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Beyond Bioproductivity: Engaging Local Perspectives in Land Degradation Monitoring and Assessment

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Abstract

Land degradation monitoring and assessment in the Sahel zone has relied substantially on temporal trends of remote sensing-based vegetation indices, which are proxies for the bioproductivity of the land. However, prior studies have shown that negative or positive trends in bioproductivity are not necessarily associated with degradation or improvement of land condition. In this short communication, while acknowledging the contributions of remote sensing-based indices and global-scale datasets to dismantling an outdated desertification narrative, we argue that local land users have much to contribute to our understanding of land degradation, and particularly to ensuring that scientific assessments of degradation capture variables relevant to them. We used the participatory photo elicitation method in three sites in the Senegalese Ferlo in order to elicit local pastoralists' perspectives on land degradation and identify the indicators that they use to characterize pasture quality, while empowering them to lead the discussion. The discussion revealed indicators far beyond bioproductivity, including livestock performance as well as composition and quality of the herbaceous and woody vegetative cover, invasive species, soil quality and water availability. We found that the pastoralists' knowledge and interest in the issue could potentially be harnessed more systematically, and at larger scales, in order to build a spatially explicit field-based knowledge base of land degradation complementary to remote sensing-based maps of trends in bioproductivity. Such a dataset could serve as a standalone product or as a reference dataset for development and validation of remote sensing-based indicators.

1. Introduction

Land degradation – the loss of the productive potential of the land – is a serious concern in drylands, in particular for land resource-based societies such as pastoralists. It features prominently in major global institutions and initiatives, including the United Nations Convention to Combat Desertification (UNCCD), the Convention on Biodiversity (CBD), the United Nations Framework Convention on Climate Change (UNFCCC), and the Sustainable Development Goals (SDG). Estimates of the extent and severity of land degradation have varied substantially (Yengoh et al., 2015), particularly at regional to global scales. This is not surprising, as land degradation is a very context-dependent phenomenon and occurs at fine spatial scales (Warren, 2002).

The West African Sahel region in particular has been considered a hotspot of environmental crisis since 1970s. New insights resulting from recent developments in fields ranging from rangeland ecology to human livelihood systems, however, have put into question the traditional narrative of widespread degradation across the Sahel (Behnke and Mortimore, 2016). Of particular importance in this context were findings of a "greening Sahel" derived from time series of satellite imagery (Mbow et al., 2015), and a better understanding of the role of local peasants and pastoralists in land degradation. Once widely and unquestionably assumed as both perpetrators and victims of land degradation, local land users have come to be seen as rather

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adaptive and resilient stewards of their environments (Niamir-Fuller, 1998), as appreciation of local knowledge systems has increased across the science and policy communities.

The need to include local knowledge in degradation assessments has been acknowledged by researchers and practitioners (Cowie et al., 2018; IBPES, 2018). However, how local land users could be involved and their knowledge be elicited has been less researched. Using insights from a pilot study carried out in the Senegalese Ferlo region, this short communication explores the potential of involving local pastoralists in the definition of degradation indicators relevant to them.

2. Remote sensing as the backbone of degradation mapping

As a result of the new insights and data sources mentioned above, remote sensing-derived indicators swiftly replaced "expert judgment" (Middleton and Thomas, 1992) in global-scale assessments of the extent of land degradation (Yengoh et al., 2015) as a more objective, systematic and repeatable way of measuring and mapping status and trends in land cover. They also form the backbone of scientific conceptual (Land Degradation Neutrality: Cowie et al., 2018) and operational frameworks (IBPES, 2018), as well as of the latest edition of the World Atlas of Desertification (Cherlet et al., 2018), all of which also take into account a range of ancillary data sources at different scales of observation.

Using coarse resolution remote sensing time series to make inferences about land degradation dates back to Tucker et al. (1991), who carried out the first analysis that refuted the idea of widespread desertification in the Sahel by showing the magnitude of interannual variations of the Normalized Difference Vegetation Index (NDVI). The NDVI is an index combining spectral reflectances in the red and near infrared region of the electromagnetic spectrum, which is highly correlated with photosynthetic activity and green biomass and can therefore be used as a proxy for bioproductivity. Many more, and increasingly complex, studies based on the NDVI and its derivatives followed, most of which pointed to a greening of the Sahel region since the beginning of the NOAA AVHRR satellite record in the early 1980s (Mbow et al., 2015).

