Climate change adaptation, development and archaeology in the Amazon

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Introduction

Conservation, Historical Ecosystem Modifications and Climate Change

Mainstream conservation and management of ecosystems often follow the philosophy that humans need to be excluded from the natural world in order to protect it (Hance 2016a). While this may be justified in certain isolated cases, 'fortress-style conservation' is often problematic. Countless examples exist of native peoples being removed from their homelands in the name of conservation, often from places they have inhabited and influenced for hundreds of years (Geisler and De Sousa 2001; Hance 2016; Oxfam et al. 2016). This has led some Indigenous leaders to view 'conservation' as one of their greatest threats (Dowie 2009).

These exclusionary conservation regimes persist, despite mounting evidence that they are often based on false assumptions or incomplete evidence. Not only do they overlook the historical role of humans in shaping contemporary ecosystems (Comberti et al. 2015), they also fail to recognize that conservation involving local participation is almost always more successful for both biodiversity (Antunes et al. 2016; Nolte et al. 2013; Oxfam et al. 2016; Stevens et al. 2014) and local livelihoods (Callicott 2008; Dowie 2009; Hance 2016b).

The concept of socio-ecological systems (Berkes and Folke 1998) is fostered by the line of thinking that humans are a fundamental aspect of ecosystems (Folke et al. 2016). It acknowledges that a systemic approach, one which considers both social and ecological aspects of the system, is fundamental to addressing environmental challenges. Climate change adds an additional layer to this challenge: the question of how to best support successful, equitable adaptation while safeguarding biodiversity and livelihoods remains one of today's most urgent challenges (Hamann et al. 2015).

Ancient landscapes shaped by long-term interactions between humans and their environments have served as potent evidence of the role past human societies have played in shaping the current natural world; and this evidence cannot be ignored if we are to understand and protect our natural environment (Mayle et al. 2007). These groups often faced and adapted to environmental challenges analogous to those faced today, and this knowledge is often retained within cultures and landscapes. Evidence of historical solutions to climate change can prove vital for forging solutions to contemporary challenges (Cooper and Sheets 2012). Further understanding of the co-evolutionary development of humans and nature is therefore crucial to guiding ecosystem management, conservation and adaptation (Folke et al. 2016).

The Llanos de Moxos: Past Ecology, Society and Adaptation

Little was known about savannas in northeastern Bolivia until geographer William Denevan (1963) wrote his PhD, *The Aboriginal Settlement of the Llanos de Mojos: A Seasonally Inundated Savanna in Northeastern Bolivia*, which provided key evidence for his landmark article, *The Pristine Myth: The Landscape of the Americas in 1492* (1992). Denevan challenged the dominant assumption that pre-colonial lands were relatively untouched by Indigenous peoples across the Americas. Yet such assumptions had been core to the modern conservation movement that led to the development of the US's first national parks, widely associated with a "heroic pioneer past in need of preservation" (Pyne 1982: 17; quoted in Denevan 1992: 369). The forgotten reality of the significant demise of post-invasion historical societies played a large part in these assumptions, which were slowly being disproven as Denevan wrote. Archaeological discov-

eries of past human impacts on the ecosystem were propped up as key evidence, while several other archaeologists, geographers and cultural anthropologists augmented Denevan's work (for example, Balée and Erickson 2006; Erickson 2000; Markos 2012). The seasonal flooding of Llanos de Moxos, low-lying floodplains of the central Bolivian Amazonia, was central to the changing view of humans as vital elements of ecosystems, which overturned the dominant paradigm discussed above. According to Denevan (cited in Mann 2000: 789), the historical Indigenous Peoples of the region "created the environment we're trying to protect".

The region of Llanos de Moxos covers 160,000km^2 (approximately the size of England) and features at least 8,000km^2 of raised fields or *camellones* (Denevan 1963) over 1,600km of raised causeways or *terraplenes*, man-made canals (Denevan 1996; Erickson 2006), artificial lakes (Mayle et al. 2007) and artificial mounds or *lomas*, some monumental in scale (Balée and Erickson 2006; Lombardo and Prümers 2010). A flat expansive floodplain mosaic of forest and natural savannah, this landscape has been further enhanced and reshaped by the hands of ancient, forgotten societies. These societies transformed the ecosystem and the services it could provide, creating a system that is believed to have been an adaptation to severe and frequent flooding (Junk 2013; Lombardo et al. 2011). Llanos de Moxos, therefore, provides a useful example of landscape management, or landscape domestication, and the provision of services to ecosystems (Balée and Erickson 2006; Comberti et al. 2015).

