesh, the Democratic Republic of the Congo (DRC) and the Philippines, as well as fictional examples. At the beginning of each section there is a checklist of the key questions you as a practitioner need to consider when integrating science.

Section 1: Defining the problem to be solved and the purpose of integrating science

There are a number of scientific disciplines that can assist in building resilience; therefore it is important to clearly define the problem to be solved and the information and expertise that will be required. It is understandable that it may not always be possible to know which science is required, so it is advisable to consult with experts either within (e.g. technical advisors) or external (e.g. academics in universities or national scientific agencies) to your organisation.



Have you clearly defined the problem to be addressed?



Do you have a clear purpose for applying science?



How will the application of science benefit the community/the project objectives?



Do you have an initial understanding of what data, information and knowledge is required?



Have you thought of some initial questions to ask of scientists?



Have you considered what you need to be monitoring to ensure that you measure the impact of integrating science from the outset?

The type of scientific information, knowledge and methods required will vary across projects and programmes depending on the problem needing to be addressed. By first identifying and defining the problem you (and the community) will have a clearer understanding of the purpose of integrating scientific information and knowledge and, as such:

- An initial understanding of what scientific information is required, which will help you to know what relevant and focused questions should be asked of a scientist.
- A reference point against which you can monitor the process and impact of integrating science from the outset of engagement.

It is important to be flexible in defining a problem (setting out the purpose of integrating science), as this is likely to alter once you start to gather the necessary scientific information. Communities' may have a perception of what the problem is, but additional information may highlight other concerns that they were previously unaware of. Furthermore, where possible be proactive and anticipate what you may have to address before the onset of a humanitarian crisis.

The questions below and in the checklist above are designed to help you think through the purpose of integrating science and are exemplified using a fictional example of a project.

What is the problem to be addressed?

Say, for example, that the community are describing an increase in the frequency and severity of flooding. You wonder whether it might be due to changing climate but you do not have any evidence to support this. You suspect that there might be other local influences on the frequency and severity of flooding but the evidence presented by the community gives little indication of this. You hope that, by using what science is available, you/the community will be able to identify the triggers for flooding and therefore take the appropriate action to reduce local vulnerability. In this example, the aim of integrating science could be:

- To determine the cause of increased frequency and severity of flooding and inform local communities to enable them to adapt their Disaster Risk Reduction (DRR) strategies accordingly.

In order to realise this aim, a set of objectives might include:

- investigate relevant and credible¹⁰ background scientific information services (e.g. from the web, scientific journals);
- seek advice from an appropriate scientist or scientific institution;
- conduct an analysis to determine the frequency and severity of flooding with the scientist's and community's knowledge;
- hold a workshop for disseminating the results of this analysis;
- promote DRR strategies that utilise this information.

Before seeking out scientific information and expertise, it is useful to think about what the current knowledge and information gaps are, in order to help determine with whom might be the best person to consult.

Where are the current knowledge gaps?

Continuing with the above example, the community may recollect several periods where flooding was more frequent but not nearly as bad as it is now. One family show you the height of the most recent flood which left a watermark against the outside wall of their house and indicate the floods 20 years ago only reached half this height.

¹⁰ See section 3



Figure 4: Community members pointing out the depth of flood waters during 2011 in Mongla, Bangladesh. Source: Kate Crowley, CAFOD.

You estimate the recent flood height as two metres above the current river height. Only one or two members of the community are able to evidence the change in flood height, the rest discuss it relatively (higher or lower than before); but all agree there has been an increase in the number and severity of floods. They describe different types of flood (e.g. fast, slow; from the river or from rainfall) but using their own descriptions and language. You want to compare this to changes in rainfall but you do not have access to records for the area or do not know where to get them. You are not aware of any maps to show how land use planning may have changed and consequently affected flooding (e.g. deforestation); although the community are unaware of any local changes.

What information is needed?

You deem it necessary to determine whether there is any supporting information that could help check the information provided by the community as well as explain the reasons for the changes in flood frequency and severity. In the long-term, it would be useful to establish a systematic method of measuring flood levels and rainfall; for example measuring the flood level at the same location using a river level gauge or predefined marker against a building each time it floods would ensure a reliable baseline of data are being gathered. In the short-term, more information on changes in local land use planning, along with information on previous floods, rainfall records and any available flood hazard maps would prove useful. An expert in water basin management could help to determine whether factors beyond the reach of the community, for example engineering structures upstream, are influencing the occurrence of flooding here. It is at this stage that you realise that you need to seek some advice upon which information is available and can be utilised for your purpose. The next section explores how to access this information.

Section 2: Access to scientists and availability of data, information and knowledge

Integration can only be successful if usable, credible and context relevant science is available and accessible. Whether you can find the information and whether the information is fit for purpose will vary according to the nature of the problem being addressed and the country where it is being applied.

There are a number of opportunities through which you and your organisation may access science, ranging from accessing information that is readily available (e.g. on the internet) to establishing a formalised partnership with a scientific organisation. The level of engagement will depend upon the context of the problem being addressed; however we advocate the use of partnerships as a key mechanism for delivering the scientific information to those who most need it. It is important to recognise that engaging with science does not necessarily involve new research; there is an abundance of existing information and knowledge that could prove useful to NGOs and communities.



What level engagement with science will help address the problem?



Does your organisation already partner/work closely with a university?



Do you know where the sources of science are within the country you are working?



Have you conducted a power analysis of science sources?



Is the available scientific information suited to your purpose?

Open-source materials

In the first instance, you may look for whatever science there is to hand through open-source¹¹ materials, such as websites, reports and some academic journals. **The analysis of secondary data**¹² is a necessary preparatory step in participatory capacity and vulnerability assessments (PCVA)¹³. This being the case, there may be a number of relevant sources of information including:

- **Maps:** hazard, vulnerability and risk maps; land use maps; geological maps; conservation maps (e.g. native species mapping), etc.
- **Risk assessments** e.g. national geological survey reports
- **Online databases** e.g. EM-DAT <http://www.emdat.be/>
- **Environmental information** e.g. water quality, deforestation, land use, etc.
- **Historical records** e.g. historical narratives, databases of previous disasters; information on previous agricultural techniques and mitigation methods

The benefit of open-source materials is that they are free and often quick to access – useful under time constraints and limited resources. The drawback is that it is up to you, as the user, to assess the credibility of the information available. Scientific information published in academic journals is subject to peer-review, in other words assessed for its credibility and robustness by other scientists. Not all the information online is subject to such scrutiny and some may reflect the opinions of those writing it, rather than having any factual basis. Many of the reports available online are classed as grey literature - information produced by government, academia, business and industry and NGOs in both print and electronic formats that is not controlled by commercial publishers (i.e. where publishing is not the primary activity of the producing body)¹⁴. It is also necessary to determine whether the information is suited to purpose and it is important to be aware that:

- Information may not be at the **appropriate geographic scale** – maps may exaggerate or ‘hide’ local differences in (for example) poverty levels; the data used to create the map may be *coarse* (limited data averaged over large geographical areas) that is impossible to *downscale* the information to the community level e.g. national or global scale maps.
- Data, maps or models may be **out of date**. Scientific understanding is advancing constantly and sometimes these advances can be significant. It is therefore important to try to ascertain when the information was developed.
- There may be a requirement to convert the **science into non-technical language** in order to communicate it to other stakeholders, including the community.
- The most readily available, understandable and **attractive information may not necessarily be the best**.
- You need the knowledge and skills to assess whether the information available is **credible** (see section 3 for credibility).

¹¹ Information that is freely available compared with information that must be subscribed to (e.g. a number of academic journals).

¹² Primary data is collected and analysed by you, whilst secondary data is collected by others examples of secondary data sources include newspapers, journal articles and other publications.

¹³ For example ACF's Participatory Risk, Capacity & Vulnerability Analysis

¹⁴ Schopf J. and Farace D.J., Grey literature. In: Bates M.J. and Maack M.N. (eds.) *Encyclopedia of Library and Information Sciences*. 3rd ed., London England: CRC Press; 2010:2029–2039.

Asking a science expert

Knowing who to ask may not always be obvious but there are a number of organisations local or international that may be able to provide expertise:

Local observatories	• e.g. volcanic, seismic and meteorological
Geological surveys	• e.g. mapping and environment agencies
Universities	• e.g. geology, geography, engineering, earth science departments
National or local government	• e.g. scientific and technical departments, social welfare departments, disaster management offices/office of civil defence and extension services
Environmental, conservation and engineering NGOs	• e.g. local organisations or technical specialist organisations
Private sector	• e.g. insurance companies
Professional societies	• e.g. accredited academic and practitioner networks

Initial consultation with an expert is likely to be informal, and dependent on your and their availability. You should be aware that there are differences in partnership approaches between those scientists work within a university (often referred to as academics), and those who work for institutions (public and private) such as national meteorological agencies or geological surveys. Differences include but are not limited to institutional or personal reputations, approach to taking on new work, contracts and administrative requirements, and flexibility. Whilst some scientists may be happy to engage others may not because of:

- a lack of time (or not timely enough);
- a lack of willingness to engage (not willing or able to share information);
- a reluctance to engage owing to concerns over whether they may be held accountable for use/misuse of the information they provide;
- a lack of understanding of how they can communicate their science.

