Interactions between local and scientific knowledge systems for weather and climate services

Learning paper #9

March 2018

Woman going to the market in Passoré, Burkina Faso, 2017. Ph: Camilla Audia

Introduction

Climate change is having a significant impact on climate extremes in East and West Africa. It is increasing the frequency and intensity of droughts and floods and threatening already vulnerable rural livelihoods. One of the key objectives of the Christian Aid-led Building Resilience and Adaptation to Climate Extremes and Disasters (BRACED) projects in Burkina Faso and Ethiopia has therefore been the development and delivery of accessible, timely, relevant weather and climate information involving the national meteorological (met) services in both countries along with the UK Met Office. This information can then support household decision making regarding livelihoods strategies, and therefore help to build the resilience of vulnerable people to climate shocks and stresses.

Working with rural households to improve their access to met service-generated climate information has highlighted the prevalent use of traditional weather forecasting, which still remains one of the main accessible and trusted sources of weather and climate information in rural communities in Burkina Faso and Ethiopia. The value of this local knowledge (see Box 1 on terminology) about the weather and climate is recognised by the BRACED project. However, climate change is also undermining the traditional or local indicators (such as insect behaviour) that farmers in these regions have used to predict the weather and seasonal climate (Ackerley et al., 2011) and impacting on agro-pastoralists' local expertise based on historical observation of climate phenomena and their contextual consequences over the years. The challenge the BRACED project, and other projects working with climate information, face is to find ways to optimise the use and availability of both met service and local forecast knowledge and communication mechanisms, in order to ensure those households vulnerable to climate extremes have the best information to help them in their decision making.

In this learning paper we discuss why it is important to take local knowledge into consideration, examining the ways this has been done in BRACED, both in the CIARE project (Ethiopia) and the Zaman Lebidi project (Burkina Faso) and more widely. We then look at the processes and methods used to combine both met/scientific information and local knowledge to give farming households the best chance they have of reaching the right decision about their livelihood options each season. We also explore the power relations that can manifest themselves these processes which can have important effects on resilience outcomes.

Box 1 Terminology

In selecting the terminology to be used in this paper, we borrow from – Roncoli et al., 2002:

"Terms such as ``scientific' and ``indigenous'' remain problematic, but for brevity's sake we will clarify our terminology without delving into the surrounding debate (Antweiler, 1998). We adhere to the common definition of science as knowledge generated by experts using recognized and rigorous approaches to observation and experimentation. We avoid acronyms, such as ITK (indigenous technical knowledge) or TEK (traditional environmental knowledge), that tend to reify diverse and fluid cognitive dimensions into an inflexible package of disembodied know-how. We avoid ``indigenous knowledge,'' which connotes colonizing discourse and policies in much of francophone Africa.

For the purpose of this learning paper we prefer the term 'local knowledge' evoking "the performance element of knowledge and the contextual aspect of its practice" (Roncoli et al., 2002, p. 410)

Box 2: Key terms related to climate information (Learning Paper #1)

Climate information services (CIS): the development and delivery, with key stakeholders, of accessible, timely, relevant weather and climate information, which can support decision-making across timeframes, sectors and livelihoods.

Climate information: information produced on the weather and climate. This can be based on science and/or local experience and knowledge. This includes short-term information about the weather (the condition of the atmosphere at a specific time and place – in terms of temperature, wind, cloud cover, rainfall, and humidity), seasonal information and long-term information about the climate (the statistics of atmospheric conditions and weather events over months, decadal periods and periods of decades or longer).

Building resilience by communicating climate information

Providing decision makers with better access to weather and climate information has been central to the resilience building aims of BRACED projects in Burkina Faso and Ethiopia. Seasonal forecasting and warnings of imminent extreme local weather events can help people to make more informed decisions about their livelihoods, for example, what seeds they sow, where to sow them and how to protect themselves from extreme weather conditions. Adapting livelihoods in this way can lead to increased resilience to shocks and stresses (Tall et al., 2012) Activities have therefore focussed on the development and communication of relevant climate information, including data generation through the installation of automatic weather stations and equipping local committees with rain gauges. In terms of communication, the national met services have provided alerts and weekly forecasts to project partner radio stations who broadcast it in project areas. Radio sets have been distributed, community level 'listening groups' established and national met services provided local Early Warning Committees with climate advisories. These processes have involved a wide range of actors, in particular, the national met services (NMS) in both countries, the UK Met Office, NGOs focussing on climate information communication (BBC Media Action in Ethiopia and Internews in Burkina Faso), local radio, local government, early warning committee members and agricultural extension services.

