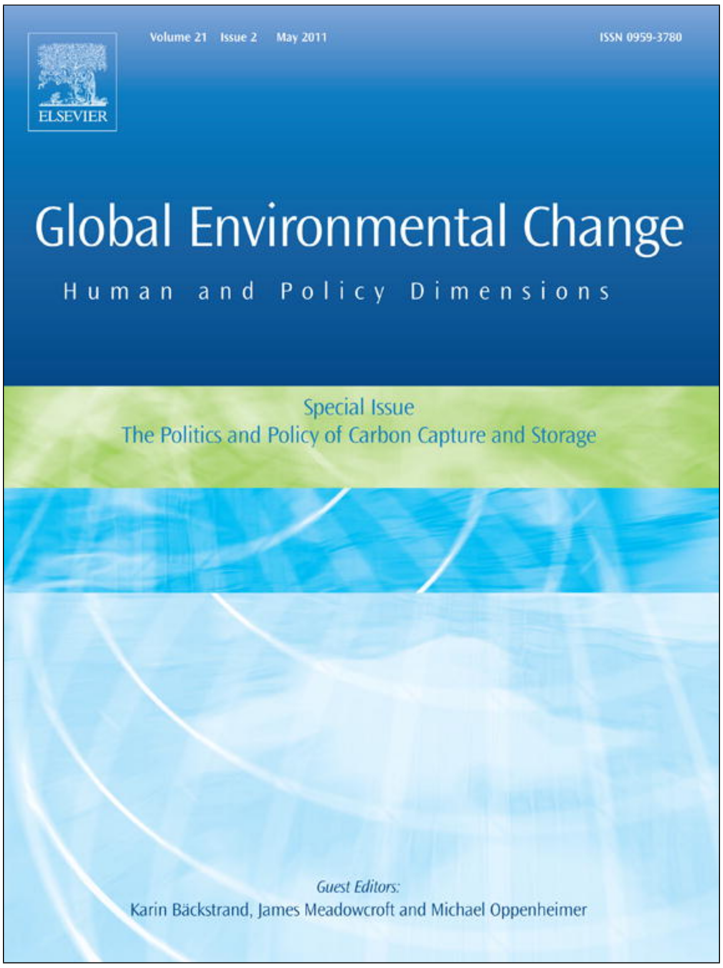
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Knowing, farming and climate change adaptation in North-Central Namibia

Andrew J. Newsham [a,b,*], David S.G. Thomas [b]

[a] Institute of Development Studies, University of Sussex, Brighton BN1 9RE, UK
[b] Tyndall Centre for Climate Change Research, School of Geography and Environment, University of Oxford, South Parks Rd, Oxford OX1 3QY, UK

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ABSTRACT

The agro-ecological knowledge held by Ovambo farmers in North Central Namibia has, for centuries, given them resilience to high levels of climate variability and associated impacts. New research, conducted in North Central Namibia, suggests that knowledge co-production between farmers and agricultural extension workers may, in addition, strengthen adaptive capacity to future climate change. However, this useful kind of knowledge co-production is far from automatic, and indeed the conditions which make it more likely to happen are not well understood. This paper explores agro-ecological knowledge in North Central Namibia as adaptive capacity, and suggests avenues for better conceptualising and understanding the conditions for adaptive capacity-enhancing knowledge co-production.

1. Introduction

The role of local knowledge(s) and capacities has long been a focus within development studies. This much can be gleaned from even a brief acquaintance with the overlapping literatures on 'farmer first' approaches to agricultural development, livelihoods and participation (Chambers, 1997; Chambers and Conway, 1992; Cooke and Kothari, 2001; Fals-Borda, 1991; Hickey and Mohan, 2004; Richards, 1985). Some of the writings on drought, famine and posited degradation in West Africa have, likewise, emphasised the hardy adaptive capacity displayed by farmers in response to climate and other stresses which threaten or decimate harvests and livestock (Mortimore, 1989; Reij et al., 1996; Tiffen et al., 1994). 'Traditional ecological knowledge' has, too, been claimed as a potential source of resilience (see Berkes and Folke, 2000 for a review).

From these beginnings it is a short leap to considering local knowledge in relation to climate change. It was covered by the IPCC's Working Group II in the Fourth Assessment Report (see Boko et al., 2007 for African examples); although some deem this engagement too fleeting (Salick and Ross, 2009). The best-known examples are from the Arctic (Cohen, 1997; Ingold and Kurtilla, 2000). It was within this literature that the value of local knowledge was given primacy, be it to complement scientific climate data, to provide insights about and for climate change adaptation or as a source of community-based environmental monitoring (cf. Krupnik and Jolly, 2002; Riedlinger and Berkes, 2001). There have since been a number of special issues, in *Ecology & Society* (Folke, 2004), *Global Environmental Change* (Salick and Ross, 2009), *Polar Research* (Ford and Furgal, 2009) and *Climatic Change* (Green and Raygorodetsky, 2010) which further champion the value of local knowledge for understanding and dealing with climate change.

This paper adds critical mass to this agenda by extending its empirical coverage: it explores the extent to which agro-ecological knowledge held by Ovambo farmers in North Central Namibia constitutes adaptive capacity to climate change impacts. It has two core objectives. The first is to leave beyond doubt the imperative need for Namibian climate change adaptation policy to engage with this knowledge system, especially given the uncertainties inherent in the projected impacts of climate change for Namibia. Such are these that the one national climate change assessment, which generated downscaled climate projections for the country, concluded that it remained unclear *what* Namibians would have to adapt to (Dirkx et al., 2008). Conversely, agro-ecological knowledge in North Central Namibia has provided farmers with resilience in the face of a highly variable, and hence uncertain, climate for perhaps hundreds of years. There is a literature on this knowledge in North Central Namibia, but it has little to say, *explicitly*, about the adaptive capacity to climate variability that is built into the knowledge system. We tease this point out of this literature, and add to it results from fieldwork conducted in the Omusati Region of North Central Namibia. In so doing, we show *how* local agro-ecological knowledge has permitted farmers to build enduring resilience to adverse climate impacts. We warn against, however, romanticisation: current farming practice is implicated in land degradation processes in North Central

* Corresponding author at: Institute of Development Studies, University of Sussex, Brighton BN1 9RE, UK. Tel.: +44 (0) 1273 915 791.
E-mail address: a.newsham@ids.ac.uk (A.J. Newsham).