The capacity and knowledge of local scientists will vary from country to country. Politics can influence the integrity of scientists, how science is used and whether it is made available; corruption and bias within science can pose a challenge, and in some contexts it may not be possible to work with local scientists in government or academia or to trust them or the information they provide. It is recommended that NGOs **conduct a power analysis¹⁵ of science** to help determine levels of corruption and power dynamics that could affect the credibility of the available science.

Asking a science expert is useful for more ad hoc engagements, particularly when relying upon existing information and knowledge. However you may identify the need for information to be tailored to support a specific project or decision making process or new research in order to address

¹⁵ For information on power analysis in general, please refer to the World Bank's PSIA Sourcebook.

the problem (e.g. the study of water availability, quality and management across a watershed shared by a number of communities). In these instances, you may decide that a formal research project is required.

Collaborative research projects and formal partnerships

In instances where research is required, it is essential to adopt a collaborative approach that includes the participation of all relevant stakeholders. The benefits of a collaborative research project include:

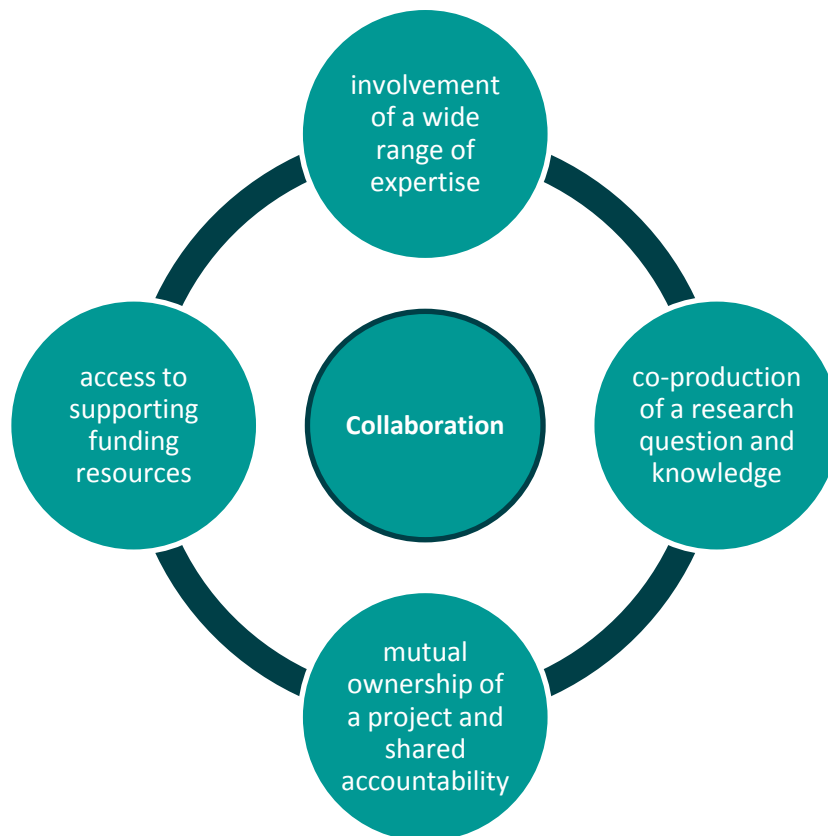


Figure 5: Some of the benefits of collaborative projects.

The objectives, ways of working and value systems of science and scientists may differ from those of humanitarian agencies (e.g. the primary objective of scientists may be the advancement of that science rather than the reduction in vulnerability). Clear and frequent communication is essential to the success of any collaborative research project, along with co-created and shared learning. Where appropriate, collaborative research projects should adopt the principles of participatory action research, meaning that those who are researched should be involved as equal partners in the process¹⁶.

Short term engagements may be difficult to sustain as they may rely upon the good will and available time of the scientist (except in the case of paid consultants). It is important to consider a long term relationship between organisations rather than individual relationships to ensure the institutional memory of science.

¹⁶ Institute of Development Studies (IDS). Participatory Methods: Research and Analysis. Available online: <http://www.participatorymethods.org/task/research-and-analyse>

Engaging with scientists should not necessarily be a one off process and there is growing evidence to suggest that the successful delivery of science is through formal partnerships with scientists (see case study 2: UCL-CAFOD partnership). Partnerships may begin informally, for example building upon initial consultations with experts or nurtured through previous colleagues who have moved from academia to an NGO (or vice versa), but these necessitate a degree of formalisation in order to **ensure accountability** and **protection to all stakeholders**.

In addition to the benefits of collaborative research outlined above, the benefits of a well-established partnership include:

- access to a greater range of expertise beyond your initial contact;
- opportunities for capacity building;
- long-term engagement to support sustainable projects;
- rapid access to knowledge and expertise in response to short deadlines;
- the development of mutual understandings, agendas and language.

As with any partnership, project design, learning and knowledge production should be mutual; whilst scientists can contribute a lot of knowledge and research, NGOs have vast experience and communities can share their knowledge of the risks they face.

Partnerships should also be inclusive of all stakeholders, engaging (where possible) with local scientists and other relevant actors to encourage long-term sustainability within country and to avoid any possible conflict. However, there are often numerous challenges to conducting scientific research in developing countries, from limited material and financial resources to poor infrastructure¹⁷; as such, the type of partnership may also reflect the circumstances of the country in question.

Christian Aid has established a successful partnership with a local scientific organisation in the Philippines¹⁸; and in the Eastern DRC, NGOs have consulted the Goma Volcano Observatory which operates in challenging conditions but is supported by international scientists:

¹⁷ Harris, E., 2004. Building scientific capacity in developing countries, European Molecular Biology Organization Reports, 5 (1), 7-11.

¹⁸ For an example of their work see *Big River Rising*, <http://www.preventionweb.net/english/multimedia/v.php?id=29335&hid=62>

Top tips for partnerships with scientists:

- Partnerships may not just be about the people who are the easiest to work with – they are also about gaining access to those with the best information;
- Often the necessary scientific expertise will vary depending on the nature of the problem being addressed; although the entry point to a partnership may be through an individual in the long term it is **advisable to partner with an organisation**, whilst also having an organisational lead on the partnership within the NGO and the scientific organisation, each of whom can facilitate linking practitioners with the relevant information and expertise;
- It may be better to deal with institutions rather than an individual as the work will be viewed as an official assignment and **allocated appropriate expertise and time**;
- Partnerships take time, commitment and long-term engagement and all stakeholders need to be aware that results may not be immediate; New research projects can take several years to deliver and scientists are constrained (in the same way NGOs are) by their institutions and the demand of their day to day job.

“The local volcano observatory faces numerous challenges but is able to maintain its monitoring and outreach capacity partly thanks to the support of some international scientists. Services that have been developed from international scientific research projects include provision of near real-time 24hr automated satellite remote sensing products which enable the observatory to advise on the status of the volcano even if ground monitoring equipment is compromised.” **Dr Susan Loughlin, British Geological Survey.**

Some of the barriers preventing NGOs from partnering with scientists include:

- a lack of funding for collaborative research;
- a lack of capacity (particularly in-country);
- a differing aims, objectives and ways of working;
- knowing who to believe amongst scientists with differing opinions;
- a nervousness amongst scientists about willingness to engage (e.g. with regard to their accountability);
- the long-time scales of carrying out research;
- a differing technical language between NGO staff and scientists.

Before succeeding in partnership, it is necessary to address the different objectives and perspectives across the scientists, NGOs and communities, as well as:

- Address any concerns you might have over **the economic and social sustainability** of the possible applications of science.
- **Question the track record** of the science they are resourcing – has it been used before successfully in a similar context? Is the skill of predictive science good enough to use for forecast-based decision-making at community level? Will scientists be open about potential negative impacts of applying their science? Do conflicts of interest exist (e.g. corporate scientists pushing their employers’ products)?
- Combine focused scientific expertise with broader, multifaceted development objectives in order to **ensure that the scientists serve the development objective**, rather than the other way around. The scientific agenda is significantly influenced by what policymakers want but much less so by what vulnerable communities may want.
- **Match the available scientific expertise with the problems** that need to be addressed from the community perspective, e.g. there may be significant scientific expertise on large-scale flooding but little on recurring, local flood or waterlogging risk.

Whilst there are a number of challenges to establishing partnerships, there are an increasing number of opportunities for funding, including joint funds for large consortium programmes, co-funded research projects and funds for project evaluations¹⁹. The **Enhancing Learning and Research for Humanitarian Assistance (ELRHA) Guide to Constructing Effective Partnerships** is a useful tool for deciding whether a partnership is best approach for your agency and how to go about establishing one. It is also a useful resource for those wishing to establish a collaborative research project with a scientist or institution.

¹⁹ Two UK funding bodies with a recent interest in partnership are the NERC and ESRC (please refer to the reference list for their website addressed).

Case study 2: Academic-NGO partnership – reflecting on the partnership between University College London (UCL) and the Catholic Agency for Overseas Development (CAFOD)

The partnership between UCL and CAFOD began in 2008. It was born out of informal discussions between acquaintances within the respective organisations and rapidly grew into a formal partnership with the signing of a memorandum of understanding (MOU). The founders of the partnership recognised the need and opportunity for rigorous analysis and research, particularly in the natural and environmental sciences, to underpin humanitarian and development policy and practice in disaster risk reduction, adaptation to climate variability and natural resource management¹. In addition to knowledge exchange activities, including field visits to examine in-country risk.

