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Research

Lessons from community-based payment for ecosystem service schemes: from forests to rangelands

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Climate finance investments and international policy are driving new community-based projects incorporating payments for ecosystem services (PES) to simultaneously store carbon and generate livelihood benefits. Most community-based PES (CB-PES) research focuses on forest areas. Rangelands, which store globally significant quantities of carbon and support many of the world's poor, have seen little CB-PES research attention, despite benefitting from several decades of community-based natural resource management (CBNRM) projects. Lessons from CBNRM suggest institutional considerations are vital in underpinning the design and implementation of successful community projects. This study uses documentary analysis to explore the institutional characteristics of three African community-based forest projects that seek to deliver carbon-storage and poverty-reduction benefits. Strong existing local institutions, clear land tenure, community control over land management decision-making and up-front, flexible payment schemes are found to be vital. Additionally, we undertake a global review of rangeland CBNRM literature and identify that alongside the lessons learned from forest projects, rangeland CB-PES project design requires specific consideration of project boundaries, benefit distribution, capacity building for community monitoring of carbon storage together with awareness-raising using decision-support tools to display the benefits of carbon-friendly land management. We highlight that institutional analyses must be undertaken alongside improved scientific studies of the carbon cycle to enable links to payment schemes, and for them to contribute to poverty alleviation in rangelands.

Keywords: climate finance; CBNRM; dryland Africa; voluntary carbon market; institutions; Plan Vivo

1. INTRODUCTION

Community-based payment for ecosystem services (CB-PES) schemes allow individuals, governments, non-governmental organisations (NGOs) and private sector companies to pay for environmental public goods such as carbon storage, biodiversity and water conservation [1], by supporting local-level projects that facilitate community development and poverty alleviation. In this study, we explore how lessons on institutional development from community-based natural resource management (CBNRM) have been incorporated into CB-PES projects in forest systems in Africa, and how they can be applied to the design of CB-PES projects in semi-arid rangelands to potentially deliver socio-economic benefits to Africa's rural poor [2–7]. As climate-change-mitigation efforts look beyond the humid forests to enhance terrestrial carbon storage, such an analysis is pressing and important, particularly as rangelands have significant carbon-storage potential [8] and are inhabited by some of the world's poorest populations [9].

Most CB-PES project activity and analysis has had an ecological focus on forest systems, particularly in Latin America or Asia [10]. However, rangelands are estimated to store 30 per cent of the world's terrestrial carbon [11], including approximately 20 per cent of global soil carbon [12]. Rangelands are defined as terrestrial ecosystems dominated by herbaceous and shrub vegetation and maintained by fire, grazing, drought and/or freezing temperatures. Rangelands include savannahs and shrublands, as well as more conventional grasslands [11]. A variety of ecological changes, notably shrub encroachment, can enhance carbon storage in both rangeland soils and vegetation (see [13]). Changes to rangeland management thus have a large potential effect on climate-change

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mitigation [14–16] with CB-PES projects offering payments for land users to manage these areas to optimize carbon storage [8]. This could potentially make a significant difference to the world's 120 million pastoralists, many of whom live in poverty [9,14].

Scientific advances in monitoring carbon and associated ecosystem services are essential in order to verify carbon storage and its longevity [17–19]. Scientific papers are increasingly reporting on these aspects in semi-arid rangelands [8,20–22], showing that pushes to alter rangeland-management practices to promote carbon storage are gaining momentum [16,23]. Within policy, two rangeland mitigation methodologies are being considered for approval under the verified carbon standard (VCS—previously the voluntary carbon standard) [14,24,25] with recent efforts seeking to merge these into a single sustainable grassland-management methodology [26]. However, scientific and policy advances are, in themselves, insufficient to enable poverty alleviation through CB-PES. Carbon payments need to link to the real-world social, economic and institutional characteristics of rangeland communities, requiring CB-PES projects to be evaluated through processes that take into account these contextual aspects. This remains challenging owing to limited global implementation of accredited rangeland CB-PES activities and the lack of approved rangeland assessment methodologies.

In this study, we initially review the CBNRM literature (§2), identifying key principles in CB-PES forest projects that address carbon storage, with a view to exploring how they can be applied to the design of CB-PES projects in rangelands. Section 3 outlines the analytical methodology used to interrogate the role of institutions and social contexts in forest-based CB-PES projects. This is then applied as an analytical framework (§4) to assess three forest-based CB-PES case studies from sub-Saharan Africa. Key social and institutional lessons emerging from the forest case studies are presented and considered in conjunction with best practices identified from CBNRM projects in rangelands (§5). The overall lessons we identify provide guidance to policy and climate finance initiatives that consider the dual carbon storage and poverty alleviation potential of rangeland CB-PES schemes.