Why consider local knowledge in resilience-building programmes?

Whilst the focus in BRACED has been on developing and communicating climate information generated by the national met services, a challenge exists in making this information accessible, relevant and useable for communities. Many barriers are apparent in the up-take of scientific information. These include the geographical scale and timing of the information (e.g. weather information may be regional rather than local and bulletins may be too late to aid decision making), language barriers (relating to both technical terminology and a lack of local languages used), high levels of illiteracy, a lack of access to phones, radios or televisions and users who are either geographically remote, scattered or mobile (for example, pastoralist communities) (Lemos et al., 2012; Lumbroso et al., 2014; Patt et al., 2005). Moreover, the skill and reliability of scientific models is highly variable over a region and might not be good enough for decision-making for a given point.

Access to information resources can also differ across socio-economic delineations (McOmber, 2013). For example, women, who make up a substantial amount of the agricultural labour force, frequently miss critical information communicated using information and communication technology since studies have shown they are less likely to own a mobile phone or have access to a radio (Chesney McOmber et al., 2013) or may be busy when climate information is broadcast. In this way, communication of scientific information can also serve to reinforce social norms and power hierarchies. Another key challenge lies in communicating the probabilistic nature of forecast information (Kniveton et al., 2015), where scientific forecasts are either communicated or interpreted in deterministic rather than probabilistic form. This leads to issues of trust and credibility (Patt and Gwata, 2002).

In contrast, local knowledge and climate indicators emerge from a tradition of knowledge and practices embedded in local institutions and structures, values and belief systems (Kniveton et al., 2015). As a result, these often have greater acceptance and weight in decision making for farming communities than scientific forecasts (Dekens, 2007). UNESCO describes local and indigenous knowledge as the understandings, skills and philosophies developed by societies with long histories of interaction with their natural surroundings. This knowledge informs decision-making about fundamental aspects of day-to-day life, including health care, food preparation, education, natural resource management; it is integral to a cultural complex that encompasses language, classification systems, resource use practices, social interactions, ritual and spirituality. Such knowledge is passed down from generation to generation, in many societies by word of mouth (UNESCO; Warren, 1991). It is due to the embeddedness of local knowledge in nature, that some consider it to be more suited to coping with uncertainty and unpredictability, since these are characteristics of natural systems (Mazzocchi, 2006).

Further to this, the timescale on which local knowledge operates provides the advantage of a longer term collective memory and timeframe for learning (Dennis Martinez, 2010). In relation to climate and weather information, local knowledge and systems of thought can link knowledge to social responsibility (Banuri et al., 1993; Roncoli et al., 2002), for example, observing certain patterns in insect behaviour or plant growth can trigger certain activities such as preparing fields for flooding. It is important to mention here, however, that local knowledge is not without challenges. For example, it has become increasingly unreliable due to climate change, it is often based on power structures and access to it may be restricted or that it can be based on religious beliefs and discredited by certain groups.

Box 3: Local vs Scientific Knowledge

We have outlined some of the shortcoming of scientific climate information alongside the reasons why local knowledge can add value to resilience building projects. However, there is perhaps a more fundamental reason as to why local knowledge should be considered alongside scientific knowledge, which resides in how both knowledge systems are viewed are used. Scientific knowledge is only one representation of the world (Mazzocchi, 2006), however, it is often presented as central, infallible, universal, globally applicable, objective and superior (Agrawal, 1995; Briggs, 2005), whilst traditional or local knowledge is often viewed as secondary, inferior, backward, subjective, too contextually specific and less efficient (Agrawal, 1995; Briggs, 2005).That Western science is as much socially constructed as local knowledge has frequently been overlooked (Briggs, 2005).

In recognition of this and of the value of local knowledge more broadly, there has been a recent growing interest in local knowledge amongst academics, development practitioners and international organisations alike (Berkes, 2018). New ways of perceiving the world are being called upon and accepted as the conventional paradigm becomes less capable of explaining observations and increased levels of complexity. Local or indigenous ways of knowing are thus being reconsidered as helpful in observing and monitoring these complex systems (Berkes, 2018).