By the end of 2013 the partnership had appointed one post-doctoral research fellow and three PhD students to research projects, some of which have attracted funding from the UK Engineering and Physical Sciences Research Council and the Natural Environment Research Council. The projects are based on sound scientific research that will have impact within CAFOD, its partner organisation and within communities, by informing policy and practice. Three of the projects are co-funded by UCL and CAFOD and all were co-developed and are co-managed by UCL, CAFOD and CAFOD partners.

For CAFOD and its partners this partnership provides access to some of the world's leading experts in natural hazards, natural resource management, climate change and disaster risk reduction, in addition to data, information and knowledge not normally accessible to NGOs. For UCL the partnership informs research, teaching and knowledge exchange, and enhances the training of early-career researchers. For both organisations the partnership has led to new relationships with universities in the countries where projects are focused, which has enhanced the capacity of these universities to perform and apply scientific research. More generally the partnership is regarded as innovative and pioneering as an example of best practice in the integration of science for humanitarian and development benefit.

The collaboration has also produced important generic learning on partnerships:

- meaningful and effective partnerships take time to build, necessitating the allocation of staff time by all organisations involved, and there is often a significant period of sympathetic learning and understanding required before projects are agreed and set in motion;*
- collaboration between universities and NGOs has to take into account their significant differences, which include ways of working, types and timescales of deliverables, contractual requirements, depths of analysis required in projects, and expectations of donors, funding bodies and partners.*

Section 3: Understanding science and assessing its credibility

Every day you are confronted with arguments that demand logical, 'scientific' reasoning. Understanding and assessing the credibility of science is no different and this section provides a pathway through the maze of facts in order to separate the credible from the suspicious²⁰ so that you can make sensible and informed decisions.

	<i>Do you/the community understand the information?</i>
	<i>Do you have confidence in the information?</i>
	<i>Is the information relevant to the problem you want to address?</i>
	<i>Do you know if there is uncertainty?</i>
	<i>Have you asked the scientist why there is uncertainty?</i>
	<i>Have you reviewed the credibility of the information you are using?</i>
	<i>Are you consulting with a credible scientist?</i>
	<i>Is the information good enough for your purpose?</i>
	<i>Are you convinced that the science is free from any conflicts of interest?</i>

Even when accessing and applying science through a partnership, it is necessary for practitioners to have a basic understanding of science in order to know:

- What questions to ask of scientists?
- Whether the data/information appears to be credible?
- How to communicate the science to communities and other stakeholders - you may have a role as an intermediary in the communication of science, facilitating the bringing together of communities and scientists and communicating scientific information when scientists are unavailable?
- What to monitor and evaluate in terms of the impact of science?

²⁰ Scheaffer, R. and Young, L., 2010. Introduction to Probability and its Application. Brooks and Cole.

The process of integrating science is not simply about science informing NGOs who, in turn, use this information to assist communities; there is evidence to suggest that community members can benefit greatly from direct exposure to scientific information if it is properly communicated and the community receive some accompanying education (see case study 3):

The provision of a comprehensive scientific training is beyond the scope of these guidelines; however a number of key concepts are discussed below.

Qualitative versus quantitative

When combining natural and social sciences, let alone applying these to humanitarian and development planning and practice, debates often emerge around the respective roles of quantitative and qualitative data collection and analysis. Some problems are suited to both approaches, while others to one or the other. The term quantitative refers to information based upon measurable amounts that can typically be recorded numerically (e.g. the level of water in a river). Qualitative research deals with problems that are not measurable, and usually emphasises 'words' (descriptions) rather than counting in the collection and analysis of data²¹, for example an historical narrative of a community member's experience of living by a river that floods. Both are essential to the integration of science for building resilience. Often quantified results are a helpful means of building baselines for monitoring and providing evidence to advocate for change. Qualitative methods are especially helpful when trying to determine the less tangible causes of vulnerability and risk, for example communities' perceptions of risk and the decisions and behaviour they adopt in the face of it.

Quality

In many of the countries within which you operate, there are likely to be issues relating to data availability and quality. If understanding science is not challenging enough, then appreciating the quality of data perhaps presents an even greater challenge. **Data quality refers to the resolution, completeness, precision and accuracy of the data.** Assessing the quality of data necessitates looking at:

- **Methods of collection:** these should follow internationally recognised protocols and principles of the scientific method;
- **Resolution:** how concisely and thoroughly defined the data are – a low resolution map may have hazard, vulnerability or risk averaged over large areas that hide the true picture risk at the local level;
- **Completeness:** whether there are any (unexplained) gaps in the data; unless a thorough baseline has been collected, it is more than likely that there will be gaps in the data record so it is important that the science you utilise mentions whether the data are incomplete;
- **Precision:** how close the data is to being exact (e.g. 2.95 is more exact than rounding up to 3). This has important implications for the reproducibility of a study. It is also important to note that precise data are not necessarily accurate;
- **Accuracy:** how close the data is to the truth. Methods to measure accuracy include taking into account how old the data are (e.g. earthquakes recorded prior to the late 1800s will be

²¹ Bryman, A., 2008. Social Research Methods. Oxford.

based upon descriptive historical records, rather than technical readings from seismographs); any bias in the data (in terms of how it was measured); whether it has been consistently and validly recorded (especially when different data sets are brought together).

For practitioners the main question should be is the information is good enough for the purpose at hand?

Credibility

The **credibility** of scientific information reflects the extent to which the information is believable or convincing; in other words if the information is a realistic representation founded on the data upon which it is based. A relevant example is the *skill* of forecasts, i.e. how well the forecasts match observations.

Practitioners need to be able to trust the information they are using in order to be accountable to donors and beneficiaries. There are mechanisms for ensuring that science is credible; for example, most published scientific work has been peer-reviewed, which means that it has been scrutinised by other scientists who have assessed its quality and ensured that it has met a minimum standard.

The difficulty is that much of this peer-reviewed literature is not freely available and it is mostly intended to be read by other scientists who are very familiar with the topic of the publication. Consequently, most scientific literature is inaccessible to the non-specialist. For this reason, there is a growing emphasis on knowledge transfer or exchange experts in the scientific community, whose role is to make the science useful to a non-specialist end-user. Despite this move, the uptake and application of science by NGOs is still very limited and more effective mechanisms need to be found to improve this.

We have to consider not only the credibility of the information but also that of the scientist. As noted in section 2, the integrity of scientists may vary, which raises a number of additional challenges you should be aware of in order to ensure that the science you use is credible:

- **Scientists do not always agree** and it may not always be obvious whom to believe so try to weigh up the balanced arguments, taking into account the uncertainty of the information presented.
- **The scientist needs to be qualified** in the problem being addressed.
- **Science and scientists may be manipulated for political gain**, again emphasising why it may be necessary to do a power analysis of science.
- **The way data are presented can affect their credibility**, e.g. by exaggerating results or hiding the reality of the situation – you will rarely find a map with blank spaces representing missing data. To ensure that the data are credible it is necessary to ask scientists where the data came from or, if this is not possible, see if the work refers to the source of the data and whether it gives the date when it was published.
- In instances of data incompleteness, conclusions and **recommendations may be based upon expert judgement**, which is fine as long as the scientist has been honest about the

uncertainties and is clearly knowledgeable in the aspect being considered. It is, therefore, necessary to look at what has informed the scientific information you plan to use.

- **Ultimately some studies will be based upon more data than others** – credible studies will outline how much data they have used and the extent to which this limits the conclusions that can be made, others might not, so using some judgement can help.

Top tips to check credibility

Use more than one source of information/expertise.

Beware of information freely available on the internet - use only reputable sources.

Where accessible, use science published in peer-reviewed journals.

Use accredited (recognised) institutions or experts.

Ensure that an explanation of the uncertainty of the science is included.

Consider the amount of and quality of the data consulted.

Conduct a political/power mapping tool of science for the country of interest.

Where the science disagrees, consider the majority of opinions rather than the extremes.

Reference and date your work (and ensure the scientific information you use is too)

Review how much (and the quality of the) data was used to create the information you want to use.

IF IN DOUBT – SEEK ADVICE

Uncertainty and probability

If uncertainty can be better understood, appreciated and harnessed, then the opportunities and limits of utilising scientific information can be more effectively realised.

Few findings from natural and social science are 100% certain²², owing to the fact that data and information are often incomplete and that scientists' understanding of processes is incomplete. In spite of this, we still have to make decisions for building resilience. In the case of data and

²² Scheaffer, R. and Young, L., 2010. *Introduction to Probability and its Application*. Brooks and Cole.

information that are not certain, they should be presented with the degree of probability or likelihood indicated. In general, probability can be defined as the chance that something will happen or that a statement is true. Predictive science (e.g. weather forecasts) is probabilistic and, as such, does not give a definitive certainty but instead a range of probabilities that need to be understood and managed.

Practitioners should not be apprehensive of using information that is uncertain so long as any decisions and actions based upon the information are made with a full understanding of the associated uncertainty and its implications. It should be remembered that uncertainty will usually promote an analytical debate that should lead to robust decisions, which is a positive manifestation of uncertainty. **Facilitating a dialogue between stakeholders on science and its uncertainty is part of an essential process for better decision making**²³. Credible scientific information will also have any associated uncertainty clearly presented.