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Namibia; although, we argue, to what extent remains unclear (Kreike, 2010; Newsham and Thomas, 2009; Sullivan, 1999).

Our second objective is to document instances of knowledge co-production, in which local agro-ecological knowledge and agricultural science are combined, and in ways that foster the kind of adaptive capacity likely, we argue, to help farmers deal better with future climate change impacts. Berkes (2004) argued that there are few examples of science and local knowledge being fitted together to provide input into resource management. Happily, however, in the case of Southern Africa, there are a number of examples of instances where this has been attempted, with encouraging results (Reed et al., 2007, 2008; Stringer et al., 2007, 2009). Here we add a Namibian case study to this exciting body of work.

Another link-up to broader debates arises from our more extensive use of the literature on science and technology studies (STS). This is poorly represented in debates on local knowledge and climate change adaptation, despite offering many theoretical and empirical resources on which to draw. These open up space for local knowledge by challenging the basis for the privileged truth status scientific knowledge is routinely given, yet without adopting an intrinsically 'anti-science' position (Barnes et al., 1996; Latour and Woolgar, 1979).

We deploy STS perspectives to situate our use of the term 'co-production' in firmer theoretical terrain. 'Co-production' is referred to with ever greater frequency, for instance in environmental governance (i.e. Cash et al., 2006; Green and Raygorodetsky, 2010). Our own use of it, to refer to instances of new knowledge made through the interaction of people with local agro-ecological knowledge and people with agricultural scientific knowledge, is similar to these usages. But there are other aspects of co-production which, we argue, must also be acknowledged; not least that "we gain in explanatory power by thinking of natural and social orders as being produced together" (Jasanoff, 2004a). Sheila Jasanoff has argued that accounts of the co-production of science and social order "seek to understand how particular states of knowledge are arrived at and held in place, or abandoned" (Jasanoff, 2004b). This is an objective of critical importance in the context of identifying useful knowledge for climate change adaptation. It helps us to focus on which knowledge is or is not taken into account and, thereby, the knowledge politics inherent in the process. It challenges us to think of what might be done to bring together different people with different knowledge in ways which foster resilience. At the same time, however, it obliges us to acknowledge the risk that knowledge co-production may entail co-option of local knowledge with a scientific agenda that is not necessarily shared locally (Clark and Murdoch, 1997). And it is in this spirit of caution that we clarify, in respect of our own work, the importance of examining the conditions which shape knowledge co-production in our own fieldsites.

The paper is structured as follows. Section 2 briefly reviews the literature on agro-ecological knowledge in North Central Namibia, and shows how such knowledge can be considered adaptive capacity. It introduces the study area, field sites and outlines the research methodology. This prepares the ground for a core research focus: the extent to which this knowledge system can *also* be taken as a proxy for adaptive capacity to future climate change. This question is explored in section three, which combines the results and discussion. Noting that this research is the start, not the end, of an ethnography on the promise and pitfalls of knowledge co-production for strengthening adaptive capacity, the conclusion charts avenues for further research and flags the work of STS veteran Harry Collins (2004) on 'interactional expertise'. This we present as a useful conceptual resource for delineating the minglings and mismatches of knowledge co-production between farmers and extension workers.

2. Materials and methods

2.1. Agro-ecological knowledge, adaptive capacity and resilience in North Central Namibia[1]

An exciting literature has delineated the contours of agro-ecological knowledge of the Ovambo peoples in Northern Namibia (for an overview see Shitundeni and Marsh, 1999; Verlinden and Dayot, 2000). In order to understand its contribution to farmers' adaptive capacity to climate variability, it is necessary to give an overview of this knowledge system. Researchers such as John McDonagh and Alex Verlinden have documented the classification system which farmers in Northern Namibia employ when making decisions about crops and livestock (Hillyer et al., 2006; Verlinden and Kruger, 2007). Farmers draw upon a sophisticated understanding of the productive potential of their environment, which Hillyer et al. (2006:252) refer to as an "indigenous land unit framework".

'Indigenous land units', or types of land classified according to specific criteria, help farmers decide what type of crop to plant and where, according to the conditions expected for a given growing season. Verlinden and Dayot (2005) classify indigenous land units according to three broad sets of characteristics: soil, vegetation and landform. For each of these three sets, they identify a number of specific indicators, such as texture or hardpan depth for soil, species and structure for vegetation, and elevation or depression for landform. On this basis, particular land units have come to be associated with particular crops under particular conditions. For instance, *ehenge*, a land unit characterised by depressions in the landscape, is desirable for planting pearl millet in drier growing seasons. In wetter growing seasons, farmers prefer to plant pearl millet in *Omutunda*, a land unit characterised primarily by elevation, and held also to be more fertile. In contrast, other land units such as the sandy, dry and well-drained *Omufitu* tend to be reserved for legumes such as bambara groundnuts, where farmers would expect little from a pearl millet crop (see Hillyer et al., 2006 for a broader matching of crops to ILUs).

Land units also identify landscape features conducive to cattle grazing. Verlinden and Kruger (2007) documented the ten land units most popular for grazing purposes, finding a preference amongst farmers for *Omutunda*, *Omutuntu* and *Omuthitu*. As with cultivation, the range of land units used by people in the Oshikoto region gave them a flexibility to graze cattle in the face of a range of dynamic environmental states linked to climate variability. As Verlinden and Kruger point out, the search for land units best suited to grazing was another factor influencing settlement decisions. The centrality of agro-ecological knowledge to Ovambo social and economic organisation is difficult, therefore, to overstate.