Yet the past societies that created the cultural landscape of Llanos de Moxos are poorly understood. Archaeologists and anthropologists agree that the earthworks are evidence of a complex and advanced civilization (Balée and Erickson 2006; Erickson 2009). Although still unnamed, these civilizations appear to rival the complexity of the better-known Aztec, Inca and Mayan civilizations (Mann 2000). Differences in ceramic artefacts, settlement patterns and earthworks across the region suggest several interacting cultures (Dickau et al. 2012; Mann 2000). This, together with evidence of fish weirs (Erickson 2000), indicate that these civilizations had relatively intensive fishing and farming practices (Mayle et al. 2007). The chronology of the earthworks is uncertain, but it is likely that these landscapes were modified extensively for at least 3,000 years preceding the time of

the Spanish invasion in the sixteenth century (Erickson et al. 1991). The precise reasons for the collapse of the social network remain unknown, though Iriarte (pers. comm., 2016) asserts that it predates the arrival of the Spanish by just a few years. Others speculate on the decimating effects of smallpox, similar to the outbreak that affected the nearby Inca empire around 1525 (Mann 2000), or catastrophic droughts (Meggers 1994).

The environmental conditions, climate and forest cover of the region's past are uncertain, but some evidence suggests that there was previously less forest cover than there is today (Carson et al. 2014; Silva 2014). Using palaeoecological analysis, Carson and colleagues (2014) have shown that remaining savannas are likely to be natural and that such grasslands were likely more predominant in the recent past. The rainforested landscape may have resulted from a forest expansion around 3000–2000BP, possibly as a result of increasing precipitation across southern Amazonia (Carson et al. 2014).

The Ancient Landscape Today: Lessons and Insights for Adaptation

Today, the Llanos de Moxos region is home to a population of around 120,000, predominantly comprised of Indigenous communities. The climate is tropical, and many of the communities rely on subsistence farming, hunting, gathering and wage labour when available (Markos 2012). Recent development of local road networks has improved accessibility across the region, but since most of these roads are still unpaved, the rainy seasons can cause severe travel disruptions.

The ancient earthworks, raised fields, mounds, walkways and ditches lie hidden under forest canopy or are exposed by the deforested plots and natural savannah of the Moxos region. Where they exist around communities, they are often integrated into daily life. In some cases, whole communities persist on top of *lomas*, which can reach 13ha or more in area and over 20m in height (Markos 2012).

The region is experiencing possible early signs of climate change, which are manifested through an increase in the severity of flooding. Major floods have been occurring during the region's wet season between December and March annually, with particularly devastating events in 2006, 2007, 2008 and 2014 (Markos 2012). The severity of droughts also appears to be

increasing, with a state of emergency declared across the region during the 2016 dry season (La Razón 2016). The Bolivian government declared it the worst drought in at least 25 years due to its extremity and impact on crops and livestock. Indeed, an intensification of the hydrological cycle, bringing more extreme floods and droughts, is predicted for the region (Gloor et al. 2013). Similarly, warming global temperatures are anticipated to bring more severe El Niño events (Jiménez-Muñoz et al. 2016). The mean temperature of the Amazon basin has already increased over 0.5°C since 1980 (Jiménez-Muñoz et al. 2013). Changing rainfall patterns and extreme events have significant impacts on both crops and cattle raising, the mainstays of local livelihoods in regional Bolivia, especially in the Beni region where the Llanos de Moxos is located (Reyer et al. 2015; World Bank 2010).

These extreme weather events have catalyzed adaptation efforts in the region. Significantly, many of these efforts have been influenced by the historical archaeological features of the region, making the case a unique example of the impacts of Traditional Ecological Knowledge (TEK) on current-day responses to climate change.

Adaptation: Top-Down versus Bottom-Up

Adaptation to climate change, defined as a process of adjustment to climate stresses in order to avoid or moderate harm or exploit opportunities (adapted from IPCC 2014), will be critical for vulnerable regions such as Beni. Adaptation can be top-down, with strategies implemented by external organizations, or bottom-up, with largely autonomous decisions made by local peoples based on lived experiences and TEK. Populations most vulnerable to climate change are also those that exist in marginal spaces; many such populations are already being forced to respond to extreme weather events, even without external support (Nakashima et al. 2012). As such, autonomous, bottom-up adaptations are already occurring in line with cultural values, although top-down, development-style, formal adaptation planning is still the norm (IISD 2003; Thornton and Comberti 2013).