There have also been calls for both knowledge systems to be viewed as less separated by a binary divide and in competition with one another (Agrawal, 1995; Briggs, 2005). A more 'entangled' or complementary view, which recognises that many people (e.g. farmers) are happy to combine traditional and modern technologies, or even not view them as coming from separate and competing sources (Scoones, 1996; Briggs, 2005). In this way, combining different knowledge systems, gives a more complete picture of reality (Mazzocchi, 2006). In relation to this, local knowledge should not be viewed as static and unchanging; instead there is evidence that people adopt new ideas into their knowledge systems providing they make economic sense and are culturally acceptable (Briggs, 2005). Further to this, knowledge can be seen as a process, with local knowledge manifesting as a sensitivity to critical signs in the environment and an intuitive understanding of what these signs mean in relation to practical tasks and responsibilities (Ingold and Kurttila, 2000). Local knowledge can therefore be seen as is fluid and constantly changing, reflecting renegotiations between people and their environments (Sillitoe, 1996).

Toward an integrated approach

If scientists focus on having a more integrated discussion with communities whereby community capabilities and resources in the area of climate forecasting are taken into account, strategies to reduce vulnerability to climate risk may be more widely accepted by locals and there is a better chance of uptake. By understanding local indicators better, particularly in terms of how they are conceptualised, communicated, shared, generated and what particular weather phenomena they pertain to, scientists can increase their understanding of user needs and gain insight into how to most effectively communicate the most sought-after types of scientific weather and climate information to aid decision-making. Developing scientific information which resonates with local knowledge will ensure the relevance of national met services to the populations they serve (Roncoli, 2006). This is particularly important given the impact of climate change on local indicators (see Box 5) (Gallo and Henley, 2017)), which is rendering them less reliable. Consequently, there is a growing need, more than ever to share different perspectives to best adapt and respond to the complex problems that are arising (Goddard, 2015).

Local knowledge in BRACED

The BRACED programmes in Ethiopia and Burkina Faso have both explored the role local knowledge can play in enabling decision makers to have access to the information they need to make the best choices about livelihood options. At a workshop in held in Ethiopia on climate information services, CIARE partner, BBC Media action pointed out how a strengthened recognition of the role of local knowledge is vital in building trust and cultural appropriateness of NMS forecasts. Participants also discussed how it can be difficult to convince pastoralists and other decision makers to move to using scientific forecasts because these are not always accurate at a local level and communication of forecasts can be limited by language barriers or access to TV/Radio. A scenario exercise carried out during the workshop highlighted the value of having both sources of knowledge to draw on in decision making. This is elaborated in Box 4.

In Burkina Faso the UK Met Office carried out a survey to determine the types of local knowledge being used by communities in the project intervention areas. This survey looked into the use of traditional indicators to forecast the upcoming season. The immediate aim of this was to understand which indicators were used and how they varied across the project regions, as well as the perceived reliability of these indicators, and whether or not this reliability was considered to have changed over various timescales. The ultimate aim was to use this information as necessary background context for any further activities in the project to integrate these traditional indicators with the scientific information produced by the Burkina met services, ANAM (Gallo and Henley, 2017). In undertaking such work the UK Met Office demonstrates how it recognises the

Box 4: Forecasts for decision making

An interactive scenario exercise carried out during the workshop in Ethiopia was used to illustrate the challenges faced by users of climate information. Workshop participants worked in mixed groups to act as decision makers at different levels (e.g. woreda/kebele (village) level, sedentary / agricultural communities). They were given national met service seasonal forecast products alongside a list of local indicators and were tasked to make a decision about what action to take. The same exercise was adapted to the context and used in the AMMA 2050-BRACED workshop in Burkina Faso in January 2017. Decision-makers across both projects, including climate scientists, mayors of rural and urban areas, meteorologists, social scientists and practitioners were given seasonal, 10-day and daily forecasts alongside traditional indicators and were asked to make a decision.