Strikingly, studies which compared some (though not all) land units to scientific classification systems – derived from detrended correspondence analysis of cropping land units (Verlinden and Dayot, 2005), and canonical correspondence analysis of grazing units (Verlinden and Kruger, 2007) – found them to capture what, scientifically, we would term key ecological characteristics. Perhaps we might infer from this scientific robustness in the land unit system. There is no reason to presuppose that that this should not be the case, nor *a priori* to privilege scientific knowledge (cf. Barnes and Bloor, 1982; Thomas and Twyman, 2004). Yet it is worth emphasising, if only so as *not* to overlook valuable sources of knowledge.

[1] See Newsham and Thomas (2009) for an explanation of the choice of 'agro-ecological knowledge' as opposed to 'indigenous, 'traditional' etc.

The existing literature on the indigenous land unit system has, then, established its prevalence, utility, rigorousness and widespread application. We add to this another insight: such knowledge makes farming in North-Central Namibia more resilient to climate variability and impacts, spanning from recurring droughts to recurring floods. Understanding agro-ecological dynamics allows farmers to adapt cropping and livestocking strategies to the highly variable climatic conditions they encounter from one rainy season to the next. Hillyer et al. (2006) demonstrate this visually by mapping farms in the village of Oshaala, Omusati Region, onto the landscape. Most farms incorporated a number of land units, as opposed to picking one specifically. This is because different land units are recognised by farmers to perform well under different growing conditions. Flexibility is, then, key to the resilience of the system. Furthermore, the continued presence of settled agriculture in North Central Namibia, stretching back for perhaps 400 years (cf. Williams, 1994), suggests that the system has been enduringly resilient. Whether it can remain so in the face of future climate change is a core focus of the research (laid out in more detail in Section 2.4). Before addressing this point, we describe the empirical settings in which the research was conducted.

2.2. Study area and field sites

Fieldwork was conducted in 2008 at Outapi, the 'capital' of the Omusati region, and at Omufitugwanauyala and Oshikulufitu, two villages within the Anamulenge constituency, 20–30 km from Outapi. As Outapi houses the headquarters of agricultural extension services in the Omusati region, interviews with extension staff duly were held there. The brunt of the research occurred in Omufitugwanauyala and Oshikulufitu.

All the fieldsites are located in the *oshana* landscape of the wider Ovambo Basin, consisting of a series of southward-flowing, seasonal watercourses that carve gentle undulations across the land, and extending across the Omusati Region. In the rainy season, pools of water form, known in Oshivambo as *oshana*, (hence the landscape's name). Along with the fish they provide, *oshanas*[2] support various forms of tree and plant life that can be eaten or used for house-building, basketry or medicinal purposes (Mendelsohn et al., 2000).

In Omufitugwanauyala and Oshikulufitu (as in Omusati more broadly), livelihoods and land use are principally characterised by an agro-silvi-pastoral system (Marsh and Seely, 1992), combining livestock herding and small-scale cereal production, supplemented by the *oshana* resources. Off-farm diversification was occurring, especially in Outapi, a commercial centre, but less so in our rural fieldsites (see Table 1). The most recent Household Income and Expenditure Survey (NPC 2006) reported that 80.5% of Omusati residents named farming as their main source of income. This was reflected in Omufitugwanauyala and Oshikulufitu (see Table 1).

The favoured livestock is cattle, mostly of the Sanga variety (ibid). Donkeys are the only other large livestock, but smaller animals, including goats, pigs and chickens, are increasingly common, in line with a general decline in cattle ownership (Mendelsohn et al., 2000). Fruit trees – especially *Berchemia Discolor* and Marula – provide widely consumed wild fruit resources to supplement agricultural produce (Marsh and Seely, 1992).

Crop production in Omufitugwanauyala and Oshikulufitu, as across North-Central Namibia predominantly, is rain-fed, with pearl millet (or *mahangu* in Oshivambo) the staple crop, as well as maize and sorghum grown in smaller quantities (Mendelsohn et al., 2006). These cereals are supplemented by vegetables and legumes. Yields vary from year to year, for which the most significant climate driver is variation in rainfall (Mendelsohn et al., 2000).

[2] Strictly speaking *iishana* in the plural, but pluralised in Namibian English as *oshanas* (the convention we follow here).

Table 1
Livelihood options ranked according to their importance to household income.

Importance	Omufitugwanauyala	Oshikulufitu
1	Farming (livestock and crop)	Farming (livestock and crop)
2	Formal sector employment	Pension
3	Pension	Formal sector employment
4	Services and goods made to sell	Services and goods made to sell

The climate in the fieldsites, as in Omusati broadly, is semi-arid. Rainfall is seasonal, falling mostly from November to April (Mendelsohn et al., 2000:9). Median annual rainfall in Omusati, as measured between 1961 and 1998, followed a south-west to north-east gradient, from 240–300 mm in the south-west, increasing to 420–480 mm in the north east (Mendelsohn, 1999). In the northwestern most reaches of Omusati, where the fieldsites were located, median annual rainfall was calculated to be between 360 and 420 mm (ibid). Significantly, the coefficient of variation of annual rainfall in the fieldsite area was calculated as 40–50% (ibid), indicating starkly the magnitude in variability of growing conditions to which farmers have to respond.

Agro-ecological knowledge in Omufitugwanauyala and Oshikulufitu was distributed evenly between men and women. More substantial expertise in a given farming activity split along the same gendered lines as the division of farming activities, with men generally tending to livestock and women to cultivation. As such, vulnerability to climate impacts did not appear to be a result of access to agro-ecological knowledge. This is not to say, however, that vulnerability to climate impacts was therefore equally distributed across both genders. For instance, some widows in both villages had been dispossessed of valuable assets such as cattle, which were claimed by the husbands' relatives upon his death. Given the well-documented importance of cattle for food or cash access in North Central Namibia (i.e. Marsh and Seely, 1992; Williams, 1994), losing this resource could not but increase vulnerability to climate impacts.