2. COMMUNITY-BASED NATURAL RESOURCE MANAGEMENT AND COMMUNITY-BASED PAYMENT FOR ECOSYSTEM SERVICE PROJECTS

CBNRM emerged in recent decades as an alternative to centralized, command-and-control environmental management approaches. CBNRM seeks to deliver sustainable natural resource outcomes while enhancing the livelihood opportunities of rural communities. Roe *et al.* [27] highlight that CBNRM refers to local and collective resource governance arrangements and practices, suggesting that CBNRM models work to 'strengthen locally-accountable institutions for natural resource use and management, enabling local groups of people to make better decisions about the use of land and resources' [27, p. vii]. Control over the natural resource base is devolved to local institutions via the transfer of legal rights, and through empowerment of communities to exercise their rights in local decision-making and through formalized links to policy and local development practices [28,29].

The extent to which CBNRM projects achieve resource conservation and development goals, drawing on their own core principles, is variable. Extensively studied CBNRM examples include those seeking to achieve wildlife conservation and poverty alleviation goals, such as the communal areas management programme for indigenous resources (CAMPFIRE). CAMPFIRE involved rural populations across Zimbabwe, supporting their sustainable management of wildlife and other resources [30,31]. Other high profile examples of different 'community conservation' approaches focus on links to eco-tourism or hunting opportunities [32,33], including wildlife management areas in Botswana [34–36] and community conservancy schemes in Namibia [37–39]. There are numerous critiques of CBNRM in terms of the processes followed and the intended and unintended outcomes [35,40–42]. Nevertheless, successful and failed examples offer potential to inform project, institutional and partnership development in the rapidly evolving climate finance sector's CB-PES investments [43]. The challenge in learning from such experiences lies in pinpointing the causes of unintended outcomes or implementation challenges and ensuring they are addressed in future project design.

All PES projects can be conceptualized as an institution that has been developed for environmental governance, in that they represent a structure that incorporates a range of norms and beliefs that jointly dictate which resources are managed, how, and by whom [44]. PES represents a neoliberal approach to environmental management [45], based on the core principle that payments can directly alter land-use and management practices. This is underpinned by the Coase economic theorem in which externalities are addressed by extending markets through property rights (see [46]), and shapes project structure and execution by requiring involvement of those groups and/or individuals who hold property rights. Holders of property rights are incentivized to provide an ecosystem service through their property in exchange for payment [47,48]. This market-based view of environmental services has been critiqued for oversimplifying complex ecological systems, for inadequately addressing the social and institutional determinants that control land use and management decision-making and for being paradoxical by considering that capitalist markets are the answer to their own ecological contradictions [49–52]. When a PES project is community-based rather than centred on individual ownership rights, further principles need to be incorporated around community empowerment, capacity building and sound local-level governance [53]. These originate in the wider concept of CBNRM and shape institutional structures because control over natural resources is devolved. This is illustrated by successful CB-PES projects in forest areas, which have involved the establishment of local forest user groups that monitor, regulate and manage resource use and conservation efforts, typically at a village level [10,54,55].

Community-based approaches to resource management, including CB-PES schemes, vary in the extent to which communities are engaged. Often, the degree of community involvement links to the requirements of accreditation standards that projects seek to attain. Voluntary carbon market projects seek verification through a range of accreditation standards [56,57]. Some standards have a strong carbon focus, for example the voluntary carbon standard (VCS), which held a 48 per cent market share of verified credits in 2008 [58]. In contrast, those standards developed by the Plan Vivo Foundation or the Climate, Community and Biodiversity Alliance's Climate, Community and Biodiversity (CCB) place a greater emphasis on the socio-economic and institutional aspects of projects and the delivery of co-benefits beyond carbon storage, requiring more meaningful and extensive community involvement [59,60].

In designing the ways in which communities can be involved in CB-PES schemes, it is important to note that projects and communities are not situated in a power vacuum. Institutional relations between the community and stakeholders at national and international levels (e.g. governments, private sector companies and individual consumers) are diverse, requiring careful consideration of the interplay of factors across micro- to macro-levels. Successful CBNRM projects are mainly located in southern Africa [33,61] and situated in macro-level contexts characterized by low levels of corruption, while legal frameworks allow communities to retain benefits from wildlife [27]. In terms of CB-PES projects, such macro-level considerations include the market mechanisms that shape demand for carbon storage [7], and are not necessarily land-use-specific (e.g. applying to rangelands or forests). Rather, they operate on a national or regional level. While these macro-level aspects provide the broader setting for CB-PES schemes, our analysis focuses on micro-level interactions (at and from the local level) to allow consideration of how lessons from the design of forest CB-PES schemes can inform the development and implementation of CB-PES based around changing land-use and management decisions in rangelands.