Lessons Learned

After completing the exercise, participants of the Ethiopian workshop reported that the terms used in the scientific forecast were difficult to interpret without prior training, and the forecasts lacked the required regional detail. Participants found that their decisions based on local vs. scientific knowledge were not always complementary, leading to discussion around the need to acknowledge both sources of information. Value was added to both forecasts by those participants who knew how to interpret the information and convert it into reactive actions.

Interestingly, similar dynamics appeared in Burkina Faso. The difference of time scales led to a reflection of the need to consider different scales of both weather and climate information as well as the flexibility in time and resources to adapt decisions to whatever information is available and relevant at the time. It was also a great opportunity for an open discussion between mayors (as local decision-makers) and scientists at different levels; while mayors had the opportunity to fully grasp the probabilistic nature of the information and the unavoidable uncertainty forecasts convey, scientists were able to focus on the nature of the information needed, not necessarily aligned with what was currently provided. Both projects (BRACED ZL and AMMA 2050) developed methodologies to address the issue of dialogue and communication between climate producers (scientists, meteorologists) and climate users (decision-makers at different levels).

value of local observation systems and complementary frameworks for analysing weather and climate phenomenon. However, whilst a brief qualitative analysis of this dataset has been realised (see Box 5) but have not been able to move towards using such frameworks as means to better communicate scientific climate information. This is therefore a project King's College London will be undertaking with the UK Met Office, details of which are included in the Next Steps section below.

Challenges of integrating local and scientific knowledge

Experiences from both countries, as well as the wider academic literature suggest that there is a clear need to draw on both meteorological, climate science and local knowledge in order to improve the lives of rural households and build their resilience to climate risks (Roncoli et al., 2002), but the challenge remains in how to do this. Creating understanding and enabling communication between distinct knowledge systems and perspectives is difficult since key concepts for one system (e.g. observations of animal and plant behaviour), may not easily speak or link to the internal logic of another system (e.g. precise scientific measurements of weather conditions) (Gorddard et al., 2016). The lack of historical records for traditional forecasts makes a scientific verification impossible, which is vital for building trust among the scientific community. Moreover, temporal and geographical scales may differ, with scientific climate information in Burkina Faso relating to regional scales more often than local scales more useful to decision-making. Like meteorology, local knowledge focuses on some atmospheric events (winds, soil moisture, temperature, rain phenomena) but, in addition, it often gives great attention and importance to impacts of these events (tree flowering, insect movements) to make informed decisions.

Further to this, challenges exist around the power structures that manifest in both scientific and local knowledge systems (see Box 6).

Co-production of knowledge

Co-production is a method that can consciously be drawn upon to help in this process. It is used to bring together different knowledge sources, experiences and working practices from across different disciplines, sectors and actors to jointly develop new and combined knowledge for addressing societal problems of shared concern and interest (Learning Paper #7).

In a co-production process, knowledge brought by all actors needs to be equally valued and power relations need to be acknowledged and managed; partners, including people at risk, need to feel comfortable that their knowledge will be equally valued so that they can productively work together. There is great importance in developing a pluralistic understanding of differing cognition and worldviews in the thought collectives, a sensitivity to underlying power relations, integrating different interests and practices, and finally, developing skills in the facilitation of collective leaning processes such as organising workshops and spaces for interactive discussion as well as time and spaces for reflection and learning (Pohl et al., 2010) .

Participatory Scenario Planning

One way in which the BRACED programme has sought to integrate local knowledge with met services climate and weather information has been through a process known as Participatory Scenario Planning. This methodology was developed by CARE International principally in East Africa to help

Box 5 – Key findings from the UK Met research report: BRACED Burkina Faso (Zaman Lebidi) Indigenous indicators used for seasonal forecasts in northern Burkina Faso (Gallo and Henley, 2017)

The UK Met Office designed a survey to gain an overview of the various types of traditional indicators used by local people across various regions of Burkina Faso. Due to the variety of indicators used, the UK Met Office grouped them into the following categories below. This allowed a focus on the key indicators and helped provide consistency of survey results across all communities. The selected categories were:

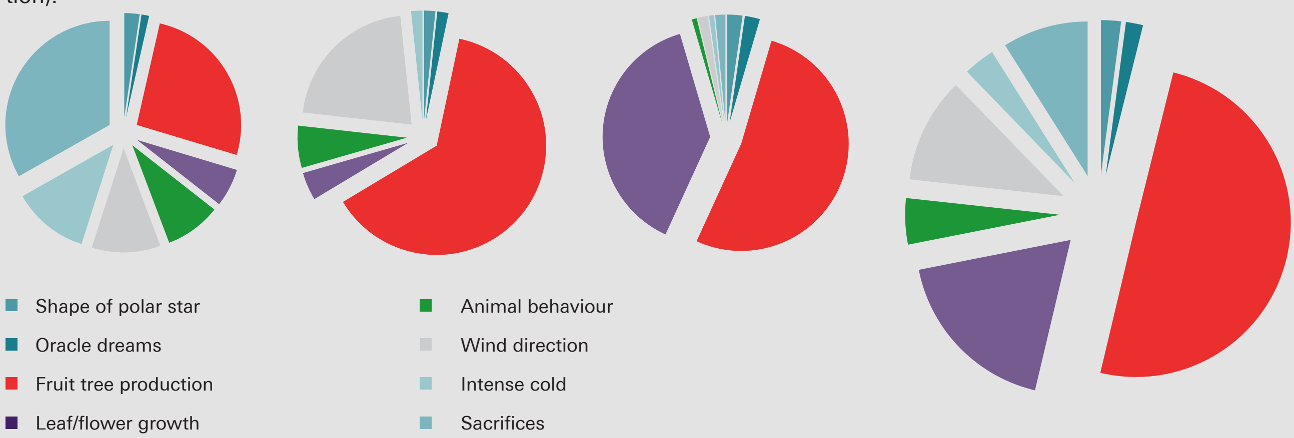
- Shape of polar star
- Bird behaviour*
- Wind direction
- Intense cold during previous winter
- Sacrifices
- Toad behaviour*
- Oracle dreams
- Production of fruit trees
- Leaves/flowers blossoming
- Insect behaviour*

* Note: In the following analysis, the insects, toads and bird categories have been merged in a fourth category called "animal behaviour".

A majority of answers (67%) indicates a use of traditional indicators for weather and climate information. The use of traditional knowledge is widespread in the Nord region (more than 87% of answers), whereas only half of the farmers use it in the Centre Nord (56%). No obvious link can be observed between the proportion of people reporting having received climate information in the past year and their use of traditional knowledge.

Figure 1 shows that across all survey results, the main type of traditional indicators used relate to trees – fruit tree production and the evolution of trees (blossoming of flowers, emergence of leaves) are cited by 50% and 18% as the main source of information, respectively. This is especially true for the Nord region, where those two indices represent more than 90% of answers. However, large discrepancies are visible across the three regions. The use of sacrifices to obtain information is common in the Centre Nord region, where it is the single most used indicator, but very limited in the other two regions.

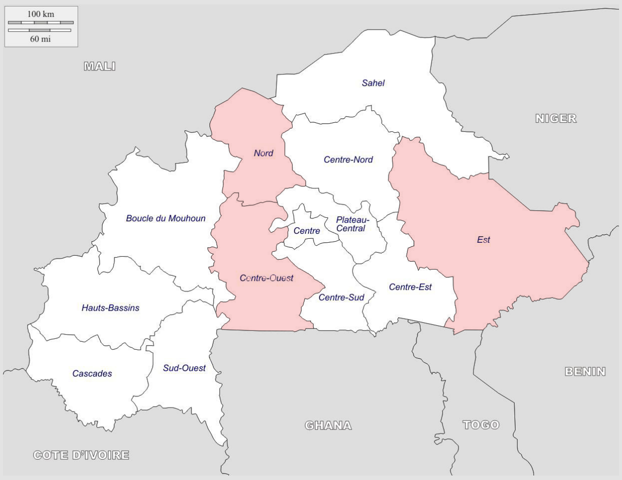
Overall, the traditional indicators are perceived as relatively reliable by the users of these indicators, three out of four answers describing them as sometimes reliable or quite reliable. This pattern is roughly the same in all three regions. The users from the Nord region appear to have even more confidence in these tools (no answers corresponding to a negative perception).