Similarly, household visits conducted during field work suggested a positive correlation between wealth, farm size and variety of different land units on the farm. Poorer households tended to have smaller farms with fewer land units. New arrivals in the village also struggled to establish farms across more than one land unit, due to increasing competition over recent years to available land. This reduced the flexibility with which they could tailor their growing strategies to fit with the weather conditions of any given growing season.

2.3. Field site selection

The fieldsites were identified in conjunction with Alex Verlinden, perhaps the best-known (non-Ovambo) expert on agro-ecological knowledge in North-Central Namibia. Using satellite imagery accessed through ArcView GIS software, the two villages were chosen on the basis of their location in terrain characterised by the principal (visible) variations characterising different land units: elevation, soil colour and location of the villages relative to *oshanas*. Map b of Fig. 1 is one of the landsat images used for the purposes of fieldsite selection. From the presence of such variety, it was inferred that a number of different land units would be locally identified and used for cropping and livestock purposes. This inference was later tested in focus group exercises and farm visits, by identifying with farmers:

1. The land units present in and around their village.
2. The land units present on their farm and the crops cultivated on them (see Table 2)

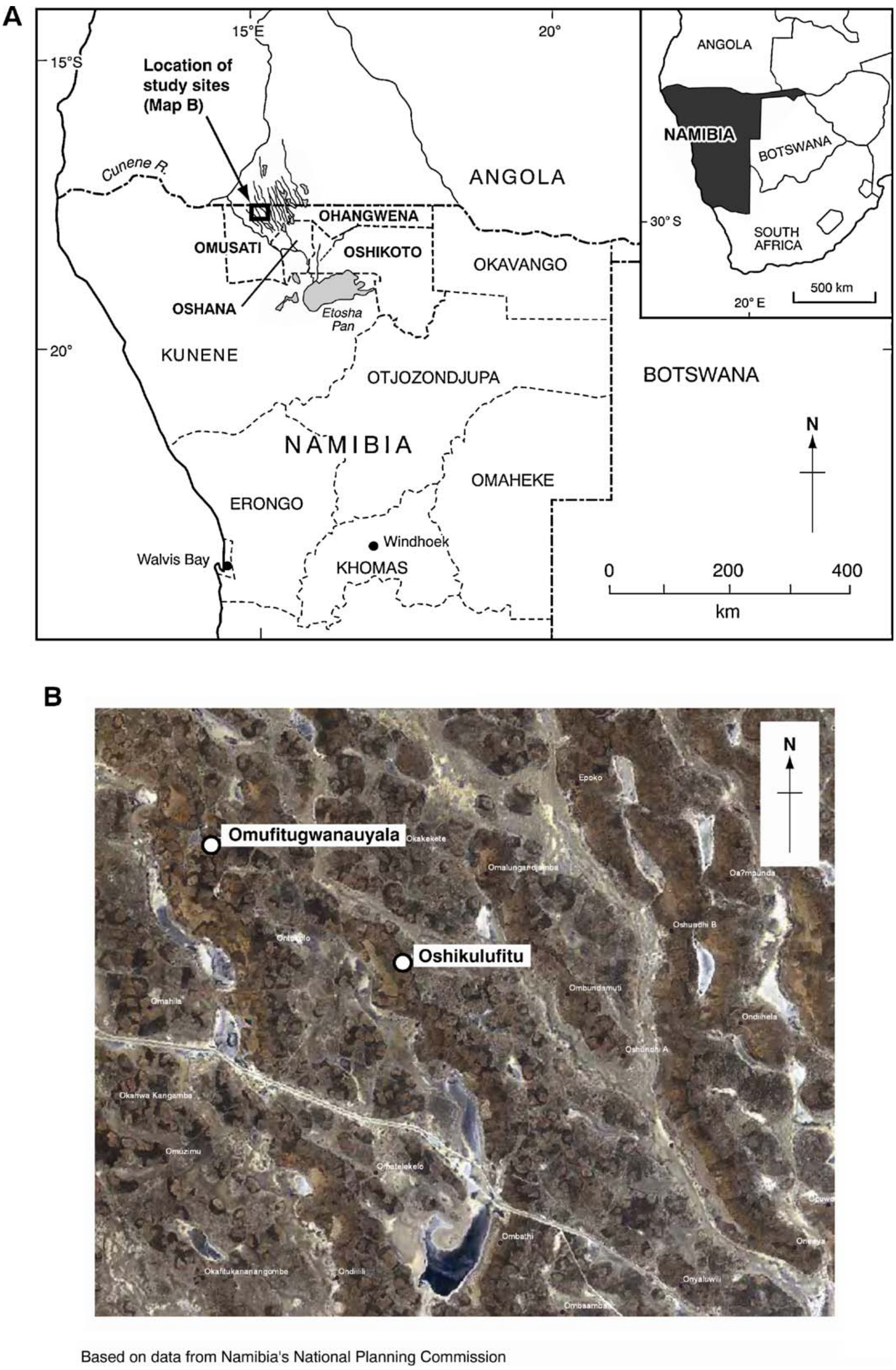

Fig. 1. Field sites in North Central Namibia.

2.4. Research questions and methods

We have argued in Section 2.1 that historically, agro-ecological knowledge in North Central Namibia has endowed the farming system with resilience to climate impacts. However, will agro-ecological knowledge prove a source of resilience to *future* climate change? Will current adaptive capacity, in the form of incremental adjustments to current farming practice, be sufficient to ensure continued system resilience? Or will adaptation entail system transformation, i.e. a move away from farming as the principal livelihood strategy? No research has, to date, considered these questions in the context of North-Central Namibia. This paper starts to address the gap, concentrating on the first and second of these three questions. The issue of system transformation,

Table 2
Land units and crops grown in Omufitugwanauyala and Oshikulufitu.