The Ancient Earthworks and Revitalization in Llanos de Moxos

Revitalization movements (Wallace 1956) are characterized firstly by people (or their leadership) who perceive their culture as a system under

stress and make deliberate moves to innovate or create a new and more satisfying cultural system. Berkes (2009) identified various revitalization movements, such as reclaiming Indigenous knowledge, strengthening cultures and asserting land rights. Such revitalization, he says, is "not merely a cultural exercise; it is about empowerment and political control" (Berkes 2009: 35). Thornton and Manasfi (2010) built on Wallace's work, identifying revitalization as one of eight key adaptation processes. However, little research has been conducted to aid understanding of the importance of or processes involved in revitalization for adaptation.

This study's data suggest that the ancient earthworks landscape of the Llanos de Moxos appears to have been involved in a revitalization movement across the region, driven by recent climate change and adaptation initiatives. The region presents a unique example of ancient practices and ideologies inspiring and informing current-day responses to unprecedented climate change. The historical earthworks have inspired both autonomous top-down and bottom-up adaptation projects. The situation therefore offers a unique opportunity to improve understanding of the role and importance of revitalization in order to adapt to climate change and, simultaneously, the synergies and trade-offs between top-down and bottom-up adaptation processes.

This paper will review both approaches to revitalization for adaptation where they occur in response to recent extreme flooding events, using the Llanos de Moxos and its *camellones* as a case study. Section Two discusses the planned, top-down development and Section Three studies the autonomous, bottom-up actions that are taking place. Section Four concludes with a discussion of lessons learned through the concurrent processes, the future of adaptation in Llanos de Moxos and the vital lessons for supporting successful adaptation elsewhere.

Methods

Data was collected during two fieldtrips to the Llanos de Moxos region, Beni, Bolivia, in 2016. These fieldtrips built upon initial research and interviews conducted in La Paz, Bolivia, in 2014.[1] The research involved:

(a) key informant interviews with employees from local NGOs, international NGOs and local government offices who were involved in implementing and managing new TEK-based adaptation projects;

(b) site visits and informal interviews at the locations of the new camellones programmes, accompanied by either project employees or local community members;

(c) visits to communities involved in the new raised field projects (Fatima, Santa Rosa, Loma Suarez, Copacabana) or isolated and accessible communities with archaeological raised fields or mounds on their territories (Bermeo, Santa Rosa, Ichasi Awásare, El Bury), as well as an additional isolated community not currently involved in the new programme, with no significant archaeological features nearby (San Jose del Cavitu).

Site visits began with introductory discussions with community leaders and presentations of the proposed research at community-wide meetings. Once permission for participant observation fieldwork was granted, semi-structured interviews, unstructured interviews and arranged visits to archaeological raised fields and lomas were conducted with guides from the local community.

Development and Adaptation: Climate Change as a Trigger

In 2008, a devastating flood struck the Beni state of Bolivia. It affected 120,000 people, around a quarter of the total population, and caused at least 60 deaths and more than $220m of damage (CEPAL 2008). This flood was a key trigger in catalyzing a project that attempted to recreate the region's ancient methods of flood adaptation (Painter 2009).

A small-scale experiment to rebuild raised fields was initiated in the town of Trinidad. These fields were some of the few structures that survived the widespread destruction of the 2008 flood, which sparked interest in the possibility of recreating these ancient structures on a larger scale (Quirogoa, pers. comm., 2014). Although Clark Erickson (1994) made attempts

1 Interviews were conducted in the summer of 2016 in Bolivia. Consultations with professionals are referenced as personal communications according to the individual's name. Formal interviews are listed below by name or have been anonymized according to each interviewee's wishes during the free prior informed consent protocol.

to recreate these structures, it was the idea that the new *camellones* could support adaptation to the increasingly severe impacts of climate change that was key to the renewed surge in interest. It attracted funding from Oxfam International, which was interested in instigating an exciting new climate change adaptation project based on local assets (Oxfam 2009; Painter 2009; Quirogoa, pers. comm., 2014). The implementation team was a local NGO, the Kenneth Lee Foundation, named after a petroleum engineer who was one of the original discoverers of the ancient structures across Beni (Markos 2012). By July 2009, the team was working with four communities around Trinidad to rebuild and revitalize raised field agriculture (Markos 2012).

The project aimed to be participatory, inclusive and locally empowering by including a series of community meetings to discuss the project. Information was disseminated through presentations and leaflets to ensure local understanding of the project aims, and efforts were made to identify local 'leaders' to act as mediators within the communities. Some of the communities agreed to participate, while others declined (Nakamura, pers. comm., 2016; Quirigoa, pers. comm., 2014).