Reliability of Local Indicators

Another aim of the survey was to investigate the perceived change in the reliability of these indicators over the last few years and decades. Overall, the perception is that the reliability of traditional indicators has either decreased (55%) or stayed the same (36%). Only 6% of users perceived an improvement in their favoured indicator. The results in the different regions are similar; the proportion of users describing an improvement in the reliability is higher (14%) but still low in the Centre Nord.

When looking at the perceived timescale of any changes reported, the results are quite variable between regions. In the Centre Nord, 89% of the users who have noticed a change think it happened during the last 10 years, whereas in the Nord 75% think it occurred more than 10 years ago (including 42% for more than 20 years ago). Looking at the most used indicator in each region, this seem to have worsened over a longer period (since at least 10 years ago or longer), even though the timescales of changes for each tool is also quite variable.



Box 6 Knowledge and Power

We have already discussed how scientific information can serve to reinforce social norms and power hierarchies in the example of women missing critical climate information communicated via mobile phone or radio, since studies have shown they are less likely to own either of these (McOmber et al., 2013).

In the case of local knowledge, the power relations are no less problematic. Factors such as age, experience, wealth, production priorities, household circumstances, political power and gender have an impact on people's access to knowledge and ability to apply such knowledge (Briggs, 2005). It is therefore essential that an awareness of power dynamics in any knowledge system is present in any co-production process, and that knowledge power structures are not ignored or unwittingly adopted (Marchand and Parpart, 1995).

Box 7: Participatory Scenario Planning process

Through the Participatory Scenario Planning process, participants consider climatic probabilities (which are an expression of the uncertainty in the climate forecast); assess their likely hazards, risks, opportunities and impacts; and develop scenarios based on this assessment. Discussion of the potential implications of these scenarios on livelihoods leads to agreement on plans and contingencies that respond adequately to the levels of risk and uncertainty. PSP forms part of the adaptation planning process, making the link between community plans and local government responses and support, as well as higher level plans. The process outlined below is drawn from Care International's guidance (Care International, 2013):

1. Identify the **meteorological services and forecasts** available for the location where adaptation is being planned and plan the PSP workshop with them and key local actors.
2. Invite participants from a **relevant range of stakeholders**, including meteorological services and local/traditional forecasting experts.
3. **Exchange** seasonal climate forecasts from local and scientific sources.
4. **Discuss and integrate** the forecasts from the two sources.
5. **Participants interpret the seasonal forecast** into three probabilistic hazard scenarios, assessing risks posed by the hazards to develop impact scenarios. **Opportunities** in the coming season are also identified for each scenario.
6. **Participants discuss the local implications** of the impact scenarios considering the status of food security, natural resources, livelihoods and sectors.
7. **Participants discuss and develop actions** for each impact scenario, taking advantage of identified opportunities: What will communities, local government and local NGOs do? How will their actions be mutually supportive and respond to both the current situation and the expected forecast in relation to livelihood and sector priorities?
8. **Develop advisories from** the actions discussed: Locally relevant and actionable information, with agreed responsibilities among local actors.
9. **Communicate advisories** to users, for e.g. through radio, local monitoring or other institutional systems, religious leaders, chiefs, government departments, local groups, NGOs, media etc.

Girl grinding millet in Passoré, Burkina Faso, 2017. Ph: Camilla Audia

build adaptive capacity at the local level. It is a process for collective sharing and interpretation of both scientific and local climate forecasts which takes place once the seasonal forecast is available from the meteorological services. The idea is that the participants discuss and appreciate the value of the two perspectives and collectively find ways to interpret the information into a form that is locally relevant and useful (Care International, 2013). The process is summarised by the Canadian Coalition on Climate Change & Development in Box 7.

PSP has been adopted as a methodology in Burkina Faso by the Welthungerhilfe-Self Help Africa (WHH-SHA) BRACED programme[1]. For each geographic area where WHH-SHA is working a Participatory Scenario Planning session took place, engaging met services scientists, NGOs and local knowledge experts. A leaflet was then produced per locality describing the interpretation of the forecast for the season. This included the national met service's predictions (e.g. relative total predicted rainfall; probable dates marking the start of the rainy season) as well as the local indicators (e.g. bird migration; presence of certain insects; star constellations). Different scenarios were then elaborated in each leaflet, providing advisory actions for dealing with different weather conditions (e.g. instructions to dig drainage channels; recommendations to use mosquito nets).