Decisions should be informed by more than one information source and any uncertainty should be clearly communicated so as to ensure accountability. It is important to be aware, however, that the provision of additional information can also increase (as well as decrease) the uncertainty.

It is essential to manage the expectations of the recipients of science by **clearly communicating the uncertainty and limits of the scientific information being provided in an understandable way**. The following case study addresses the application of probabilistic information in the context of climate science.

“

Natural sciences are not exact because of data sampling, area representation, and limited number of monitoring stations. As monitoring points increase the 'facts' are likely to change

Ayub Shaka Kenyan Meteorological Dept

”

²³ Visman, E., 2014. *Knowledge is power: unlocking the potential of science and technology to enhance community resilience through knowledge exchange*. Humanitarian Practice Network Paper Number 76.

Case study 3: Increasing Access to Climate Science for Small-Scale Farmers in Kenya

In Mbeere District, Kenya, Christian Aid supported local partner Christian Community Services Mount Kenya East (CCSMKE) to increase access by small-scale farmers to seasonal forecasts and short-term weather forecasts. The basic hypothesis was that better use would enable better decision-making which in turn could result in a yield increment of 10-20%. The first step was to get the forecast from the Greater Horn Regional Climate Outlook Forum and organise training for implementing staff and farmer group leaders, who could then relay the scientific information together with agricultural recommendations back to their wider group membership. Through an exchange (coordinated by the Humanitarian Futures Programme at King's College London) scientists from the Kenya Meteorology Department (KMD), the UK Met Office and the University of Sussex were involved in the initial training, with CCSMKE staff and local Ministry of Agriculture advisors providing follow-up and organising other channels of information, such as a text messaging service for the 7 day forecast through the season.

The project was acutely aware of the need to consider farmers' own beliefs, values, motivations and perceived control. Without this, efforts to increase use of science for decision-making based on the pursuit of scientific education alone would be unsuccessful. So the training covered a variety of aspects of the climate science involved as well as exploring how local indicators could be combined with the forecast. This and understanding how farmers have responded to climate variations in previous seasons added contextual information to facilitate farmers making climate-smart decisions for the upcoming season.

Although the KMD forecast is released in a deterministic format, farmers were provided with the probabilities and training in how to interpret it. Concerns about forecast reliability were addressed by explaining how forecasts are compiled and how often they had proved accurate in the past (about 80%, so 4 seasons in 5 are successfully forecast). This was a concept familiar to farmers since they apply different levels of reliability and usefulness to their own indicators. Those used by farmers were focused primarily on when the rains would start, although their use was assessed as having declined in recent years. This was partly due to modern education and religious influences but mainly due to the loss of some local indicators, e.g. certain tree species traditionally used for forecasting, as land is cleared for agriculture and other uses. Initially farmers expressed reservations about the usefulness of forecasts, perceiving that they were only relevant to neighbouring districts with climate stations but not to their own, drier situation. The 7 day forecast was therefore tailored to reflect this concern for local relevance. The compatibility between local indicators and the seasonal forecast, which gave information in addition to the onset date, was also made clearer.

Measuring the impact of the work over two seasons followed a basic evidence chain to get to an understanding of how enhanced use of forecasts might deliver the initial hypothesis (figure 5).

Farmers confirmed that the advice they received was relevant and had largely been communicated effectively, although they also provided clear recommendations on how this could be improved.

They valued direct training with a scientist most highly but recommended improved use of radio, barazas (local meetings) and mobile phones (through text messaging).

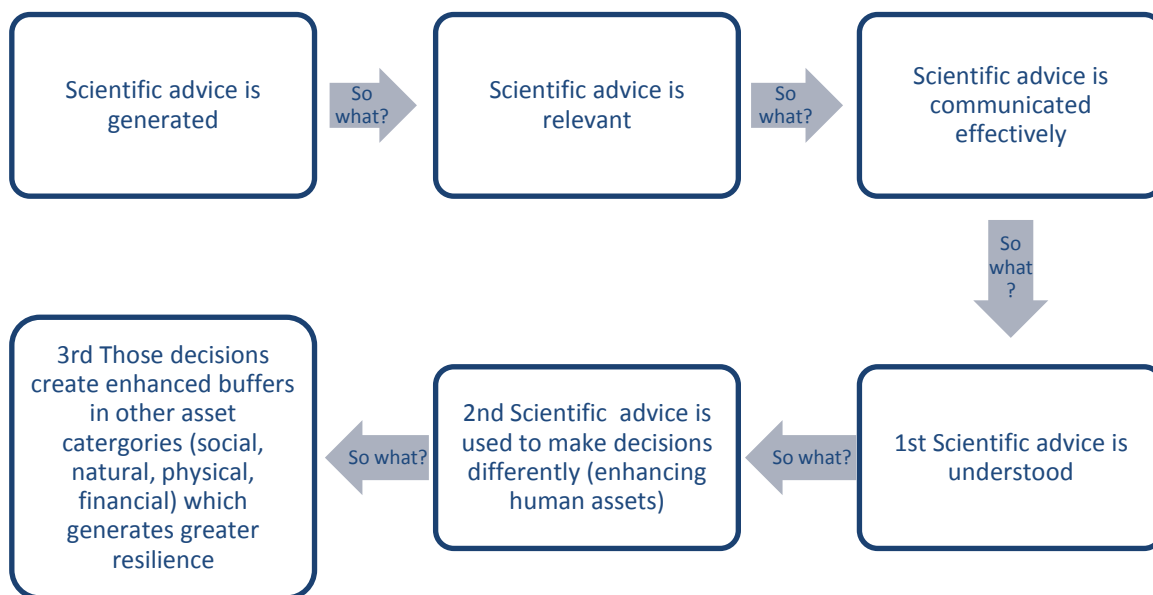


Figure 6: Basic evidence chain for the impact of climate science in the context of small-scale farmers in Kenya. Source: Richard Ewbank, Christian Aid (2013).

Their understanding and use for decision-making was demonstrated through their feedback on decisions they had changed as a result of receiving forecast science. These included (in order of importance):

1. *changing the planting date*
2. *planting drought-resilient varieties of their usual crops*
3. *planting more drought-resilient crops*
4. *changing to conservation agriculture techniques to conserve soil moisture*
5. *improving the timing of on-going operations, such as fertiliser application and pest control.*

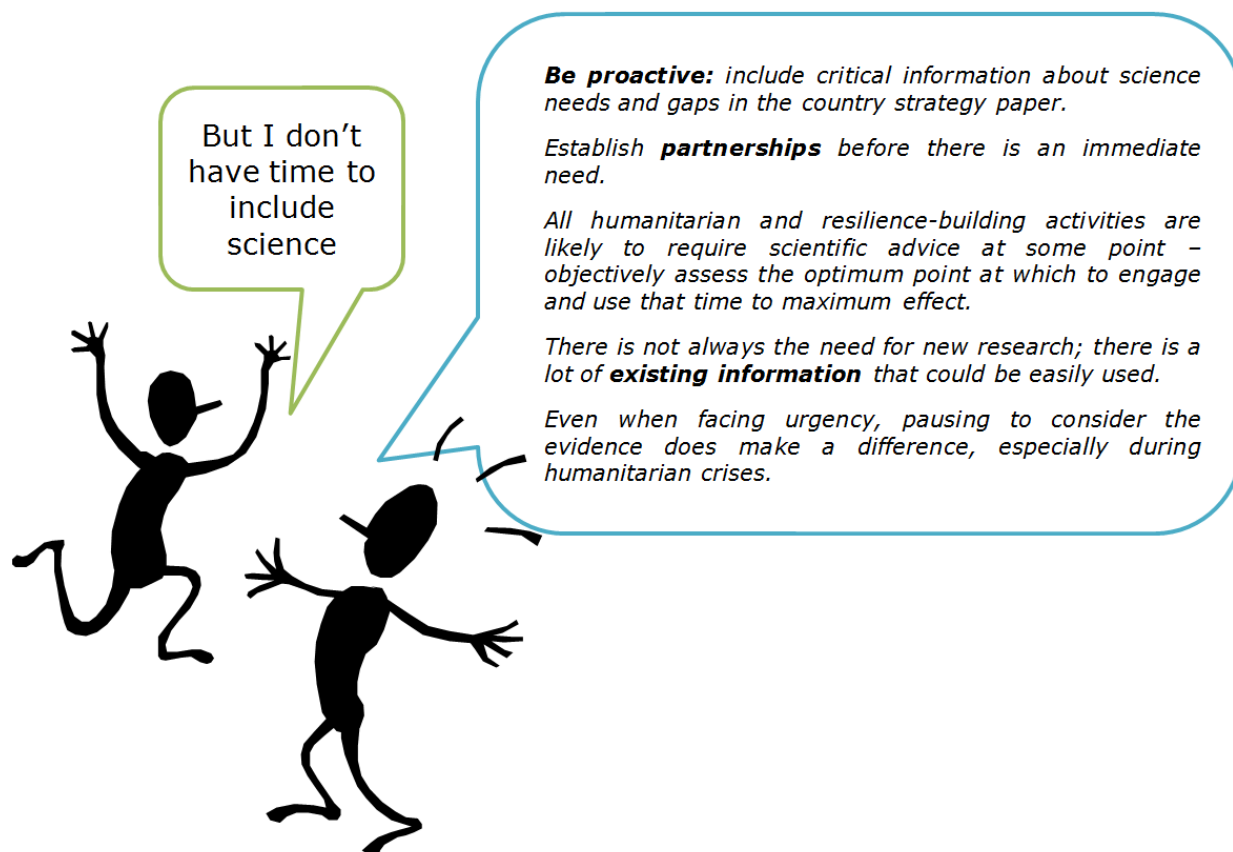
As a result, 96% of farmers reported an increase in yield due to improved decision-making based on forecast use, and about two-thirds assessed the increase as in excess of 15%. Given this result, farmers felt the best way forward included KMD establishing a climate station in their district to measure climate but also provide advice, forecast training and support to assist farmer groups establish their own rain gauges. This would expand the network measuring key climate variables, engaging science users in the generation of improved science, and also facilitate a sustainable link to the sources of climate science support.