Land unit	Crop grown	Found in
Omutunda	Pearl millet (mahangu)	Oshikulufitu
Omuhenye	Pearl millet, beans, watermelon, squash	Oshikulufitu and Omufitugwanauyala
Ehenge	Nuts, mahangu, beans	Oshikulufitu and Omufitugwanauyala
Oshindabo	Sorghum, watermelon and maize	Oshikulufitu
Ehenene	Sorghum, maize, watermelon, matanga, beans	Oshikulufitu and Omufitugwanauyala
Ombode	Mahangu, sorghum, melon	Oshikulufitu and Omufitugwanauyala
Omufitu	Mahangu, beans, maize, nuts, pumpkin, watermelon	Oshikulufitu and Omufitugwanauyala

principally through livelihoods diversification, is dealt with elsewhere (Newsham and Thomas, 2009). The research findings presented in this paper sketch the outlines of a preliminary answer to this broader question, by examining:

1. Adaptations to farming practice over time; some of which constitute instances of knowledge co-production between farmers and agricultural extension workers.
2. The coping strategies people have developed in the face of extreme weather events, and their limitations.
3. Potential maladaptations in farming practice which could undermine system resilience.

The structure of Section 3 reflects this focus. We argue that, *to the extent that* agriculture remains an important livelihood activity into the 21st century, this type of agro-ecological knowledge is likely to be a source of adaptive capacity to future climate change. Moreover, agricultural practice has adapted considerably, over the course of the 20th century, to take advantage of the introduction of technological innovations.

The research adopted an essentially ethnographic and inductive approach (Fetterman, 1998). However, due to the short timeframe available for fieldwork, our findings should be considered as the foundations, not the final result, of a fuller ethnographic enquiry. Research utilised focus group exercises, semi-structured interview schedules with farmers, agricultural extension staff and policy makers, as well as farm visits. Four focus group exercises were conducted in Omufitugwanauyala and four more in Oshikulufitu, with 10–15 participants in each group, selected to be representative for age and gender. The exercises included timelines (cf. Estrella and Blauert, 2000; Reenberg et al., 2008) exploring memories of and responses to drought and flood, ranking exercises (cf. Chambers, 1997) on the relative importance of different livelihood activities. Issues emerging from the focus groups were further explored in 30 in-depth household interviews and farm visits, 15 in Omufitugwanauyala and 15 in Oshikulufitu.

Given how little is known about future impacts of climate change in North-Central Namibia (see Dirkx et al., 2008), adaptive capacity is not a value amenable to precise calculation. In such circumstances, from a resilience perspective, capacity to predict future climate change accurately and plan accordingly may be less important than flexibility in response to surprise and disturbance. The land unit system appears historically to have offered this flexibility. As Lugo argues (following Holling, 1986), the management of available natural resources "does not require a precise capacity to predict the future; but only a qualitative capacity to devise systems that can absorb and accommodate future events" (Lugo, 1995). For this reason, a core research aim was to capture *change* in local agro-ecological knowledge and concomitant changes in farming practice over time. This approach conferred three advantages:

1. It permitted an understanding of the ways in which such changes had enhanced or weakened the resilience of the farming system in the face of the climate variability experienced.
2. It shed light on the extent to which such changes were incremental in character or constituted a transformation to the system (Nelson et al., 2007).
3. It allowed clearer understanding of how responses to extreme climate impacts – notably droughts and floods – were more than short-term coping mechanisms, and fostered system recovery.

3. Results and discussion

3.1. Adaptations to farming practice over time as instances of knowledge co-production

3.1.1. Early-maturing varieties of staple crops

One of the most effective changes evidenced in Omufitugwanauyala and Oshikulufitu is the introduction of early-maturing crop varieties. Of these, far and away the most popular are the Okashana 1 and 2 varieties of pearl millet (*mahangu*). Zimbabwean in origin, they were first tested in Namibia in the late 1980s (Uno, 2005). Farmers highlighted two principal advantages over other pearl millet varieties. First, the length of time between seeding and harvesting is reduced; and second, they require less water to mature, and were therefore hardier in low rainfall conditions. Using these varieties is essentially an adaptation to the drier conditions characterising rainy seasons throughout the 1980s and the 1990s in Namibia and across Southern Africa. Yet they were also appreciated in wetter years: one focus group participant used early-maturing varieties to yield two millet harvests in growing seasons with good rainfall. There were disadvantages too. Some farmers found the taste of these varieties inferior to conventional *mahangu*; though others maintained "we cannot tell the difference!". They produce shorter, smaller plants than their longer-maturing counterparts. Finally, they cannot be stored for as long. Yet the increased likelihood of producing a harvest outweighs the disadvantages.

Unsurprisingly, given an agricultural extension presence in Oshikulufitu since 1992, all the research participants used Okashana varieties; often as a result of contact with extensionists. Significantly, though, uptake of the Okashana varieties was almost equally high amongst research participants in Omufitugwanauyala *despite* no extension presence. This change in cropping practice was, then, brought about just as effectively through social networks.

The introduction of early-maturing varieties such as Okashana 1 and 2 shows a clear tendency of farmers to mix the products of agricultural science with their agro-ecological knowledge. Critically, in this case it has strengthened resilience to impacts associated with drier conditions, and increased harvesting options in wetter years. It is, then, a fruitful co-production of knowledge between farmers and extension workers. And yet it is less clear that, conversely, agro-ecological knowledge is taken up by agricultural extension workers. For instance, Verlinden and Dayot (2005) point out that experiments involving fertiliser, at an agricultural experimental station situated exclusively on the *Omufitu* land unit, would have benefited from farmers' knowledge that the effects of fertiliser on *Omufitu* would be of comparatively short duration, disinclining them to use such a scarce resource on that particular land unit. Elsewhere, Hillyer et al. (2006) make a similar argument about an agricultural extension programme which sought to persuade people to use legumes and animal manure to boost soil fertility, with a view to strengthening yields of pearl millet. A central reason why farmers did not adopt the suggested practices, even when doing so appeared to be in their interests, was that their current decisions about where and where not to plant legumes, and for what reasons, was determined by the land unit framework. But this basis for decision-making processes was not understood by the extension programme.