3. RESEARCH DESIGN AND METHODOLOGY: LEARNING FROM CB-PES IMPLEMENTATION

Studying a project's design, particularly its local-level institutional aspects, is recognized as a useful starting point for explaining successes and failures in community-based initiatives [1,62–64]. CB-PES projects based on strong institutional designs can encounter problems owing to clashes with existing local institutional and socio-economic contexts [65]. Conflicts arise from differences between the perspectives of communities around economic functions, and the economic functions that are embodied by projects [66]; the forms and distribution of land rights and roles of communities [67]; and the distribution of entitlements to benefits arising from projects [68]. Often, existing local-level institutional structures may be insufficient or unable to implement new institutional rules and procedures, and the need to strengthen institutions in order to implement PES projects is widely recognized [1,63,69]. Focus on the implementation challenges encountered by projects structured upon strong CBNRM principles enables identification of the features of the social context that must be considered when implementing CB-PES to deliver multiple benefits.

To this end, Dolsak & Ostrom [70] identified eight characteristics of institutional design for a successful CBNRM, being that:

— rules are devised and managed by resource users;
— compliance with rules is easy to monitor;
— rules are enforceable;
— sanctions are graduated;
— adjudication is available at low cost;
— monitors and other officials are accountable to users;
— institutions are devised at multiple levels; and
— procedures exist for revising rules.

In order to examine the micro-level interactions that lead to implementation challenges, we examined the implementation of Plan Vivo CB-PES forest-based projects across sub-Saharan Africa. We looked first at the similarities between Plan Vivo characteristics and the Dolsak and Ostrom criteria to ensure that Plan Vivo projects are well placed in their design to deliver a successful CBNRM and then we assessed their communications and connections to national- and international-level support. Plan Vivo is a standard that draws on core CBNRM principles and places a particular focus on the delivery of socio-economic co-benefits in conjunction with carbon storage [71]. The principal criterion for participating in a Plan Vivo project is clear ownership/tenancy/recognized user rights of land, whether as an individual or formal user group. Projects are coordinated by a project coordinating body (PCB) that works closely with local government authorities to support project objectives. The PCB is responsible for: marketing Plan Vivo certificates; handling policy matters; database management; coordinating project activities; and annual reporting to the Plan Vivo Foundation. The PCB typically has a team of field staff responsible for training and capacity building, community engagement and leading carbon-monitoring activities. Plan Vivo Foundation staff are involved in the verification of annual reports, whereas projects are validated by third parties who are approved by Plan Vivo according to clear guidelines. Carbon accounting periods are calculated between 25 and 100 years, and usually front-loaded, being paid to participants during the first 10 years of accreditation. This compensates for the costs of altering land-management practices and provides money prior to the delivery of additional economic benefits from trees, such as from fruit harvests, non-timber forest products and/or increased crop yields owing to improved soil fertility [72]. The ways in which Plan Vivo meets Dolsak and Ostrom's characteristics for successful CBNRM are summarized in table 1.

Table 2 details the four existing and four planned CB-PES projects across Africa certified under the Plan Vivo Standard (as of early 2012). Three of the

Table 1. Characteristics of successful community-based project design and links to Plan Vivo project features.

characteristic of successful institutional design [70]	Plan Vivo project design features
1. Rules are devised and managed by resource users	— communities are engaged from the beginning of project formulation — PCB, community members and forestry experts co-design a range of possible land-use technical specifications — participants can select the technical specifications they want to adopt — community members are engaged in the process of structuring payments (e.g. temporal loading of credits, crediting period, price)
2. Compliance with rules is easy to monitor	— participants agree technical specifications and contractual targets that are quantifiable and measurable
3. Rules are enforceable	— performance-based payments that are conditional upon monitoring
4. Sanctions are graduated	— payments are withheld if the agreed contractual targets are not met — community payments can be withheld if the community has not fulfilled its targets, creating peer pressure to comply
5. Adjudication is available at low cost	— third parties are used to validate projects — PCB has field staff on site available to liaise with participants
6. Monitors and other officials are accountable to users	— PCB staff and community members carry out monitoring together
7. Institutions are devised at multiple levels	— the PCB is created and works with community members, village natural resource management councils, and local-, regional- and national-level forestry officers — capacity building and extension work aims to ensure that communities have systems to work with government extension services
8. Procedures exist for revising rules	— participants can adopt new technical specifications — PCB acts as a continuous presence (via field staff) to engage with community

existing projects were selected for more detailed analysis, as well-developed examples of operational CB-PES projects (figure 1). Three projects were chosen owing to the depth of available information about their institutional characteristics and on the basis of their achievement of Plan Vivo certification. The projects are in Malawi (Trees of Hope), Uganda (Trees for Global Benefits) and Mozambique (Sofala Community Carbon), and encompass different communities and institutional histories, enabling analysis of diverse implementation contexts. Content analysis of the most recent Annual Reports to the Plan Vivo Foundation for projects in Uganda (2009 and 2010) and Mozambique (2009 and 2010) was undertaken. For the Malawian project, which achieved Plan Vivo accreditation in September 2011, Annual Project Design documents (2010 and 2011) were analysed (full reports available at www.planvivo.org/projects/). We noted instances where implementation and project design challenges were identified and where planned procedures had been changed or adapted. Challenges outlined in each project were grouped according to their similarity in emphasis to enable comparisons across the three projects (§4*a*). We then situated the findings within the wider literature on these forest projects (§4*b*) in order to understand the role of institutional interactions in creating these challenges and how they relate to a failure to fulfil Dolsak and Ostrom's design characteristics for successful resource management. Finally, we contextualized the implementation challenges identified as important considerations emerging from rangeland CBNRM projects (§4*c*). This allowed us to draw out the key institutional aspects from the analysis that can inform the development of future rangeland CB-PES projects.