Training and skills development

This guide has thus far shown that it is essential for NGOs to build a certain level of in-house understanding of science, so that NGO actors may act as effective intermediaries in accessing scientific information and resources, using them, and transferring them on to their partners and the communities within which they work. There are two effective mechanisms for achieving the necessary increase in understanding, which have been effectively demonstrated by the (re) insurance sector over the past 15 years:

- (1) employ more scientifically trained staff and
- (2) train existing and future staff in the necessary skills to engage with and use science

Both of these should also lead to more partnerships with scientific organisations. Unfortunately, building scientific capacity within NGOs is a challenge because of the need to minimise what donor and other sources of funding refer to as overheads, into which scientific capacity may fall. This challenge has to be overcome if understanding and using science is not to become yet another element of rhetoric. To this end, training is a relatively quick, simple and cost effective way of introducing meaningful numbers of NGO staff to science and the scientific method in order to improve their scientific literacy, skills and confidence. Such an approach should be linked to initiatives to professionalise the humanitarian and development sectors within the UK and elsewhere.



Section 4: Applying scientific information and methods to humanitarian and development work

The sections described so far have looked at defining the problem to be addressed and the reason for integrating science, how it might be accessed and what sort of information might be available, as well as some basic insight into understanding science and being able to assess its credibility. All of these have to be considered when applying science. In order to apply science, it is necessary to present information so that it is understandable and, therefore, enables users to make informed decisions. The application of science is iterative and involves learning and adapting in light of new information that may become available.

In this section, we discuss not only the application of scientific information but also the use of scientific methods for collecting, analysing and presenting data. Suggestions are also made as to how to manage the process of integrating science in an ethical and accountable manner.



Do you know when to include the science?



Do you know what scientific methods could help?



Have you discussed accountability with the scientist/source of information?



Have you ensured that the information users have the right tools and capacity to manage uncertainty?



Have you ensured that information users have a clear understanding of the credibility of the science?



Have you spoken to the scientist about any ethical guidelines they have to adhere to?



Are you and the community aware of the levels of confidence and uncertainties of the information you are using?



Have you combined the relevant sources of scientific and other technical expertise with what advice on what to do?

Opportunities for applying science

Table 2 outlines some examples of where science can be integrated into existing strategies and programmes at varying scales.

Level	Scale	Application
International/strategic	Regional	Country prioritisation <ul style="list-style-type: none"> ➤ Multi-hazard assessments in order to prioritise strategic interventions.
Programme	National	Country strategy paper <ul style="list-style-type: none"> ➤ Evidence of existing and future risk ➤ Data with regard to past risk ➤ Quantifiable risk
	Sub-national	Natural resource management <ul style="list-style-type: none"> ➤ Remote sensing ➤ Environmental impact analysis Human displacement <ul style="list-style-type: none"> ➤ Expertise in health and shelter
Project	Local	Local level assessment, e.g. content analysis (hazard, vulnerability and capacity), needs assessment, livelihoods analysis <ul style="list-style-type: none"> ➤ Use scientific information to complement local knowledge ➤ Use scientific expertise to interpret change seen at local level Early warning system <ul style="list-style-type: none"> ➤ Threshold for triggering the warning system

Table 2: opportunities for integrating science

Of particular interest to NGO practitioners is the application of science at the community level and whether this information can be transformed into something that is understandable and useful to the community. Examples of where science might be applied are listed below.

1. Participatory vulnerability and capacity assessments should incorporate scientific advice in the risk assessment and community planning process:

- **During pre-screening of risks** (largely top down, where scientific advice can give an NGO guidance on the key issues to address in a particular region or locality);
- **By bringing together community-based mapping with similar scientific processes**, such as GIS mapping, to develop accurate participatory maps of risks and vulnerabilities;
- **During event timeline development**, where the perceptions and recollections of climate, geophysical and other events are triangulated against the scientific record to accurately establish past and identify potential future trends;
- **During the action planning** - an interactive and iterative process at the community level. Local knowledge can provide local specificity and context to enable more specific scientific advice to be guided by the priorities as expressed by the community, information users, etc.
- **By guiding the revision of community-based plans/repeat PVCAs** as new scientific information is developed or new risks and stresses amenable to scientific solutions/mitigation emerge.

2. Training and education: science-based field schools e.g. climate field schools that bring user groups together with climate scientists in a series of training sessions over a specific period of time to enable better integration of short, medium and long-term climate science into community or group-led resilience and development processes.

3. Participatory research: where scientific research and advisory services are based on diagnostic studies of community-prioritised issues and challenges rather than those of the scientific/policy-led bureaucracies. Research is likewise based in the community (e.g. participatory research involving farmers) rather than in isolated research environments. There is a need to ensure that community interaction and consultation is designed to identify challenges, issues and opportunities that could benefit from subsequent support by scientists.

In order to explore this further, let us look at a fictional scenario of building flood defences for a community living close to a river:

The community are regularly affected by flooding. The local people have good knowledge with regard to the flooding but this is based solely upon their recollection rather than any systematic monitoring of the flooding. They have no memory of a large scale flood and there is a proposal to build flood defences by the banks of the river in order to protect the community. The heights of these defences are based upon the flood height as described by the community. They indicate that the flood waters rose to their knee height.



Figure 7: Local communities examining flood waters in Xai Xai town Mozambique February 2013. Source: Laura Purves, CAFOD.

There are two reasons why science needs to be applied:

- 1. In order to check (triangulate) the communities' knowledge with additional information and knowledge.*
- 2. To establish a more systematic method of determining the height of the flood defences, as flood heights (even during the same event) can differ from place to place. Obviously you can take an average of what the community indicate as the height of the flood but this omits the fact that some may have been standing in dips or at raised points at the time of the flood. As such, their memory of the flood height may not be*

representative. Flood depth can change depending on whether the height was measured at the peak of the flood or when the waters had begun to recede.

You are able to find support from a local hydrologist (a scientist who specialises in water and geology) who has actually done some mapping of large-scale flooding in the area – they are able to:

- *Demonstrate the flood height of a much larger flood that occurred 70 years ago.*
- *Assign a return period (inverse of probability) for a flood of this height to occur.*

Based on the additional scientific information, the community decide to invest more in their flood defences and build them higher. However, the hydrologist points out that the proposed flood defences are unsuitable as they are likely to increase the risk of flooding to downstream communities. He speaks to a colleague who is an engineer who suggests a more appropriate measure of drainage and improved land use planning.

Given what you and the community have learned from the hydrologist, you decide that this is a good opportunity to improve the communities' understanding of flooding in their region and establish a baseline of data regarding flooding. The community, therefore, establish their own monitoring system:

- *Volunteers from the community to be flood monitors are given a camera, map and mobile phone as well as training on the health and safety of measuring the height of the flooding as well as where to take regular measurements of the river level (and after periods of heavy rainfall) from a set of predefined points;*
- *The hydrologist teaches the volunteers about different types and sources of flooding.*

As a consequence of engaging with the scientists, the community soon discover that the reason for the increased magnitude of the floods is attributable to surface water flooding (combined with that from the river) because of a new road the local government recently built through the town that is preventing the water from draining away. The baseline of information collected by the community is regularly shared with the hydrologist who helps the community establish an early warning system for certain types of flooding. A low cost rain gauge based warning system for surface water flooding is also funded.

This scenario highlights two important points:

1. Scientific opinion and information may disagree with what the community and/or NGO would like to do (e.g. flood defences were in appropriate). Such a situation needs to be well managed and changing attitudes can only come about if people have complete trust in the science they are using;
2. Scientific methods of monitoring and recording data can assist with increasing resilience and empowering communities to better understand and take ownership of their own situation and establish 'community scientists'.

Despite a tendency to polarise the views of scientists and local communities, they can very much learn from one another. Communities, if adequately trained and capacitated, can be invaluable in

the systematic collection of data regarding hazards and risk, which can be interpreted by scientists to inform strategies for increasing resilience²⁴.

Community knowledge can often be the only immediate information available and by ensuring that it is systematically recorded and (as far as possible) bias removed, baselines can be established. By applying good scientific procedures to ensure the quality of the data being collected the information produced will be more robust. Simple techniques to ensure data is well recorded include:

- Having a **consistent approach to when and how often to record** information and take measurements.
- Knowing to take these **from the same, predefined point** (or persons to compare interviews over time) in order to create a baseline and capture subsequent changes.

Educating communities on how to measure their own risk scientifically should help to inform their decision-making and also internalise the science that is being presented (see Case study 4).