Given the widespread use by farmers of the land unit system, it is surprising that it does not appear to find its way more systematically into agricultural extension, or indeed into agricultural policy more broadly. Verlinden and Dayot (2005:166) attribute this to "scepticism" on the part of scientists and extensionists. This plausible explanation nonetheless leaves room for further enquiry. Interviews with agricultural extension workers in Omusati and other Northern regions tended to confirm a lack of engagement with the land unit system. For instance, one extension worker conceded, "We go in with our own knowledge, we do not use the indigenous knowledge in our work". However it also underlined that it was not, on the whole, as a result of lack of exposure. Many of these extensionists – if not the majority – hailed from, as well as worked in, Northern Namibia and grew up with the land unit system prior to attending agricultural college. Such conditions might even be considered propitious for a cross-fertilisation of two partially separate, partially convergent knowledge sets.

In the light of well-rehearsed critiques of arrogant development intervention which failed to recognise knowledge and skills held by local people across the world (Chambers, 1983; Nelson and Wright, 1995), this apparent lack of engagement could well be interpreted as par for the course. But the extension services at Outapi do not easily fit this picture. Lukas Nantanga, then Senior Agricultural Extension Officer at the Outapi office, was a keen student and advocate of the 'farmer first' approaches that have been so instrumental in establishing the validity of local farming knowledge for agricultural development (Scoones and Thompson, 2009). His concern, rather, was that recent policy changes in the Ministry of Agriculture, Water and Forestry would replace the "bottom–up" extension he favoured with a "top–down" approach that pushed for rapid modernisation of subsistence agriculture. The result of such changes for farmers, he argued, was that "[agricultural] technicians now have to serve farmers food that the ministry cooked for you". It would be inaccurate, therefore, to pin labels of arrogance and complacency on Nantanga or the local-level extension services he headed.

Despite little systematic engagement by extensionists with the agro-ecological knowledge system, the willingness of extension services to work with farmers on their own terms may explain the popularity of agricultural extension services. As one Oshikulufitu farmer put it, "What we have learned [from extension services] is bringing us an improvement". Demand for them considerably outstripped supply in both Omufitugwanauyala and Oshikulufitu. Indeed, the chief complaint given in the Oshikulufitu focus group was "We are getting some service from the ministry but not enough". Furthermore, in the case of early-maturing varieties of pearl millet, farmers could see the benefits of an innovation which could slot easily into their agro-ecological knowledge system. Therefore, the level of extensionists' engagement with that knowledge system was not such an impediment to the uptake of the innovation, unlike in the example given by Hillyer et al. (2006). Nonetheless, these considerations touch upon the very conditions which facilitate or hinder knowledge co-production, a question which requires more extensive ethnographic research than was possible under the remit of this study.

3.1.2. Introduction of the donkey for field preparation

Another important change in farming practice flagged by the timeline exercises relates to the introduction of the donkey to plough the fields, which had hitherto been carried out manually. Farmers in Oshikulufitu traced the arrival of the donkey back to the 1950s, attributing the change to the influence of exposure to different farming methods arising from migrant labour patterns under South African rule. Ovambo farmers were induced in various ways to provide labour on the commercial farms owned and run by white settlers (Werner, 1998). Once on such farms, they learned the practice of employing draft animal power for ploughing and, thereinafter, became desirous of introducing the donkey on their own farms, sometimes accepting a donkey as payment for a season's work. Here, then, is another instance of knowledge co-production, the uptake of a technology probably because it slots relatively easily into the agro-ecological knowledge system.

An important consequence of this innovation, aside from its labour-saving attractions, is that it permits greater quantities of land to be prepared for cultivation. Either as an important response to unforeseen disturbances such as drought, or as a means of better exploiting the increased opportunities of a good rainy season, this extra capacity offers greater flexibility. Increasingly, moreover, the uses to which draft animal power is put have been extended. In Oshikulufitu, almost a third of farmers had experience of using donkeys for weeding as well as ploughing purposes. Mendelsohn et al. (2006) report that in Northern Namibia, weeding one hectare by hand takes on average 13 days, a figure which drops to 4 days with draft animal power, and 8 h with a tractor.

Increased use of the donkey is not, however, devoid of risk. Farmers in both villages highlighted difficulties in maintaining the efficacy of draft animal power in lean periods following droughts or floods. Although donkeys are ostensibly well-adapted to semi-arid environments, focus group participants viewed them as more vulnerable to the effects of drought than cattle. This is chiefly because donkeys, as a recent introduction to the North-Central environment, are not well-adapted to the range of potential sources of food. When grazing is unavailable, the local Nguni cattle can browse on a variety of different shrubs. Donkeys, conversely, appear unable to make this switch. There are knock-on effects for cultivation when donkeys are not strong enough to provide ploughing services. In addition, the more central to cultivation strategies donkeys become, the harder it is to sell them; unlike cattle, which can generate household income without reducing the likelihood of producing a harvestable crop.

3.2. Changes in livestock farming: mal-adaptation with serious implications for social-ecological system resilience?

In the literature on resilience, thresholds are expressed as boundary points, beyond which a social-ecological system undergoes a transition from one state to another (Berkes et al., 2003; Nelson et al., 2007); and which may be irreversible (cf. Walker et al., 2004). For those living within a social-ecological system, such transitions may be undesirable. In the context of the grazing system in North Central Namibia, it is legitimate to ask whether there could be in process a transition into an undesirable and/or irreversible state.