Initial reports suggested that the project had been a great success. For example, Oxfam's 2009 report suggested that the raised field system significantly increased agricultural yields and harvest frequency (Oxfam 2009; Quirogoa, pers. comm., 2014). This meant that harvests were now sufficient to accommodate not only household consumption, but also the sale of harvest portions in local markets. As well as increasing local income, it granted more autonomy to women: they could now manage funds in addition to carrying out their traditional roles in farming (project employee, pers. comm., 2014). One report stated that the project had successfully increased the communities' resilience to climate change due to its reduced susceptibility to flooding (Oxfam 2009).

However, these initial reports of projected success may have been, at best, premature and exaggerated and, at worst, false. In fact, the project had failed in many fundamental aspects. The next section explores the reasons why the project was unsuccessful in transforming local circumstances.

Development Failures: What Actually Happened?

Many of the newly constructed camellones outside of communities now lie barren, with few being sown or used. Within local communities, low engagement, interest or even awareness of the project was observed. Fieldwork in 2016 revealed that few of the original projects remained active. Several factors, ranging from ecological to bureaucratic issues, may have been responsible for the project's failure.

Ecology

Field observations and interviews conducted with both community members and project workers suggest that the project had been compromised by one fundamental problem: soil management. Below a few inches of fertile soil lay many metres of clay-rich soil, used locally to bake bricks with solar heat. The process of constructing the new *camellones* involved digging up this clay using industrial diggers and laying it in attractive mounds atop the fertile soil. These *camellones* were extremely difficult to cultivate as the clay had baked in the sun, which came as no surprise to the local population.

The ecological unsuitability of the new brick-like *camellones*' soils for agriculture very rapidly dissuaded local workers from engaging with the project. As one community member (LC 2016) stated: "[the new *camellones*] don't provide us with any benefits at the moment; since the earth is hard, nothing grows. They've tried to plant on it already—nothing grows". Considering the future, he explained, "In 10 years there'll be weeds, forest, and some will die and provide some fertilizer. But right now, they don't work for anything". The *Coregidor*, elected leader, of the same community confirmed that a group had tried to cultivate the raised fields, but "the earth is too hard. We can't plant anything"(2016).

Some interlocutors reported that community members were paid daily wages to work on the raised fields when external funders visited. In addition, fertilizers were used by the NGO to boost yields. However, this was a temporary fix that did not resolve soil infertility problems, and which was ultimately an unsustainable long-term solution. Thus, the problem has persisted in the intervening years, as the project has

been handed over to the Ministry for the Environment and Water (MMA), which appeared to be replicating the original project's methods.

Organization of Labour

The NGO project required collaborative and communal labour on shared camellone plots. However, this type of social organization and shared labour went against existing production norms for the involved Indigenous communities (Markos 2012). Currently, communities in the region grow crops in small 1-2ha plots owned by single families, and produce is consumed within the single family farming it, rather than shared across the community as a whole. Even if the communities were willing to reconsider the project's suggested shared labour and product distribution approach, the scale of the project means its produce could not provide for a whole community, which was a critical challenge in community engagement. According to one member of the project (LM 2016): "If they plant on them [*camellones*], they'll give us a tiny amount—it isn't enough. It isn't enough for anything".

Practical Knowledge and Logistical Issues

The raised fields are just one part of a large and complex system. As Michael Nakamura (pers. comm., 2016) explains, the *camellones* are one of five key aspects of the system. They sit within a protected inner space created by *terraplenes* joined at the nodes by *lomas*, which create a barrier to regulate water influx and protect the inner space from flooding, thus maintaining optimum water levels in both wet and dry seasons via gates. Canals and artificial lakes are crucial to ensuring an adequate water supply.

One problem with the newly-built raised fields, according to Nakamura, was that they were not conceived in relation to the greater landscape: as a result, the water supply is inadequate. Poor planning means that canals to supply water are insufficient for the system's requirements.

The techniques employed in building the new *camellones* have further limited their potential. Large industrial machinery, including diggers and bulldozers, are used to dig trenches and canals and build raised fields and walkways. Transporting such machinery up the region's small rivers would be impossible; thus, these interventions are restricted to areas and communities acces-

sible by road. While the local government wanted to prioritize the region's most vulnerable communities, they were unable to do so since it was typically the communities lacking road access that were the most vulnerable.

Economy

The complexity of the new project setup also increased costs. The cost of constructing the camellones, according to Nakamura (pers. comm., 2016), is the single biggest challenge. The construction costs alone are estimated at $50,000 for 2ha of raised fields. To enable their uptake by the community, Nakamura estimates a minimum of two years of skill-sharing workshops, training and constant visits by local workers; this would cost around $4,000 per month in total.