Managing stakeholder expectations

The process of applying scientific information relies upon good communication and continual discussion that challenges and reviews of all the available information throughout the process. Where community knowledge contradicts the science (or vice versa) it is important to engage a participatory dialogue, whilst also triangulating any other available sources of information.

In general, experience has shown that communities are amenable to outside information, even if it contradicts their own. There may, however, be resistance to the science from the community, who may not be willing to accept or take appropriate actions based on the results. It is not only necessary to know where and when to bring in science but also who to target – some community members may not be willing to engage with scientists (and vice versa), whilst others may be more open to listening to this information (see case study 5). In order to help manage the process of integrating science, engagement with science should not be a one off; it should be maintained throughout the project.

Scientists are also limited in their time and availability, often due to factors beyond their control (e.g. institutional (funding) constraints) and their willingness to engage with NGOs may be because of a desire to do so and not necessarily because they are incentivised to do so by their institutions. It is important that NGOs are mindful of this, especially if frustrations develop over the immediate availability of the scientists. Likewise it is necessary to ensure that scientists are aware of the resource and time constraints upon NGOs and the communities they assist.

However, arguably it is through well-established partnerships that some of these potential conflicts can be surmounted; by having a key contact within a university, information may be more quickly acquired. **Establishing formal partnerships enables the development of Terms of Reference – agreement on what to expect, what not to expect and any resource sharing to facilitate enhanced scientific support.**

²⁴ The Big River Rising Documentary is available online <http://www.christianaid.org.uk/whatwedo/in-focus/big-river-rising/background.aspx>

Case study 4: Citizen Science in action

In flood prone Malawi, Christian Aid with local partner Evangelical Association of Malawi brought together community members from Village Civil Protection Committees with scientists from the Department of Climate Change and Meteorology and District Council staff responsible for water management and disaster risk reduction. This enabled:

- *Flood risk mapping*
- *The development of an action plan and implementation of flood mitigation measures.*
- *The calibration and correct siting of river level gauges, with an easy-to-read traffic light system to facilitate early warnings.*
- *The establishment of community-managed rain gauges to enable them to supplement this system and their local indicators with their own data recording for water and drought management.*



The Chikwawa community in Malawi check their own rain gauge as part of their flood monitoring system. Source: Richard Ewbank, Christian Aid

Case study 5: Integrating science is more than just the provision of information

In February 2006, a major landslide buried the barangay (village) of Guinsaugon in Southern Leyte, Philippines. Shortly afterwards, technical investigations were made of nearby slopes to determine the risk to adjacent communities. Below is an extract from 'From Catastrophe to Opportunity: Children in Asia creating positive social changes after disasters' (page 50-51), which describes the actions Plan Philippines' and the community took based upon the available scientific information and the resistance they experienced from some members of the community.

The Mining and Geosciences Bureau [MGB] in the Philippines Department of Environment and Natural Resources conducted a thorough technical study of the landslide-prone area and found that two villages were high-risk zones, as cracks in the mountains above could potentially lead to dangerous landslides. With this vital information, it became clear that those living in the threatened areas – one of which was Santa Paz – ought to take precautionary steps to prevent a disaster from occurring...

After the result of the bureau's findings, the children in Santa Paz made a significant decision. Their school was located below an area in the mountains considered to be hazardous, and they noticed that mud and rocks had fallen down near the school. After a minor mudslide occurred nearby, some students, under careful supervision, ventured up the mountain to investigate the situation. Once they saw the cracks in the mountain, they decided that it was indeed too risky for the school to remain in its location. The school children overwhelmingly voted to evacuate and the teachers agreed. Within 12 hours, Plan Philippines offered to provide temporary tents for the children to learn in. Plan also gave approval to build a school out of range of the landslide danger zone, and construction of their new school started shortly after...

According to Plan Philippines' DRR advisor, Baltz Tribunalo, "The adults' level of consciousness mattered in this process. While children were making their decision, teachers and other community leaders like the members of the Municipal Disaster coordinating Council and Plan frontline staff helped in the processing of their decisions and related consequences, and also contributed by facilitating and maintain the difficult but liberating decision."

The children's bold determination turned out to be controversial, as some parents were concerned that their children would have to walk more than an hour or longer to the new school. Other community members living near the old school were unhappy because it had been abandoned, and some criticised the children strongly for their decision to move. This upset the children, who felt that they were only looking out for their own safety... Despite the rift with some parts of the community, almost all of the children continued to attend the school in its temporary tent site from July 2006 to March 2007 and then moved in June 2007 into the new school. They were grateful to Plan for the new, safer school and the training they had received. "All students, as well as citizens in the country, ought to be trained in DRR," said a 16-year-old boy from Santa Paz.

There are a number of interrelated reasons (e.g. related to culture and day to day, livelihood priorities) why some members of the community chose to act upon the science whilst others did not. However, whilst the MGB conducted their technical study, which they shared with Plan Philippines, they appear not to have been involved in discussing this risk with the community. By properly communicating the risk and the associated uncertainty, they could have helped bolster the argument the students were making for relocation. The scientific information provided is only as useful as the quality of its communication.

Ethics and accountability

If science is to be used to support planning, decision-making and practice then its **inclusion needs to be transparent and reflect the contribution of all stakeholders**. NGOs and scientists operate within different systems of standards and with different ethical expectations. It is important to be aware of the ethical frameworks under which scientists must operate and develop ways of managing areas where these frameworks may come into conflict with NGO approaches to accountability. You will need to consider how to approach co-production of knowledge in a manner that is consistent with principles of participation (a core component of accountability to disaster affected communities) in circumstances where scientists offer advice that is in conflict with the desires and views of the community.

There are systems in place to ensure the protection of participants in scientific research and UK academics must adhere to the ethical research principles of their institutions' and funders' ethics committees. Examples of the ethical frameworks for researchers in the UK include those outlined by the Economic and Social Research Council's (ESRC)²⁵ and the Natural Environment Research Council's (NERC)²⁶ regulations.

The ethical issue of particular concern is the fact that those who will ultimately benefit from the integration of science through the increase in their resilience and reduction in their vulnerability may also be the focus of the research study, however, the ideological perspective of action-research is that those who are researched need also to be involved as equal partners in the process.

With regard to ethics, it is important to be aware that:

some natural scientists may be less familiar with the potential ethical impact of their research, owing to less experience of working with people communities

local in-country scientists may not have the same systems in place to ensure ethical conduct

partnering with scientists in the private sector may bring further complications, as the objective of a private company or even a local government may not align with those of a humanitarian agency

When conducting research involving people, scientists are mandated to²⁷:

obtain informed consent from participants

maintain anonymity and confidentiality where appropriate

adhere to regulations regarding data protection

similar to NGOs, ensure no harm comes to participants and the environment

give participants the right to withdraw from the study at any point

²⁵ ESRC Framework for Research Ethics. Available online: <http://www.esrc.ac.uk/about-esrc/information/research-ethics.aspx>

²⁶ NERC Ethics Policy. Available online: <http://www.nerc.ac.uk/about/work/policy/ethics/>

²⁷ Bryman, A., 2008. *Social Research Methods*. Oxford.

However, these general principles are outlined with two caveats: First, the ‘do no harm’ principle in scientific research is often combined with a weighing of risks and benefits of the research. The risks posed to the research participants are weighed against the broader benefits to society. This kind of risk-benefit calculus may sit at odds with NGO practice of do no harm, which is underpinned by an NGO’s mandate to improve the lives of others. With an NGO’s approach to ‘do no harm,’ posing a risk to a single community on the basis that there may be a wider benefit for other communities may not work as a justifiable approach.

A second caveat is that research ethics frameworks are developed and applied differently across different scientific disciplines in the same country. For example, clinical trials are regulated under different frameworks than social science, and natural science & technology fields can feature their own iterations of the above general principles. Not all scientists will have the same view on research ethics and it will be important for you to arrive at a clear understanding of how a particular scientist or university department approaches its ethical obligations in research. It is, therefore, necessary to **agree upon a common set of established ethical guidelines** prior to visiting the project site so as to ensure the protection of the beneficiaries of science as well as the scientists and NGOs.

Accountability is a particular sub-set within the broader ethical obligations of an NGO or scientific community. With regard to NGOs, accountability mechanisms serve as the main frameworks for ensuring an ethical approach to their interventions²⁸. The Humanitarian Accountability Partnership (HAP)²⁹ standard explicitly covers accountability to both the people that an intervention aims to assist and the local partners involved in that intervention. So requirement 3.2 expects an implementing organisation to:

‘share with the people its aims to assist and other stakeholders’ information appropriate to their need’ and 3.6 expects an organisation to ‘work with its partners to agree on how and when they will share information, including with the people they aim to assist, and to put this agreement into practice.’