Focus group participants in Omufitugwanauyala and Oshikulufitu identified the decreasing tendency to practice transhumance as the most significant change to livestock farming practice within their lifetimes. Both in focus groups and individual interviews it was estimated that since the 1980s, it had become increasingly common practice to leave cattle all year round at the *ohambo* (cattle post). Formerly, cattle had been kept close to the village during the rainy season (October to May) and, with the arrival of the dry season, taken off to the *ohambo* where grazing was more abundant. Research participants thought that grazing around the village was no longer sufficient to maintain cattle, largely as a result of increased (human) population density in the area. This led to competition over land use between settlement and cropping on the one hand, and grazing on the other. Focus group participants also lamented that the distance between cattle posts and their village was increasing, as cattle were moved from nearer posts once grasses had been exhausted to posts further away. Participants expressed grave concerns about the durability of this practice.

This would appear to be evidence of a change from transhumance, assumed to have been predominant in Namibia (Marsh and Seely, 1992; Williams, 1994), to migration. This tendency has been documented at some length by Verlinden and Kruger (2007) who, in a study in the Oshikoto region, suggest that this migration practice has become so widespread that it has led to increased competition and conflict between herders and cultivators. They go even further, suggesting that what has been taken historically as a transhumance system may have in fact been all along a migration system, which has only recently become problematic owing to greater human and animal population density.This is an intriguing reinterpretation of livestock farming practice in North Central Namibia; albeit one for which no historical evidence is presented. Yet it fits with the general view of livestock farming in Namibia, embodied by the Government's Integrated State of the Environment Report (2006). This report concludes that "Large areas of land in northern Namibia are severely degraded due to deforestation, overgrazing, overstocking, high population pressure, unsustainable farming practices . . ." (Nangolo et al., 2006:viii). It ranks land degradation as the most urgent environmental priority for the country to address. Adding to the sense of concern is the increasing tendency of some farmers to fence off ostensibly communal land exclusively for their own livestock (Kerven, 1997; Marsh and Seely, 1992; Mendelsohn et al., 2006; Mendelsohn et al., 2000). Compounding these worries yet further are projections that grassy savannah will be overtaken by desert and arid shrubland as Namibia's most common vegetation by 2080 (Midgley et al., 2005). Bush encroachment on this scale would clearly have repercussions for grazing (but see Newsham and Thomas, 2009 for a sceptical review of these projections).

If local farming practice is so heavily implicated in degradation, then is it misplaced or misguided to attach so much importance to the agro-ecological knowledge on which it is based, or to present it as a source of adaptive capacity? In the light of these arguments, it may almost appear a rhetorical question, but it is in fact not nearly so clear-cut: this view of degraded landscapes is the subject of greater uncertainty than is commonly acknowledged. The State of the Environment itself concedes that there is no national measure of degradation "due to a lack of regular data" (2006:15). Given the vast literature on debates around the difficulties and dangers of inferring widespread degradation without sufficient evidence (i.e. Thomas and Middleton, 1994; Thomas, 1997; Swift, 1996; Robbins, 2004), it may be precipitate to make strong claims about its extent. Nor does the report give much attention to abiotic drivers of landscape change. This is especially pertinent given work done in Northwest Namibia that re-examined claims to land degradation purportedly caused by livestock farming, and found little or no evidence to support them (Sullivan, 1999; Ward et al., 2000).

In the context of North Central Namibia, recent work by Emmanuel Kreike (2009, 2010) challenges accounts of unilinear degradation over the course of the 20th century. These, he maintains, were not grounded in sufficient evidence and did not leave space for the possibility (and likelihood) that degradation levels could fluctuate in ways which reflected changing and often unstable conditions over time.

It would be well to heed Kreike's warning that we should neither assume local farming practice to be inherently or unchangingly sustainable or unsustainable. Nor can we ignore the ways in which, historically, it has been shaped by colonial intervention as much as by famine or flood. Without wanting to reify local agro-ecological knowledge, we maintain that the doubts raised about degradation by Kreike and other opens space to give this knowledge system more credit than it has historically received. We wish also to recast its relationship with agricultural science. It is not 'backwards' or 'primitive', to be replaced with more modern scientific practice, but rather a knowledge tradition that can and does mingle with the agricultural science available in North Central Namibia. This is not to romanticise local knowledge, and there is a clear case for advocating further historical research on how it has changed over time. Nevertheless, until the degradation thesis can be made less problematically, we cannot assume local farming practice to be on the brink of breaching a threshold; especially given the length of time large parts of that practice have persisted for.

3.3. Short and long term capacity for responding to extreme events

The damage caused by floods in 2008 and 2009 (cf. Rukandema et al., 2009) demonstrate unequivocally that farming, despite the adaptive advantages of the agro-ecological knowledge system, remains vulnerable to the effects of extreme events. When such events strike, people make recourse to a number of short-term coping strategies, most commonly:

- Sharing food with family and neighbours.
- Selling cattle.
- Hunting wild animals.
- Increasing consumption of hardier wild resources such as leaves.
- Digging wells for water.
- Government assistance post independence (from South Africa in 1990).
- Purchasing food to compensate for a shortfall.

Whilst many of these responses are of use for floods as well as droughts, farmers deal much better with the latter than the former. Many of these responses have changed over time. Game is no longer available for hunting. Digging wells for drinking water is less necessary because more boreholes are available. The element of reciprocity in food sharing has become ever rarer over time. Focus group participants identified an increased dependency on state aid, lowering peoples' capacity and willingness to assist neighbours.

Yet farming in North-Central Namibia is in many ways premised on the possibility of preparation for and recovery from the toughest years and, thereby geared more toward medium-to-long-term resilience than short-term coping capacity. Even in good years, surpluses are not sold at market, but stored in *eshisha* (grain storage baskets), to compensate for poor harvests. The same logic influences farmers' tendency to keep livestock herds and sell them only at times of distress, if they seem unlikely survive the dry season.