Bureaucracy/Institutions

The new camellones project has also been thwarted by the organizational and bureaucratic situation in Bolivia. Changing government legislation created a barrier to the project's success. A 2013 law and presidential decree have made any work by NGOs beyond the government's control nearly impossible. Thus, many NGOs involved in local work, including the Kenneth Lee Foundation, have been forced to close.

The project was transferred to Bolivia's MMA, where the capacity and funding for on-the-ground, community-based work was vastly reduced. *Camellones* are still being built, but with very little community input and even less buy-in than before. One local government worker (Anon., pers. comm., 2016) involved in the project explained that the short funding cycles and long timescales necessary for effective community engagement mean that efforts to collaboratively decide where to build the new raised fields with the local Indigenous organizations have failed. The MMA thus decided where to build them very rapidly, with minimal community engagement, resulting in poor outcomes. There have been assertions that the *camellones* were left unfinished and that, with no fertile soil atop the raised beds, they are of very little use. As one local commented, referring to one of these failed MMA projects: "The company cheated us. They were supposed to put soil on top but they didn't. They did it cheaply and kept the rest of the money for

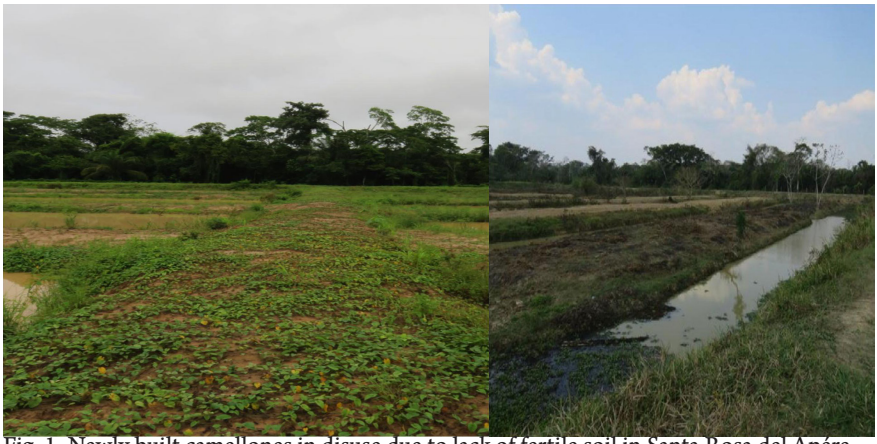

Fig. 1. Newly built camellones in disuse due to lack of fertile soil in Santa Rosa del Apére (photographs by Claudia Comberti).

themselves. It seems there's been some corruption. They said they'd come back to finish; I don't think they will now" (Anon., pers. comm., 2016).

These newly-built structures now generally sit completely unused and barren, gathering weeds, like huge monuments to failed development or 'development archaeology', as Markos (2012) fittingly described them (see fig. 1).

Climate Change

Finally, although the new structures were built with climate change adaptation in mind, the severity of the flood in 2014 exceeded what was thought possible for the region. Even those systems that had remained in use in one or two communities were compromised by the 2014 flood, which overwhelmed the system's defences and destroyed the raised fields' crops. In August 2016, those few systems that were still in use were dilapidated and awaiting improvements to raise external walls and provide fertile soil for the beds from the local government, which possessed limited funding and no fixed timeline.

It is evident that numerous factors contributed to the *camellones* project's failure to strengthen local climate change adaptation potential, as had been hoped. The successes of ancestral approaches proved too complex to

duplicate. After ignoring much of the TEK, the new projects would have required a complete restructuring of the current social, institutional, economic and environmental contexts.

Small Successes: Seed Banks

There have been, however, some positive, epiphenomenal effects of the *camellones* project. The greatest potential for the new *camellones* now appears to be their repurposing for use as seed banks. The 2014 flood destroyed entire fields of crops. Thus, a space where key crops can be maintained and protected is significant for community resilience. Carmen Rosa Belez Nosa (pers. comm., 2016), who is the director of the Fatima community's water committee and lost her crops in the 2014 flood, explained: "We're using them [new *camellones*] to protect the seeds, so we don't lose them [when a flood happens] and can plant them elsewhere. They're useful for that. But they're not [big] enough to provide for the whole community". Copacabana is one of the few other communities still showing interest in the *camellones* project one to two years after their construction. Although currently in a state of disrepair and disuse due to the 2014 flood, some community members expressed hope that the *camellones* could be revived and maintained as the community's seed bank.

Autonomous Revitalization of Ancient Earthworks for Adaptation

In addition to the planned, development-style earthworks rebuilding project, there is evidence of some bottom-up, autonomous responses that revitalize old knowledge and techniques. This section describes these uses pre- and post-2014 flooding, examine the reasons for post-2014 changes in use and consider potential adaptation going forward.