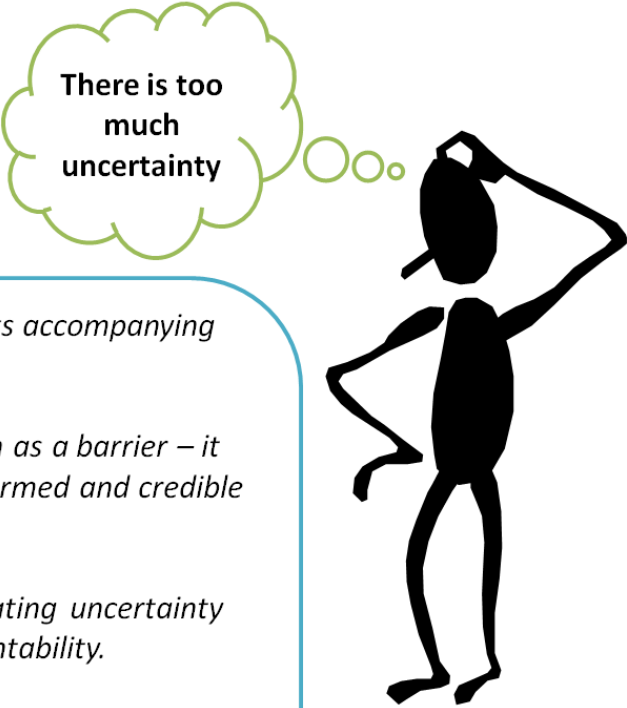
However, these mechanisms do not include specific requirements or criteria that dictate what credible science is and how it should be used. This is partly due to the lack of any internationally agreed standard and partly due to the context-specific use of science, which makes it difficult to define standards that would cover every intervention. Some of what NGOs do with the community is innovative, and there is a need for transparency and accountability concerning the source of the scientific information used so that those involved can make the right choice as to whether or not they want to use the information, and be involved in generating the evidence of its benefit to their situation. What is important, as the HAP Standard makes clear, is full accountability and informed consent by all stakeholders and especially from those the intervention intends to assist.

Scientists are held to account by their peers and the process of peer-review. They are also accountable to their institutions and funding bodies but there is little definitive guidance as to how this accountability might be extended to engagement with the humanitarian sector. Accountability needs to be clearly mapped and defined, especially if agencies want to incentivise scientists to engage in humanitarian and development work.

²⁸ See DEC accountability framework; People in Aid; and Interaction Accountability standards.

²⁹ Humanitarian Accountability Partnership, 2013. Available online: <http://www.hapinternational.org/>

The idea of co-production of knowledge by integrating science with local and other sources of knowledge may assist in overcoming any fears scientists may have about being held solely accountable for any decisions based upon the scientific information and knowledge provided. In order to be successful there is, however, a need to remove fear of failure and encourage flexibility in light of new information.



There is too
much
uncertainty

All scientific information has its accompanying uncertainty.

Uncertainty should not be seen as a barrier – it should help to make a more informed and credible decision.

Understanding and communicating uncertainty helps to ensure accountability.

*Often it is difficult to quantify, but where possible, the degree of uncertainty can be measured.
Use more than one source or type of information to explore whether these may help to reduce the uncertainty.*

Section 5: Monitoring and evaluating the impact of science

Whilst all projects require a process of monitoring and evaluating (M&E) their impact (e.g. a reduction in vulnerability), here we make specific reference to the M&E of integrating science in a project. Monitoring the integration and therefore the impact of science should take place throughout the entire process of engagement since it cannot be assumed that the science makes a valuable contribution or that you will learn and progress from this engagement without first collecting evidence. Monitoring and evaluation (M&E) cannot be reduced to simple formulae; however this section makes *suggestions* on how the impact of integrating science may be measured and how you might adjust your existing techniques

Although M&E of science integration is recognised as important it is a relatively new approach for the NGO sector.



What are you trying to measure?



Do you know when you should be measuring impact?



What indicators are appropriate to the project?



Have you managed to capture the learning as well as the outcomes of the project?



Have you measured the communities' perception of change?



Are there impacts that you can quantify as well as describe?



Have you recorded the unanticipated as well as anticipated impacts?



Have you communicated these impacts beyond your organisation and funder – even if parts of the project were unsuccessful?

What do we mean by the impact of science?

To some extent impact is shaped by donors and funders, meaning that both NGOs and scientists are constrained by how their respective funding institutions define and measure impact. Yet partnerships with scientists create dialogues and require flexibility to continuously adapt programmes and projects in light of the learning and knowledge produced as stakeholders work

together on a problem. There is, therefore, a need to challenge the funding structures that require predetermined goals and impacts. The best way to influence donors is to demonstrate positive impact through these partnerships, however this requires us to monitor and provide evidence.

Scientists are encouraged to strive towards ‘academic excellence’, with impact being measured in the context of the number of peer-reviewed articles published in ‘high-impact’ journals. However, NGOs demonstrate impact through positive change for their target vulnerable communities. Therefore measuring the impact of science information may be new to scientists who may currently only have to demonstrate a *pathway* to impact rather than actual change. Key issues are therefore those common to all impact assessment – the need to **detect** an impact, **attribute** it to the use of scientific information and advice and **triangulate** the impact using more than one assessment methodology or source of information.

In terms of measuring the impact of integrating science, this should encompass not simply the communication of science to users, but also whether:

- the scientific information has been understood;
- the scientific information has been used to guide a decision-making process;
- that decision-making process has resulted in an enhancement of resilience;
- this contributes to achieving the project purpose (or specific objective) and/or any other unexpected purpose;
- the process of integration has been mutually beneficial and accountable to all stakeholders, e.g. scientists, NGOs and communities, resulting in not only learning and change for those using the scientific information but also for those providing it (see case study 6).

This approach is similar to the Kirkpatrick model for training evaluation³⁰ which has four levels of evaluation: **reaction, learning, behaviour and results**. Importantly, we are not just talking about the evaluation of the outcome of using science but also monitoring and learning from the process of engaging with science.

Why do we want to measure the impact of integrating science?

It is necessary to measure and learn from both successful and failed approaches in integrating science, as it is only through acknowledging those failures that improvements can be made to future projects. Beyond ensuring that the aim of the project and the needs of the community have been addressed, we need to measure impact in order to:

- **inform on-going management** of science integration initiatives, enabling NGO practitioners, scientists and (most importantly) those applying the science to support their resilience to understand the impact of the science they are using and make adjustments accordingly;
- meet **the impact evidence requirements of donors** and influencing their future funding strategies;

³⁰ Information on the Kirkpatrick model available at <http://www.kirkpatrickpartners.com>

Case study 6: Climate Exchange Approach – impact for all stakeholders

The information below includes the reflections of the stakeholders included in the climate science exchange outlined in case study 3, which was coordinated by the Humanitarian Futures Programme (HFP). Between 2009-2012 HFP developed a series of two-way exchanges between climate scientists and meteorologists from national meteorological services in Kenya, Senegal and UK and a number of UK universities, communities at risk of flood and drought in Senegal and Kenya and partnering humanitarian and development organisations, with Christian Aid coordinating exchange activities in Kenya (as outlined in case study 3), and the Senegal Red Cross parallel activities in Senegal (Visman 2014).

Consisting of a series of community-based workshops and evaluations, tailored systems for provision of seasonal and weekly forecast updates directly to at-risk groups, technical reviews and national workshops timed around the rainy seasons, the exchange has been able to demonstrate benefits for all actors: communities at risk, partnering humanitarian and development agencies and participating scientists:

Communities at risk: *Participating groups have increased their trust in and use of forecasts provided by national meteorological services, becoming ‘demanding customers’ of community-based climate services and also developing for themselves innovative relevant channels for communicating climate information. Participating farmers attributed significant yield improvements to their ability to change key agricultural decisions based on improved access to and understanding of seasonal and short-term forecasts. Communities at risk of flood and drought were able to use information to inform a range of life/livelihood decision making processes, protecting vulnerable members and household assets when heavy rain was forecast, and employing seasonal forecasts and community-managed rain gauges to support planting decisions.*

Humanitarian and development agencies: *The exchange supported increased access by participating humanitarian and development agencies to climate information providers, resulting in the signing of formal agreements with national meteorological services and on-going engagement in regional climate fora. Exchange between the two country demonstration studies heightened awareness of the potential to employ climate information across timeframes, to support humanitarian, disaster risk reduction and development decision making.*

Scientists: *The exchange process has been as much about scientists learning how best to contextualise their learning within the realities of those living in complex risk situations, as their developing sufficient understanding amongst directly affected people and policymakers for them to begin to ask the right kind of questions. Creating channels for community concerns to directly inform scientists opens the possibility for re-interrogating existing data to identify new and additional relevance, as well as enabling directly affected people an opportunity to inform the focus of current and on-going scientific research.*

- **grow an evidence base of projects** where science has been integrated successfully (or not) for multiple advocacy objectives:
 - the development of future strategy on what scientific research should focus on;
 - the promotion of public investment for science that is considered useful by vulnerable communities and the organisations providing humanitarian and development services to them;
 - to support advocacy on rights-based issues related to science e.g. preventing the intellectual property rights of vulnerable communities being privatised under corporate copyright laws;
 - to inform strategic planning and promote the uptake of science within NGO as a whole, rather than on an individual project basis;
- **capture learning** from the process of integrating science to inform good practice;
- **ensure accountability** to all stakeholders.

For more information on the challenges of gathering evidence for humanitarian action please refer to the Evidence & Knowledge in Humanitarian Action paper, produced by the Active Learning Network for Accountability and Performance in Humanitarian Action³¹.

When is impact measured?

M&E are processes that should be incorporated into any project from the very outset. The impacts of integrating science do not simply relate to the outputs of the project but unexpected outcomes (such as organisational change) can also come about through the engagement with scientists. Projects should be monitored against the aim of integrating science, whilst maintaining a degree of flexibility in the monitoring process to capture any unanticipated changes.