4. IDENTIFYING LESSONS FROM CB-PES FOREST PROJECTS

(a) *Challenges and opportunities in implementing Plan Vivo projects*

Our three project case studies all encountered problems in successfully including participants in the process of project design and implementation, notably in relation to the development of rules and sanctions at a local level. For example, in Mozambique, project communities had been displaced during the civil war and therefore had no way of proving formal long-term rights over land. Customary rights to agricultural land through land tenure and use rights conferred by customary norms and practices were therefore used as the basis for project participation. This involved a protracted process of identifying individual landowners and seeking formal and informal legal support/evidence for land ownership in the complex post-conflict institutional setting. The process was mired with difficulty, as traditional and government leaders struggled to agree on land-right allocations. A formal use agreement over forestland was ultimately negotiated through a donor-funded project involving a local land-rights organization. In contrast, the Uganda

Table 2. Details of Plan Vivo projects in Africa (as of March 2012) including those certified (1, 2, 3 and 5) and those with Project Inception Notes developed (4, 6, 7 and 8). NB. All projects funded are in tropical forest or Miombo woodland regions (figure 1). This paper focuses specifically on projects 1–3 due to their Plan Vivo certification and the depth of institutional information available for analysis. Afforestation (A), reforestation (R), agroforestry (AG), avoided deforestation (AD), sustainable forest management (SFM) and community forest management (CFM).

	year						generation of Plan Vivo certificates	
project and country	started	registered	project size (ha)	project activities	participants	annual ES payment to communities (USD $)	annual production (tCO_2 per annum)	total issued to date (tCO_2)
1. Sofala Community Carbon, Mozambique	2003	2007	11 744	AG, AD	1834	244 621 October 2009–September 2010	100 000	252 120
2. Trees for Global Benefits, Uganda	2003	2003	1210	A, R, AG	909	61 057 in 2010	100 000	277 208
3. Trees of Hope, Malawi	2007	2011	488	A, R, AG,	1290	0 in 2010 (pre-registration)	70 000	20 000
4. NTFP-PFM, Southwest, Ethiopia	—	—	—	AD, CFM	0	0	101 228	0
5. Emiti Nibwo Bulora, Tanzania	2010	2010	130	A, R, AG	24	1294 in 2010	40 000	1861
6. Community PES in the Congo Basin, Cameroon	—	—	2984	AD, SFM	0	0	0	0
7. Mongo wa Mono, Tanzania	—	—	—	AD, CFM	0	0	0	0
8. Mikoko Pamoja, Kenya	—	—	107	AD	0	0	2 023	0

and Malawi projects had clearer customary rights over land, which proved to be an important element for defining tenure. Traditional authorities played an oversight role in ensuring that land ownership adhered to local resource use rules and regulations such that community members did not falsify claims. Nevertheless, in Uganda, migrant tobacco farmers could not be included in project activities owing to uncertain tenure arrangements.

A further challenge for projects related to their ability to channel benefits directly down to the community level. In Mozambique, the New Land Law of 1997 allows for communal land ownership, therefore providing a mechanism for delivering direct financial benefits to the community. In both Uganda and Malawi, the Plan Vivo projects acted as a catalyst in attaining community land titles for community forests, and in the generation of community forest management plans, providing benefits at different scales. Such formalization of land rights allowed individual community members to benefit from payments linked to their own land holdings, while the community as a whole benefitted from payments linked to the management of the communal forest area. In Uganda, farmers even formed a community fund for the wider distribution of benefits.

Building connections between multi-level institutions and actors was a challenge to varying degrees across all three projects, especially in linking to national-level forest and agricultural policies. This matches insights gained in previous studies of community forestry initiatives in Kenya and Tanzania [73,74]. In all three projects, PCBs met with the local communities (including traditional authorities), local and national state authorities, and other stakeholders (such as NGOs) prior to deciding on project activities. In Malawi, this happened smoothly through links between the project body and an established Village Natural Resource Management Committee, providing a clear interface between these two institutions. In Mozambique, such local committees did not exist, and the PCB struggled to maintain a presence in the communities owing to the reluctance of skilled staff to live in remote project locations. Project documentation suggests that such staff absence limits the PCB's ability to manage the project and build the necessary capacity for communities to take on these management responsibilities. Despite some problems with local interactions, all our case study projects successfully developed links to wider networks, including to nearby universities that provided research and support personnel. Both the Ugandan and Mozambique projects are in close proximity to national parks, and their activities complement buffer zone activities, creating opportunities for biodiversity conservation, research and for developing new fire management practices through managed firebreaks.