Earthworks Use Before the Floods

Many of the communities in the Moxos region have existed in between or, sometimes, on top of these ancient earthworks since their formation. One of these is the recently-founded community of Ichasi Awásare, where the existence of the ancient mounds and history of past inhabitancy were key to decisions to move there. In other cases, single households or families reside on these mounds. For example,

one community member still lives on the site where he was born, atop an ancient mound close to the current site of Bermeo community.

Community members in the Moxos region often use artificial mounds as hunting sites. In addition, there is often a particularly high density of fruiting trees atop the mounds or in their immediate surroundings, indicating past human seed dispersal of these tree species (for example, Balée 2013; Balée and Erickson 2006; Posey 1999; Posey and Balée 1989). The author visited one of these *lomas*, a three-hour walk from the community of Santa Rosa, that is often used for hunting. The community member who guided the visit explained that it is the fruiting trees that attract the animals. The peccaries enjoy the *chonta* (peach palm or *Bactris gasipaes*) fruits especially, he explained, and there were 22 chonta trees alone atop the *loma*, an area around 0.3ha. The *loma* also featured three motacú (*Attalea phalerata*), another edible palm fruit tree, as well as five other types of trees (some of which were used for construction and their bark used for clothes) and other 'useful' plant species, amounting to 45 species in total (Posey 1999).

Finally, where large expanses of raised fields exist close to communities, they have been used as refuges for cattle. The largest *terraplenes* house cattle at nighttime and also came into use during recent flooding events.

The Floods as Catalysts for Using Earthworks in Adaptation

The floods of 2008 and 2014 triggered changes in the uses of existing ancient earthworks around the present communities and, arguably, in their perceptions. During the 2014 flood, many artificial *lomas* were used as emergency refuges because they are, according to an elder (MY), "the only high place there is". When the waters rose in 2014, higher than anyone had seen in living memory, entire communities retreated to mounds and camped there for several days or, in some cases, weeks. As one community member remarked:

> The 2014 flood was huge! We had to leave to search for high ground. We found a *loma*, a big one, about 15ha—1km away, and there we set up a shelter—like what you're sleeping under [referring to my tarpaulin shelter]. We stayed for 15 days. The water went down a little, but there were tracks of caimans and snakes everywhere so we were scared to return to the house. Wild animals came to seek refuge on the *loma* too. Armadillos, wild pigs, deer… we had a lot of meat to eat!

> And the armadillos tried to get under our mosquito nets! For the warmth. And that's true, that's not a joke.

After the flood, many people began to search out more areas of high ground for longer-term flood relief, as sites on which to either build houses or plant their crops. As one community member explained, "I'm going to plant there again because maybe it'll happen again". This person was one of several undertaking a new adaptation strategy: revisiting abandoned ancient raised fields to plant crops.

Although a region of large ancient *camellones* has always existed close to the home of Humberto Temo Nuni of Bermeo and his brother, Eleutherio, they had never attempted to cultivate them before 2016. Humberto explained that their plan to plant there is an attempt to save seeds if another flood happens. "It's always good to be prepared", he cautions. "Maybe there'll be a flood this year—and where are we going to keep the seeds? We need to save them, so we're planting here". They are attempting, in other words, to turn these ancient *camellones* into their own seed bank.

However, not everyone agrees that the *camellones* are good sites for planting vulnerable crops and seed stocks. Some say the soil atop the ancient *camellones* is hard and thus difficult to cultivate or that the alternative practice of swidden agriculture on flat land is much easier.

In addition, there are grassroots initiatives for development-style projects, inspired by the ancient engineered landscapes, that community members believe will be useful for adapting to the increasing risks of severe flooding. In Santa Rosa del Apere, the community leader (LC) hopes to construct a raised causeway using the machinery employed in building the nearby trans-TIPNIS road. "When the machines come past to build the road, we're going to ask…if they can build us a *terrapléne* [causeway]... We'll use it if the floods happen again". The idea, he says, came from the earthworks nearby made by the "ancient peoples—by hand, it seems".