As any methodology, PSP has merits and constraints. Observations from experts taking part in these processes perceive the approach to often focus on discussing local indicators as opposed to wider localised knowledge that does not necessarily translate into tangible indicators but is nonetheless essential to local decision-makers. An example would be local water and soil conservation techniques, potentially affected by climate extremes but rarely the focus of scenario planning. However, PSP provides a forum, a regular meeting point amongst scientists and decision-makers, which is an incredibly valuable resource to focus on longer term adaptation strategies leading to more resilient communities.

Next steps

To further examine the processes involved in combining local and scientific knowledge, King's College London (KCL) is undertaking research with the UK Met Office, funded by the Natural Environment Research Council (NERC). This partnership between KCL and the Met Office is a way of applying social science research to help climate scientists make full use of available resources, contextualise them at local scales and integrate participatory approaches.

The research has two key objectives. Firstly, it aims to build on data on local indicators collected by the UK Met Office in Burkina Faso during the BRACED project. KCL will examine further what these indicators mean, how they are used, who uses them and how they relate to social responsibilities. Secondly, KCL researchers will look at approaches being applied in Burkina Faso (and in the region) such as the Participatory Scenario Planning and examine the ways and extent to which co-production processes enable both scientific and local knowledge systems to combine. It will look at how co-produced outputs are used and take into account power dynamics present in these processes. Research will also include an appraisal of other consensus building methods and techniques with an aim to develop guideline and recommendations for the UK Met and national Met Offices.

References

Ackerley, D., Booth, B.B.B., Knight, S.H.E., Highwood, E.J., Frame, D.J., Allen, M.R., Rowell, D.P., 2011. Sensitivity of Twentieth-Century Sahel Rainfall to Sulfate Aerosol and CO 2 Forcing. J. Clim. 24, 4999–5014. https://doi.org/10.1175/JCLI-D-11-00019.1

Agrawal, A., 1995. Dismantling the Divide Between Indigenous and Scientific Knowledge. Dev. Change 26, 413–439. https://doi.org/10.1111/j.1467-7660.1995.tb00560.x

Antweiler, C., 1998. Local Knowledge and Local Knowing. An Anthropological Analysis of Contested "Cultural Products'' in the Context of Development." Anthropos 93, 469–494.

Banuri, T., Apffel-Marglin, F., World Institute for Development Economics Research (Eds.), 1993. Who will save the forests? knowledge, power, and environmental destruction. Zed Books, London ; Atlantic Highlands, N.J., U.S.A.

Berkes, F., 2018. Sacred ecology.

Care International, 2013. Building multi-stakeholder processes for climate change adaptation in Sub-Saharan Africa (Case Study). Canadian Coalition on Climate Change & Development.

Chesney McOmber, Amy Panikowski, Sarah McKune, Wendy-Lin Bartels, Sandra Russo, 2013. Investigating Climate Information Services through a Gendered Lens (Working Paper No. 42), CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). CCAFS, Copenhagen, Denmark.

Dekens, J., 2007. Local knowledge for disaster preparedness: a literature review. International Centre for Integrated Mountain Development, Kathmandu.

Dennis Martinez, 2010. The Value of Indigenous Ways of Knowing to Western Science and Environmental Sustainability.

Gallo, F., Henley, E., 2017. BRACED Burkina Faso (Zaman Lebidi) Indigenous indicators used for seasonal forecasts in northern Burkina Faso. UK Met Office.

Gorddard, R., Colloff, M.J., Wise, R.M., Ware, D., Dunlop, M., 2016. Values, rules and knowledge: Adaptation as change in the decision context. Environ. Sci. Policy 57, 60–69. https://doi.org/10.1016/j.envsci.2015.12.004

Ian Scoones, 1996. Range management science and policy: politics, polemics and pasture in southern Africa, in: The Lie of the Land: Challenging Received Wisdom on the African Environment. International African Institute, London, pp. 34–53.

John Briggs, 2005. The use of indigenous knowledge in development: problems and challenges. Prog. Dev. Stud. 5, 99–114. https://doi.org/10.1191/1464993405ps105oa

Kniveton, D., Visman, E., Tall, A., Diop, M., Ewbank, R., Njoroge, E., Pearson, L., 2015. Dealing with uncertainty: Integrating local and scientific knowledge of the climate and weather. Disasters 39.