Adhering to monitoring procedures and meeting payment schedules has not been straightforward. The Ugandan project reports delays in participants' submission of supporting documents (bank account numbers and passport photos). Small banks were located close to the project, but participants preferred to use larger urban banks. Farmers also lacked tools to

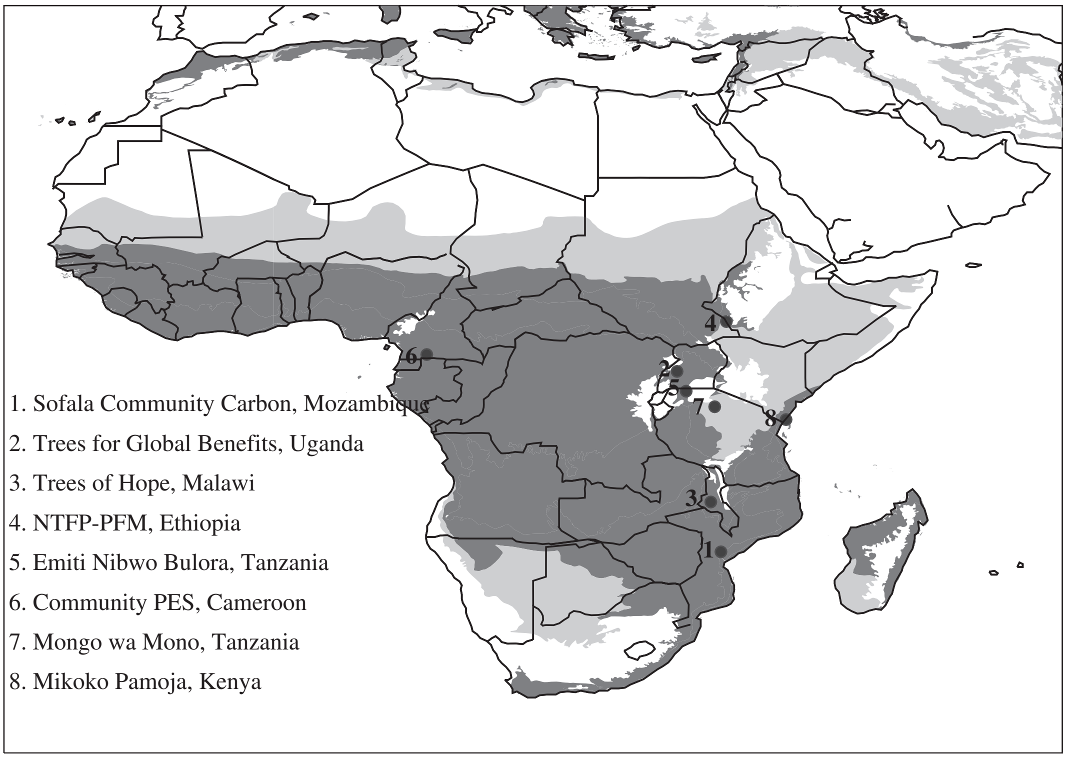

Figure 1. Distribution of woodland and forest (dark grey) and rangeland (light grey) ecosystems across Africa based on FAO agro-ecological zones. The locations of existing and planned Plan Vivo projects are plotted with circles with numbering matching that in table 2.

measure the area of their formally owned land. In Mozambique, computer equipment used to connect the GPS recorders used in monitoring proved problematic and there are plans to improve the monitoring technology. These issues are illustrative of the challenging logistical context in which projects operate and highlight the need to use locally available technologies.

Securing behavioural change among the participants has proved difficult in all projects. In the Ugandan case, participants are struggling (or reluctant) to fit their activities to the timings of the Plan Vivo project schedule. They do not delay spot weeding/general weeding/slashing, thus limiting the carbon-storage potential of their activities and making monitoring difficult. They have also failed to make improvements prior to the scheduled monitoring exercise at which time payments are allocated and improvements are made. This has generated frustration among farmers that there is a delay to the financial recognition of their work—particularly where they wanted to be involved and planted trees, but then were not immediately able to join the project.

The Mozambique project is struggling to match demand for carbon certificates to the willingness of landholders to supply carbon sequestration services. The PCB bought carbon from the landholders in order to front-load payments, but has failed to sell the credits, leading it to stop signing new contracts until the backlog has been rectified. This is a source of disappointment to participants as they have come to expect annual opportunities to sign new contracts, with many becoming reliant on the project's carbon payments as an additional income stream. The Malawian project anticipated such reliance as a potential problem and worked with participants from the beginning to guard against it. For this, Local Programme Monitors acting as volunteers have been identified and trained across the project communities to work alongside government extension staff, supplementing the Village Natural Resources Management Committees that were already present. Training increases Local Programme Monitors' technical capacity to manage and diversify income streams such as through bee-keeping and the sale of non-timber forest products and produce from fruit trees.