Analysis of the Situation Using a Framework for Transformational Adaptation

Thornton and Comberti (2013) propose a framework that describes key factors requisite for transformational adaptation to environmental change

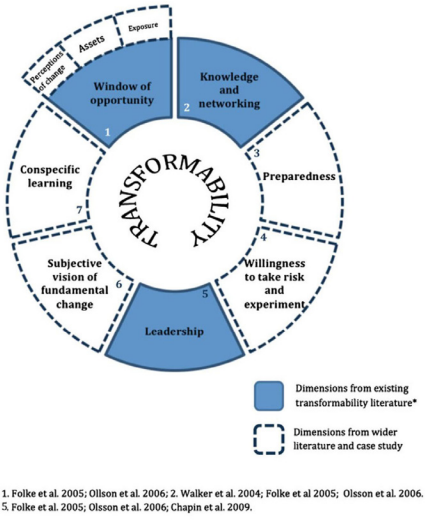

Fig. 2. A conceptualization of community based factors contributing to transformation adaptation (adapted from Thornton and Comberti 2013).

to occur in local communities (fig. 2).

Window of Opportunity

A trigger, such as an ecological crisis or social/environmental shock, may be required to provide an opportunity for a transformation or large-scale response to occur (Folke et al. 2005; Olsson et al. 2006; Thornton and Comberti 2013). The extreme flood of 2008 appears to have provided the window of opportunity to kick-start the new *camellones* project.

Assets, Exposure and Perceptions of Change

The scale or type of window required may additionally be determined by exposure to or shock following the crisis or shock, assets available for response and subjective perceptions of change (Thornton and Comberti 2013). The 2008 flood highlighted the vulnerability of the Beni region and its local communities in terms of flood exposure. Local people were also exposed to the potential to escape extreme floods atop camellones. There was international coverage of the flood's devastation, and international funds from Oxfam and other bodies were earmarked for projects to improve the situation through investment in local assets. The flood was also an indicator to local communities and practitioners alike that the climate situation posed by such extreme events was fundamentally different from what they had previously experienced. Further, these events were likely to continue or perhaps even worsen. Those perceptions were a key factor influencing behavioural responses to environmental change. As

Eleutereo Temo Nuni summed up the situation: "Nothing is certain now. With climate change, everything has changed a great deal".

Knowledge and Networking

Knowledge, including TEK, is key to a community's adaptive capacity (Berkes 2008; Levine et al. 2011), and networks distribute this knowledge and information relative to transformative change (Thornton and Comberti 2013). The idea of the *camellones* was spread by the increased attention on the region from international archaeologists after the discovery of the pre-Columbian earthworks. This enabled the dissemination of knowledge regarding the possible revitalization of this strategy as an adaptation response to current environmental vulnerabilities. The knowledge was shared as a technical strategy through local NGOs, connecting communities with project ideas. The TEK related to camellones construction and cultivation, however, was less accessible, since the traditional social and labour organization to support these earthworks had not been in practice in many places for generations.

Preparedness

The presence of plans or ideas for coping with future shocks can facilitate transformational change projects (Olsson et al. 2006). Ensuring preparedness among local communities can be a long process of meetings, dissemination of information and engagement with key figures. This was apparently attempted in the initial development projects run by the Kenneth Lee Foundation (Nakamura, pers. comm., 2016; Quirogoa, pers. comm., 2014), and, in some cases, local community uptake was successful. However, later iterations of the project have not been adopted, in part due to the lack of socio-ecological fit with the needs of local communities, as demonstrated above.

Willingness to Take Risk

Willingness to experiment and take risks is important due to the high commitment of labour and time involved in the *camellones* development project and the magnitude of uncertainty involved in contemporary climate change (Chapin et al. 2009). If there is a perception that the project

will fail, willingness to spend numerous working days planting and maintaining the raised field system is compromised due to the risk of costs outweighing potential benefits. The initial issues related to soil were perhaps enough to put people off, and failures in regards to subsequent flooding presented additional early failures that broke crucial confidence and, thus, communities' willingness to take risks with the system. However, risk aversion should not be confused with learning from experience. Indeed, the negative experiences with the severe floods made planting on ancient *camellones* seem like a risk reduction strategy for a number of local farmers. Willingness to take risk depends on perceptions of different sources of risk.

Leadership

Leadership may be vital to initiating and guiding transformations (Folke et al. 2005; Olsson et al. 2006) and is central to catalyzing revitalization movements (Wallace 1956). In this case, one local champion was crucial to initiating the development project: Oscar Saavedra, a Trinidad local, gathered local interest, external funds and momentum to support the idea. Although local, he was not Indigenous. For success in adaptation to climate change, it is important that the revitalization leadership ensure that the camellones continue to meet the exigencies of changing social and ecological conditions without placing undue risk or stress on communities.