Learning Paper #1, Rigg et al, Building Resilience to climate shocks and stresses: addressing the knowledge gap, King's College London and Christian AID, available at: https://goo.gl/nIF4jy

Learning Paper #7, Visman et al, Underpinning principles and ways of working that enable co-production, King's College London and Christian AID

Lemos, M.C., Kirchhoff, C.J., Ramprasad, V., 2012. Narrowing the climate information usability gap. Nat. Clim. Change 2, 789–794. https://doi.org/10.1038/nclimate1614

Lumbroso, D., Hurford, A., Winpenny, J., Wade, S., 2014. Harnessing hydropower: Literature Review. https://doi.org/10.12774/eod_cr.august2014.lumbrosoetal1

Marchand, M.H., Parpart, J.L. (Eds.), 1995. Feminism/postmodernism/development, International studies of women and place. Routledge, London ; New York.

Mazzocchi, F., 2006. Western science and traditional knowledge: Despite their variations, different forms of knowledge can learn from each other. EMBO Rep. 7, 463–466. https://doi.org/10.1038/sj.embor.7400693

Patt, A., Gwata, C., 2002. Effective seasonal climate forecast applications: examining constraints for subsistence farmers in Zimbabwe. Glob. Environ. Change 12, 185–195. https://doi.org/10.1016/S0959-3780(02)00013-4

Patt, A., Suarez, P., Gwata, C., 2005. Effects of seasonal climate forecasts and participatory workshops among subsistence farmers in Zimbabwe. Proc. Natl. Acad. Sci. 102, 12623–12628. https://doi.org/10.1073/pnas.0506125102

Pohl, C., Rist, S., Zimmermann, A., Fry, P., Gurung, G.S., Schneider, F., Speranza, C.I., Kiteme, B., Boillat, S., Serrano, E., 2010. Researchers' roles in knowledge co-production: experience from sustainability research in Kenya, Switzerland, Bolivia and Nepal. Sci. Public Policy 37, 267–281.

Roncoli, C., 2006. Ethnographic and participatory approaches to research on farmers' responses to climate predictions. Clim. Res. 33, 81–99.

Roncoli, C., Ingram, K., Kirshen, P., 2002. Reading the Rains: Local Knowledge and Rainfall Forecasting in Burkina Faso. Soc. Nat. Resour. 15, 409–427. https://doi.org/10.1080/08941920252866774

Sillitoe, P., 1996. A Place against time: land and environment in the Papua New Guinea highlands, Studies in environmental anthropology. Harwood Academic Publishers, Amsterdam, The Netherlands.

Tall, A., Mason, S.J., van Aalst, M., Suarez, P., Ait-Chellouche, Y., Diallo, A.A., Braman, L., 2012. Using Seasonal Climate Forecasts to Guide Disaster Management: The Red Cross Experience during the 2008 West Africa Floods. Int. J. Geophys. 2012, 1–12. https://doi.org/10.1155/2012/986016

Warren, D. M. (1991) 'Using Indigenous Knowledge in Agricultural Development', World Bank Discussion Paper 127. Washington, DC World Bank.

UNESCO ; What is Local and Indigenous Knowledge? http://www.unesco.org/new/en/natural-sciences/priority-areas/links/related-information/what-is-local-and-indigenous-knowledge/

1. "Changing farming practices to prepare for heavy rain and high temperatures" project is one of the two BRACED projects in Burkina Faso. Led by Welthungerhilfe (WHH) and Self Help Africa (SHA), the project aimed at building the economic, ecological and organisational resilience of 620,000 rural people in Burkina Faso and strengthen their ability to cope with the effects of increased rainfall variability and higher temperatures. This will be achieved by diversifying agricultural production and increasing incomes (through improved, sustainable access to drought-tolerant seeds, soil fertility improvement and enterprise development), together with strengthened government extension services to reduce crop losses and early-warning weather systems. The project ran from 2015 to 2018 and a small extension will see it run until 2019.

This material has been funded by UK aid from the UK Government. However, the views expressed do not necessarily reflect the UK Government's official policies.

Authors : Frances Crowley, Camilla Audia, Emma Visman, Mark Pelling