(b) *Institutional interactions and their impacts*

Implementation challenges around identifying participants and channelling benefits to the community level result from the projects' interactions with existing property rights and institutions. Projects in Uganda and Malawi benefitted from strong local actors or enforcers of traditional and formal property rights, whereas a lack of clear property rights in Mozambique significantly affected project set-up. In some cases, PES projects can play a key role in strengthening or formalizing property rights [75], shaping the institutional context and offering further project benefits through the empowerment of local resource users [76]. This was the case in Mozambique where under the auspices of Plan Vivo, the terms of community land ownership were strengthened.

Challenges in meeting administrative requirements of Plan Vivo projects and creating multi-level links are shaped by the interface between the project and the institutional infrastructure in project locations. The presence of the local-level village committee in Malawi was a

Table 3. The challenges in developing and implementing Plan Vivo projects as community-based PES projects as identified from our analysis of Plan Vivo forest projects in Uganda, Mozambique and Malawi.

implementation challenges experienced	causal institutional interaction issues identified	CBNRM design characteristics not fulfilled (from Dolsak & Ostrom [70] design characteristics shown in table 1)
1. Identifying project participants	— weak or absent existing property rights (land tenure)	— rules are *devised* and managed by resource users
2. Channelling benefits to community	— weak enforcement of community-based management schemes	
3. Connections and communications between multi-level institutions/actors	— insufficient existing institutional infrastructure and communications (e.g. from project to extension services, or weak financial services at local level)	— compliance with rules is easy to monitor
4. Following established monitoring procedures	— uncertainties in use of appropriate carbon-monitoring tools	— rules are devised and *managed* by resource users
5. Securing behavioural change	— participants' perceptions of the project (as having low benefits and high risk) based on limited information of associated livelihood benefits	

critical factor in ensuring that links could be made between project actors and the community. This committee is formally recognized by government, works closely with agriculture and forestry staff and operates at the community level. It therefore acts as a stable boundary actor between the PCB and the community, communicating between the two and facilitating the project in a manner sensitive to local needs. This kind of connection between community and project strengthens the interplay between the project and other policy initiatives or external institutions [19,77]. The Mozambique project lacks an equivalent actor owing to the lack of existing physical infrastructure, creating challenges in fulfilling administrative requirements and complicating the running of the project. However, the projects themselves can help to overcome these challenges. For example, in Uganda, the project facilitated the establishment of women's credit unions. In Mozambique, PES income has been used by participants to buy motorbikes, bikes, telephones and radios, improving their access to markets and infrastructure outside the project's locality.

Failure to secure behavioural change and the ongoing reliance of participants on the projects partly relate to participants' perceptions of benefits and physical threats. Delays between action and payment can mean that participants do not recognize the benefit of their actions. Indeed, the high transaction costs associated with starting carbon-focused PES activities leads to trade-offs between costs and actions that optimize carbon storage, limiting incomes, particularly while carbon prices are low [78]. In the Mozambique project, high transaction costs and marginal financial gain in the face of numerous risks associated with taking action led to participants' reliance on the project because the PCB accepted risks by providing Plan Vivo payments up front. However, they cannot always account for unpredictable threats, such as high losses of trees during planting [77,79]. Participants do not have the capital to accept and manage risk themselves, and therefore lack the will to operate without the PCB [80]. Consequently, measures were put in place to minimize risks through the introduction of committees, training and new infrastructure and management practices at a local level (alongside the use of conservative carbon calculations). Pests and diseases are managed through a surveillance system and selection of indigenous tree species that are resistant to known pathogens. Avoidance plans are incorporated into project design to tackle the risk of forest fire through establishment of fire monitoring committees, education and fire breaks. Participants are trained in practices including tethering and zero grazing during periods when trees are most vulnerable to livestock damage.

The impacts of the institutional interactions outlined earlier shaped each project's abilities to deliver community development benefits. Initially, the interactions impacted upon the ability of the Plan Vivo projects to fulfil Dolsak and Ostrom's requirements for successful CBNRM (table 1), in the ways summarized in table 3. In turn, this shaped the framing of 'community' within the projects. For example, in the Mozambique project, there are reports of elite capture of benefits in that male-headed and high-income households are favoured as project participants because poorer households wait to see positive results before committing (assessing benefits and risks), or were incapacitated through sickness, old-age or lack of labour resources [81]. This means that some sectors of the community encounter barriers to their participation, limiting the ability of the project to benefit the community as a whole, and thus reducing its ability to meet development goals for the entire community. Such case-study lessons identified across the three projects, alongside those reviewed by Reynolds [7], show similar findings to other forest CB-PES project analyses globally, including from Cambodia [82], China [83] and Mexico [84]. These similarities imply the transferability of lessons across forest systems and potentially into wider environmental contexts such as rangelands.