Any impact will take time to emerge, so focusing significant impact assessment in the first year or two of a project is likely to generate slim returns. However mid-term reviews provide an opportunity to identify where impact is emerging and how the evidence gathering process should develop between the mid and end points of an intervention as impact is expected to strengthen. Typically this requires that, and often works best when, evidence gathering is planned and incremental – getting community leaders to maintain simple logs or records ensures that the impact recorded is grounded in community experience and can be used to support community management of scientific advice as well as projects and other stakeholders. This gradual accumulation of results can then be periodically aggregated and assessed so as to ensure that it will meet the anticipated requirement at the end of the project, e.g. from an external evaluation. It also avoids the frantic diversion of staff to intensive impact assessment processes in response to external demands. A key feature of this approach is to measure a smaller number of strongly attributable, priority indicators well and measure them consistently, rather than trying to measure a lot over an unmanageably large sample size.

How do we measure the impact of science?

You may wish to explore how impact can be related to the existing structures and frameworks your organisation adopts. If, for example, we relate impact assessment of science to the Sustainable

³¹ Available online: <http://www.alnap.org/story/147.aspx>

Livelihoods Approach, scientific advice is about enhancing human capital or capacity to make decisions which, in turn enhance the other asset categories (see figure 8). So the focus of impact assessment is how scientific advice has enabled an improvement in effective decision making that delivers a more tangible impact, such as an increase in yield (as in case study 3), an improved flood management system at catchment level or an early warning system that saves lives and assets.

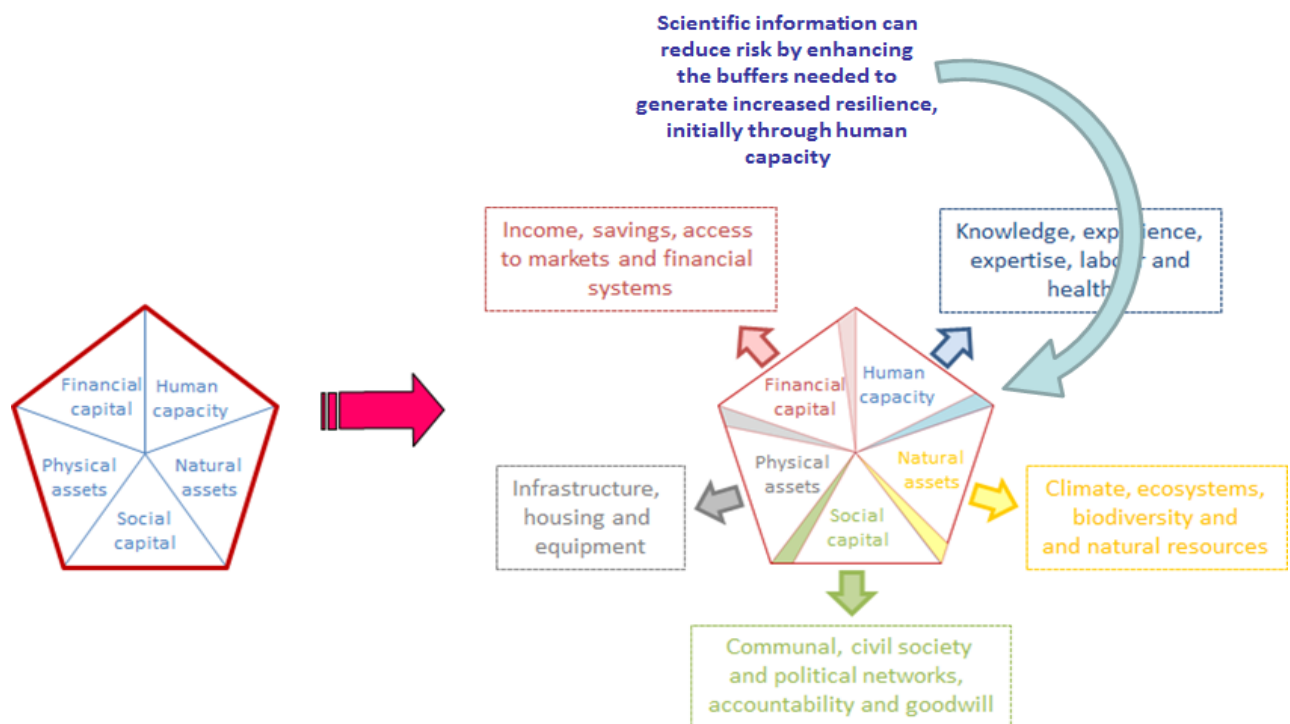


Figure 8: Relating the integration of scientific information into the sustainable livelihoods approach. Source: Christian Aid (2013).

The ELRHA *Dialogues for Disaster Anticipation and Resilience*³² house a number of case studies, with the impact of each of these projects being measured under the following headings:

- Baseline against which impact is measured
- Impact on vulnerability
- Informing specific humanitarian decision making process
- Informing focus of current/proposed scientific research

These case studies are a useful resource in terms of understanding how projects that have integrated science have been measured in terms of the impact of the science.

The challenge is in determining **whether communities have fully internalised the scientific information** (has it been used to inform decision-making and been put into practice) and **how to attribute change (especially in long-term) to the integration of science**.

Attributing the impact

The impact of science can also be viewed as time-dependent; whilst there may be more short-term benefits in terms of knowledge acquired by the community, the long-term impact of integrating

³² See: <http://www.elrha.org/dialogues>

science on increasing resilience may only be truly measured when tested by (for example) the occurrence of a stress or shock and whether this results in a major disaster or deterioration of development aims. However, it still may be possible to determine whether things have improved, by looking at the changes that have been made, e.g. in land use planning, the implementation of building codes and the deployment of training.

An example of measuring the impact of science comes from case study 3 and 5. In this case, the emphasis was on following the impact chain as far as was practically possible. So impact at the relatively superficial level could involve simply ascertaining that the climate science being extended to farmer groups was understood, but this raises the question...with what consequences? It should also inform a decision-making process, in this case when to plant, what to plant, etc. But even inquiry to this extent does not draw out the evidence needed to justify the hypothesis that yields will improve, so further investigation attempted to answer this question by asking farmers to what they might attribute the improved production they experienced. Additional resources would have allowed further progress down the chain. So what if yields have increased – does this result in increased income? What has that income been spent on? How has this expenditure improved resilience for the future? Has the experience had any influence on the future generation of climate science and provision of climate services? These are all lines of enquiry to deepen the evidence of the impact of science.

Triangulating the impact

A challenge for impact assessment as we seek to move further down the impact chain is guarding against bias. In the above case, the yield results were based on self-attribution by farmers, which can be prone to a variety of biases. A solution is therefore to triangulate this result with a more quantitative assessment, for example a statistical measurement of yield and comparison with the average yields in the District or comparing with a group that had not used climate science in the same way. This would involve a substantial addition of effort and resources, but will increase the value of the information for both management and advocacy purposes.

Consulting many different sources of information, e.g. from the community, NGO, scientists and other stakeholders involved in the process will help to better determine the extent to which science is responsible for any observable strengthening of resilience. Where possible combining both qualitative and quantitative (e.g. a recorded decrease in the number of floods) measures will also help.

Once impact is measured, it is essential that it is communicated not only to all stakeholders, but to wider audiences in order to inform other agencies and institutions of the benefits (and challenges) of integrating science.

Summary

The integration of science necessitates the **incorporation of all the relevant, available and credible sources of natural and social scientific information and knowledge deemed essential for solving a humanitarian/development problem and thereby contributing to increased resilience**. The process of science integration should also **help scientists present their results in a relevant and user-friendly context, which should be assisted by those at risk informing and/or being involved in research**.

Science can provide useful information and knowledge but also a series of methods that can help to improve the analysis conducted by NGOs. The process of integrating science is iterative and will require revisiting each of the five components listed below, within a single activity. The users of science should learn from and adjust their approach in light of any new scientific information that emerges during the process of engaging with science and scientists.

- 1. Define the problem and the purpose of integrating science with the users of science*
- 2. Access the science*
- 3. Understand scientific information*
- 4. Apply the science*
- 5. Monitor and evaluate the impact of science*

Finally, science should not be viewed as an added burden but valued as something that can help NGOs and communities make better informed decisions about building resilience.

In order to increase the current level of scientific integration for the purpose of building resilience, we suggest the need for greater funding for interdisciplinary partnerships between NGOs and scientists as well the need to increase scientific capacity within NGOs.

Acronyms

ABUHC	Aon Benfield UCL Hazard Centre
BGS	British Geological Survey
CCSMKE	Christian Community Services Mount Kenya East
DRR	Disaster Risk Reduction
CAFOD	Catholic Agency for Overseas Development
ELRHA	Enhancing Learning and Research for Humanitarian Assistance
ESRC	Economic and Social Research Council
HAP	Humanitarian Accountability Partnership
HERR	Humanitarian Emergency Response Review
HFP	Humanitarian Futures Programme
KMD	Kenya Meteorology Department
NERC	Natural Environment Research Council
PCM	Project Cycle Management
UCL	University College London
UKCDS	UK Collaborative on Development Sciences

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Genuine willingness by practitioners to integrate science creates an environment of trust and openness on part of the scientists

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