Whilst storage over sale is an idea unlikely to muster support within the World Bank as an agricultural development strategy, from an adaptation standpoint, it makes farmers in Omufitugwanauyala and Oshikulufitu less prone to 'double exposure' – that is, to globalisation *and* climate impacts simultaneously. A growing body of literature has argued that structural adjustment and trade liberalisation policies have weakened agricultural capacity in developing countries (i.e. Bryceson, 2004). Simultaneously, the push to sell produce on international markets has tied livelihoods into highly volatile international food prices, *and* led farmers to abandon crops better-adapted to local conditions for cash crops (Eakin, 2005; Leichenko and O'Brien, 2008).

Ultimately, however, focus group participants worried that they may not be able to deal with any increase in the frequency of extreme weather events of the kind projected for Southern Africa by Stige et al. (2006). Focus group participants in both villages were

Table 3
Early warning indicators used by farmers in Omufitugwanauyala and Oshikulufitu.

Indicator type	Indicator	Indicates
Plant	• *Uumpishi/uutwishi*, or mopane sugar, secretion on mopane leaf	Good rainy season
	• *Omhuzi* tree produces fruits before start of rainy season	Good rainy season
	• Trees and plants i.e. mopane lose leaves slowly	Poor rainy season
Animal	• *Oimote* birds seen walking on the ground	Poor rainy season
	• Appearance of small white butterflies	Army worm invasion next growing season
	• Goats give birth in April	Early onset of rains
Climate	• *edhiva* (mini oshana) holds first rain water for two weeks	Poor rainy season
	• Continuous or east-west winds in summer	Good rainy season

asked how many surplus-producing harvests they might expect to receive over a ten-year period. The answer varied between participants, but responses ranged from three to five years. Farmers in both focus groups perceived these conditions to be more difficult than they had previously been in the 1960s and 1970s, and worried that any increase in the frequency of dry years could make crop farming impossible. Likewise, farmers felt that they would require a period of at least five years to recover from the adverse effects of flooding at the scale of 2008; a finding which makes the 2009 reoccurrence of floods across North Central Namibia all the more disconcerting.

Moreover, many participants had lost confidence in the accuracy of their early warning indicators for wet or dry rainy seasons (listed in Table 3). TV and radio weather forecasts were frequently deemed too general for use in cropping and livestock decisions; a finding echoed in other work in the Omusati region (IECN, 2008).

4. Conclusion

4.1. Facilitating knowledge co-production to enhance resilience: interactional expertise and hybrid knowledge in Southern Africa

We have demonstrated how agro-ecological knowledge has imbued farming with resilience to climate variability in North Central Namibia, whilst noting that it is no panacea. Whatever the potential contributions or drawbacks of bringing the land unit system into climate change adaptation policy in the subsistence farming sector, they will inevitably be mediated through agricultural extension policy and intervention. In this regard, we have also argued that potential of instances of knowledge co-production between extensionists and farmers may serve as a proxy for adaptive capacity to future climate change. Yet the conditions for this type of co-production are not well-understood.

We conclude, then, with suggestions for furthering understanding of these conditions, which we argue are amenable to analysis informed by the concept of interactional expertise (Collins, 2004; Collins and Evans, 2002). Collins distinguishes between three states of expertise:

1. 'No expertise' of a particular body of knowledge.
2. 'Contributory expertise', having sufficient expertise to *practice* a given body of knowledge, and *add to or modify it* in ways that other expert users of that knowledge can engage with critically.
3. 'Interactional expertise', an 'in-between' state in which an individual possesses enough expertise to *understand* contributory expertises but cannot use it or do with it what contributory experts – "full-blown practitioners" – can (Collins, 2004: 125–127).

Michael Carolan (2006) deploys Collins' work on expertise to demonstrate its utility in a US agricultural setting. He found that local farmers with 'interactional' expertise in agricultural science had more helpful exchanges with agricultural scientists than did farmers without it. Likewise, agricultural scientists with interactional expertise of "farmers' talk" were able to make more targeted, intelligible suggestions to farmers; and in turn gained insights which made them rethink, and in some cases modify, agricultural science. One highly useful advantage of interactional expertise lies, then, in getting people who are contributory experts in *different* bodies of knowledge to make the effort to understand each other.

In the case of Omufitugwanauyala and Oshikulufitu, we could argue that farmers and agricultural extension workers possess contributory expertise in relation to agro-ecological knowledge and agricultural science, respectively. Measuring how much interactional expertise farmers and extensionists have in relation to each other's knowledge, how this is acquired and how to encourage it would improve understanding of the conditions for more fruitful forms of knowledge co-production. It is potentially empowering, too, for farmers, in that knowledge co-production offers the possibility not just of greater participation in agricultural development intervention, but of defining what there is to participate *in*. Finding out how to make it easier for both sets of 'practitioners' to acquire interactional expertise may therefore be a useful policy objective.

These considerations link up to another research agenda important in southern Africa. A number of commentators hold that not only can there often be a significant amount of overlap between local and scientific knowledge, but that bringing both to bear consecutively is more effective than employing either in parallel. This is because a co-produced or 'hybrid' knowledge base of this kind offers the opportunity to use advantages and avoid limitations found in scientific or local knowledge (cf. Reed et al., 2007, 2008; Thomas and Twyman, 2004). Work in Botswana to bring together scientific and local knowledge appears to have served as an inclusive exercise in knowledge co-production (Reed et al., 2007, 2008). A review of the potential salience of the Botswana experience in the Namibian context may prove a good launch pad for fruitful research into the interactions between local agro-ecological knowledge and agricultural science as used by the extension services.

Asserting that hybrid knowledge is *better* than scientific or local variants on their own is not raises questions when different knowledge sources disagree; nor does knowledge co-production occur in a power vacuum. For this reason, it is also important to understand better *what* agro-ecological knowledge counts for, and for whom. For better or for worse, the land unit system is what farmers use to make farming decisions. Bringing it more consistently into processes which attempt to bring about change in farming practice can only increase the legitimacy of the decision-making processes underpinning those changes.

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