5. CHALLENGES FOR CB-PES PROJECTS IN RANGELANDS

Analysis of the forest CB-PES experiences has highlighted a number of considerations for rangeland projects, particularly linked to institutional aspects. These include the need for strong links to existing local institutions, clear land tenure arrangements, community control over resource monitoring and management and the need for up-front and flexible payment schemes. Rangelands introduce additional complexities owing to both the spatial and temporal dynamism of ecological changes in semi-arid systems [85–88] and specific institutional issues associated with the rangeland context [89–91]. This complexity has been illustrated by studies assessing the integration of local and scientific knowledge [92,93] and through the development of dynamic systems models of change [94,95]. This section identifies rangeland-specific considerations that will affect the development of CB-PES carbon schemes. To achieve this, we build on our review of key implementation challenges identified from forest project analyses (table 3), including land tenure and participant identification, communications between multi-level institutions/actors, local financial systems and the need for improvements in carbon-monitoring tools.

Clear boundaries and property rights have been shown to be an important prerequisite for successful CB-PES forest projects and are equally important in rangelands [14,24,96,97]. However, access and ownership rights assigned to different individuals and groups are difficult to define in rangelands, making project boundaries very difficult to explicitly identify [96–98]. Land tenure in African rangelands varies from private ownership to traditional communal management and in some cases includes land leased to pastoralists [99,100]. While the first two forms of tenure allow establishment of who manages the land and neatly link to the delivery of payments, it is less clear as to who should receive payment benefits when land is leased. Indeed, the unsuitability of CB-PES projects in contexts where land is rented or squatted has been outlined in the literature in relation to the United Nations' Reducing Emissions from Deforestation and forest Degradation (REDD) programme and wildlife conservation schemes in Africa [100].

Landholders or community groups who lease land may have a legitimate claim over the carbon payments, and/or the collateral ecosystem service benefits resulting from carbon-friendly land management (e.g. improved soil-water-holding capacity; decreased soil erosion; improved productivity linked to enhanced carbon storage). Lease-holding pastoralists incur the opportunity cost of adopting alternative land management and are expected to abide by certain management rules. Such a situation does little to provide pastoralists with a way out of poverty if their land-use activities are restricted by more powerful and wealthy (often absentee) landholders. Both parties are likely to be reluctant to engage in long-term carbon-management efforts, as leases are often agreed only over short periods and are renewed seasonally [101]. Overlapping access rights further complicate the identification of actors in, and users of, rangeland CB-PES projects, but studies suggest that this is a central factor to consider, as actors are more likely to negotiate if collective action looks likely to deliver greater benefits [97].

Benefit-sharing across different ecosystem service dimensions is another possible solution. Pastoralists could receive the carbon payment as a short-term benefit, whereas over the longer term, the carbon-friendly land management will improve the condition of the land, with the landowner receiving the benefits from the ecosystem service improvements that ensue. These kinds of considerations are vital if leakage is to be avoided (i.e. if pastoralists are not to shift their unsustainable grazing practices elsewhere). The extensive form of rangeland management by mobile communities in low production systems (e.g. arid rangelands) further complicates CB-PES in these areas [102]. The integration of unclear boundaries and seasonal mobility over vast areas in CB-PES methodologies will be required to ensure that projects can benefit mobile pastoralists [103]. Mobility of pastoralists might demand payment sharing or pro rata distribution of payments according to when land is being used. Integrating spatial analysis with geographical information systems and/or remote sensing tools could provide the basis for monitoring these vast areas. These approaches are nevertheless costly to implement and operate, and potentially shift control and transparency to actors other than the pastoralists, complicating lines of accountability. Leakage could have substantial implications in extensive systems requiring more complex monitoring, reporting and verification [25,104], particularly if introduction of CB-PES in one area changes the distribution of costs and benefits in another. Contractual conditions thus need to prevent leakage, while monitoring is required to provide regular assurance that successful leakage management is in place [25].

Payment systems would need to be front-loaded in rangelands, as has been the case in forestry CB-PES projects [103]. However, questions remain about the timeframe and permanence of carbon sequestration. Some afforestation/reforestation projects on the regulatory carbon market use expiring certified emissions reductions to address permanence [105]. Use of buffer credit systems may also be appropriate [25]. These protect against the reversal of carbon mitigation and allow a reserve of carbon credits to accrue according to the assessed level of risk, with payments being adjusted following verification and further risk assessments. The regional opportunity cost of carbon storage payment schemes can be seen around major remaining conserved rangelands where valuation of ecosystem services including carbon storage [106] is vital. For example, debates on whether to extend cattle grazing into wildlife management areas surrounding the Makgadikgadi Pans National Park in Botswana [107] have led to a government Management Plan valuing the current benefits of current land-management practices [108]. Carbon sequestration is presented as the largest contributor to the total value of this conserved area, providing an estimated 85 per cent of the indirect use value, greatly outweighing benefits assigned to wildlife conservation (incomes from eco-tourism and hunting).

Our case-study forest CB-PES projects have built technical capacity in managing and monitoring carbon storage at a community level. However, such monitoring and assessment will be more difficult in rangelands as most of the carbon is stored in the soil [20].