Subjective Vision of Change

Traditional knowledge, customs and beliefs are fundamental in shaping and sanctifying visions of change (Thornton and Comberti 2013). It may be that, although based on ancient cultures, the *camellones* project was insufficiently conceptualized as a revitalization movement at the community level. The vision of the *camellones* was primarily one of a technical quick-fix (see Sterner et al. 2006), rather than a social-ecological-technical complex requiring a local vision of cultural revitalization broader than just the adoption of the earthen mound technology itself. The significance and local interpretations of the *camellones* were not considered. Equally, the geophysical role of the *camellones* within a larger, multi-component water management system was not taken into account. Critically,

the *camellones* were not sufficiently reconsidered within the context of ongoing cultural and social change experienced by the local communities.

Conspecific Learning: Los Antiguos

A necessary factor of transformational change is that options are learned from or shared by others who are perceived to be sufficiently culturally similar to allow the learner to see the idea as plausible (Thornton and Comberti 2013). The ancient peoples, "*Los Antiguos*", are recognized by contemporaries as 'conspecifics'—that is, ancestors like themselves—with local knowledge and wisdom that is relevant to continued thriving in these cultural landscapes. People brought up stories of "*Los Antiguos*" often; any connection with them is clearly a source of pride and legitimacy for current Indigenous communities, and the structures they left behind are respected as legacies of that wisdom. As one community member said of the ancient lomas, "*Los Antiguos, los abuelos* [the Ancient Ones, the grandfathers] built them—to put their houses on. They knew very well that the land could flood in the rainy season". He went on to explain that he had chosen the site of an ancient loma for his current house. On the one hand, these ancestors made the project seem possible and appealing, since it had been done in the past, revitalized past wisdoms and offered a connection with the ancestors. On the other, the incredible feat of these ancient peoples was so great that many see it as unattainable in the present. In stories of "*Los Antiguos*", many would mention their bravery and dedication: "They were strong, they worked hard" (HB). In contrast, there is a pervasive idea that the feats of the ancient peoples cannot be replicated. As JB said of the ancient loma of Ichasi Awásare next to her house: "The *tata abuelos* [great grandfathers] built it, because they were brave, not like us, we're lazy now".

Discussion and Conclusion: Autonomous and Planned Adaptation in Llanos de Moxos: Failures, Successes and Lessons Learned

The ancient earthworks of the Llanos de Moxos have been revived for climate change adaptation, both autonomously by local peoples and through a parallel development programme. The TEK of "Los Antiguos", transmitted via the ancient peoples responsible for the earthworks, has been important. The knowledge has provided a potent

ancestral reminder of pre-existing local knowledge and solutions relevant for current climate change adaptation. In addition, they have offered inspiration for reviving old structures autonomously and formed the basis of a prototype for the construction of new *camellones*.

At the same time, the case of the *camellones* shows that, as social and ecological conditions change, the translation of ancient knowledge and practices into contemporary contexts is not necessarily straightforward. Archaeology, in combination with contemporary ethnography, has an important role in contributing knowledge not only about ancient technologies, but also about the socio-cultural systems of organization and meaning in which they were able to function. It may be impossible for climate adaptation technologies to materialize changed circumstances when used in isolation. The differences between the successful, autonomous revitalization of traditional *camellones* and the failed, externally-led development project *camellones* seem to lie largely in the processes of adaptation, particularly in how people perceive potential integration of socio-ecological changes in relation to TEK and practices. Local recognition of the transformability of ancient cultural patterns via the adaptive revitalization of TEK and techniques identified with ancestral wisdom and applicable (with appropriate modifications) to contemporary climate change stressors (such as flooding) and imperatives (such as protecting seeds) has led to successes in autonomous place-based adaptation.

Local community members' ultimate rejection of the development project's *camellones*, compared to their emerging interest in their own ancient *camellones*, also points to the ways that 'adaptive' technologies are not culturally neutral, but rather are embedded in cultural contexts and processes. This paper suggests that the socio-cultural and ecological conditions of construction (where, why, how and by whom) are just as important to understanding and embracing adaptation innovations as are their form or intended function. The ancient *camellones* are directly associated with a concept of cultural heritage and past civilizations, as well as a sense of stewardship and belonging in the local communities. The new *camellones*, by contrast, are not. Furthermore, negative experiences with the *camellones* development project may give the impression that the project's construction conditions are illegiti-

mate since they utilize the wrong forms of knowledge, serve the wrong purpose or get implemented by the wrong people or in the wrong place.

Both ancient and modern earthworks may nevertheless be used during emergencies. Fully reviving the *camellones* system for agriculture, however, requires additional, and potentially costly, social commitments. These investments in time and effort will likely only be undertaken as climate change brings a greater frequency of severe flooding events and other deleterious impacts. Weaving together both ancient and modern engineering with socio-ecological knowledge, as well as internal and external inputs and approaches, will be essential for successful place-based climate change adaptation.

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