Scientific understanding of carbon storage in dryland rangeland soils remains poorly developed and differs from that in wetter areas (see [19]). Dryland soil carbon is concentrated in the upper surface layer of the biological soil crust [109] and is altered by sunlight, fungi and microbial activity that react to moisture stress in different ways to carbon in mesic and humid soils [110,111]. Scientific advances, combined with the development of cheap, simple and accurate ways for local monitoring of carbon changes, are vital if carbon storage in rangelands is to be adequately validated. There is also a need to develop awareness and understanding within pastoralist communities of the processes of land-use change and CB-PES, in order to feed into relevant monitoring, verification and reporting processes. Experiences from locally appropriate rangeland assessment guides [112,113] resulting from the integration of local and scientific knowledge [92] show the potential to identify thresholds for decision-change [114] and could be further developed to explicitly outline benefits and incentives associated with moves towards managing land for carbon storage.

A number of software tools to visualize forest management impacts on carbon sequestration in trees and soil have been developed in the past decade (e.g. CO2FIX [115]; Forest Accounting Software [116]; FORCARB2 [117]). Rangeland assessment guides would benefit from being linked to these kinds of predictive tools to inform local decision-making [118]. Nevertheless, for rangeland and forestry, community-based alike, these tools need to be adapted for non-professionals by using simpler methodologies. Community forestry projects show that communities can be empowered if they have the means to monitor carbon stocks and make decisions [54,119]. Visual simulation software can also integrate options to compare the outcomes from several different management alternatives (e.g. reducing stocking levels, preventing crop encroachment over pastures, tree-planting or combined alternatives). Extending community-level rangeland assessment tools to include carbon-storage assessments and their links to visual simulations and decision-support tools is therefore a vital next research step to assist project design and implementation. It is essential that such rangeland monitoring tools recognize the need to integrate the important local institutional factors we have identified to enable practical advice to be given on land management decision-making. The development of such approaches needs to incorporate scientific advances [120,121] related to understanding carbon storage and ecological processes into rangeland monitoring tools that can initially be used by PES project staff. These approaches will then require extension to enable pastoralist communities to be involved in monitoring carbon-storage changes and the associated (costs and) benefits that accrue from changes in land-management practices.

6. CONCLUSIONS: DESIGN AND IMPLEMENTATION OF RANGELAND COMMUNITY-BASED PES SCHEMES

Plan Vivo's approach has been demonstrated to map on to Dolsak and Ostrom's institutional design characteristics for successful CBNRM. However, challenges in meeting these criteria in project implementation have been identified from analysis of forest-based Plan Vivo-accredited projects (table 3) and extended by a review of the rangeland literature. Lessons from forest project experiences include the need to design schemes to:

— build on existing institutions and systems for dealing with undefined or unsecure property rights (including cases in which land tenure does not accurately reflect the existing community uses of land);
— appropriately manage the perceived balance of risks and benefits, influenced by high transaction costs and high physical risks; and
— enable flexibility in improving communications between the levels of institutional infrastructure.

Where inadequately considered in the case-study Plan Vivo projects, these issues have hindered local participation, threatening community empowerment goals that underpin the shifts required for successful CB-PES projects to be implemented. Institutional factors act as barriers to the success of projects, specifically around the ways in which multi-level institutions are created and the manner in which communication channels are developed. Similar institutional issues were identified from the literature analysis of experiences with rangeland CBNRM. Additional challenges in rangelands include problems of boundary setting, as access and land ownership rights are often difficult to define, with absentee landowners being a complicating factor. There are also greater difficulties in building local capacity for managing and monitoring carbon storage, especially as the bulk of carbon storage is in soils. Monitoring methods for soil carbon will require the adaptation of those used in other regions to address the different nature of soil carbon storage and cycling in dryland soils. Pastoralists are also relatively unaware of the opportunities presented by managing rangeland for carbon storage. The development of software to provide visual simulations of different land-management options and related payment, and ecosystem service outcomes are essential, to enable scenarios of change to be assessed. Such decision-support tools can inform the development of different CB-PES project models for rangelands.

Drawing on our analysis of forest CB-PES projects and the rangeland CBNRM literature, our recommendations for the design and implementation of rangeland CB-PES projects include the need for: (i) links to strong existing local institutions; (ii) clear land tenure arrangements; (iii) community control over land management decision-making; and (iv) up-front and flexible payment schemes. Rangeland CB-PES project design also requires consideration of: (v) project boundaries; (vi) benefit distribution; (vii) capacity building for community monitoring; and (viii) awareness raising using visual simulation tools to support decision-making by highlighting the long- and short-term benefits of rangeland management options. Scientific advances and CB-PES project analyses alone will not realize local-level changes in rangeland management practices. It is essential that lessons from institutional analyses are assessed alongside improved dryland carbon cycle studies to enable the development of CB-PES projects that contribute to both carbon storage and poverty alleviation for the rural poor of the world's rangelands.

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