If land degradation is determined solely by a long term decline in bioproductivity, remote sensing evidence indeed indicates no degradation but rather an improvement in land condition across most of the Sahel. However, a comparison of maps of NDVI trends with people's perceptions of their changing environment has shown that the greening trend is only partly associated with a perceived improvement in rangeland conditions, whereas some undesired ecological trends, such as changes in vegetation composition, cannot be captured through such broad-brush remote sensing assessments (Herrmann et al., 2014). A study contrasting local managers' perceptions of pasture degradation with remote sensing results in Kyrgyzstan also found mixed agreement between the two (Eddy et al., 2017). While remote sensing has proven a highly useful tool that has contributed much to dismantling an outdated desertification narrative, as a top-down approach it is not without shortfalls when it comes to a concept as complex and context-dependent as land degradation. If used as a stand-alone tool, remote sensing risks giving rise to

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new orthodoxies of widespread improvement of land conditions (Herrmann and Sop, 2016). The discrepancy between remote sensing-based findings and local perceptions calls for alternative datasets of field-based degradation indicators that are relevant to local land users, in order to complement and add local context to remote sensing-derived indicators of degradation.

3. Perspectives from the ground

The lack of spatially explicit field observations over large areas is currently a weak link, which has hindered progress on the validation of remote sensing indicators of land degradation and the analysis of its driving forces and impacts. Extensive field data collection by scientists is expensive and time consuming, thus the presence of scientists in the field inevitably remains limited in space and time. However, scientists are not the only potential source of scientifically valuable data and information (Enquist et al., 2017). Local land users, while not scientifically educated, often have accumulated a vast knowledge of their environment which, unlike that of scientists, benefits from their continuous and long term presence in the region. Their environmental observations are informal, typically not systematic, lack quality control and can be biased (Reed et al., 2013). However, these biases can sometimes be leveraged by researchers to better understand priorities of local land users.

Local (ecological) knowledge, and related concepts of traditional or indigenous ecological knowledge, are not new concepts, but have received increasing interest and visibility since the pioneering work of Robert Chambers using innovative and creative approaches of Participatory Rural Appraisal (Chambers, 1994). The continuum of stakeholder participation ranges from the role of local participants as mere data providers on one end to their collaboration in defining and re-defining research questions on the other (Chouinard and Milley, 2018). To fill knowledge gaps and help overcome the inadequacy of conventional science and management, knowledge co-production approaches are beginning to be implemented in different regions of the world and make use of both indigenous and western local knowledge (Berkes, 2017): Woods and Ruyle (2015) documented informal monitoring used by ranchers in the US Southwest and found it generally compatible with and highly complementary to natural science and of interest to formal conservation planning. Likewise, Oba (2012) found that East African pastoralists have developed an in-depth knowledge of landscape classification using diverse environmental indicators, which is compatible with scientific ecological knowledge and can be used to assess landscape grazing potential.

While local knowledge has been embraced as a mechanism for validating and interpreting monitoring data in the Land Degradation Neutrality framework (Cowie et al., 2018), examples of how to implement the participation of local land users, and solicit not only data from them but their insights and understanding of the issue, are few and far between. On the contrary, the views and perspectives of local pastoralists are still largely absent from assessments of degradation, even though local land users are meant to be the ultimate beneficiaries of an improved understanding of rangeland dynamics and of any management interventions enabled by it.

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A systematic collection of local knowledge could form the basis for an alternative geospatial representation of land degradation, valuable both in its own right and as a reference for remote sensing-derived estimates of degradation. A first step toward such an endeavor is to learn what indicators pastoralists use to characterize the state of health or degradation of their rangelands.

4. Tapping into local knowledge: a pilot study in the Senegalese Ferlo region

4.1. Study site

We carried out a pilot study in the Senegalese Ferlo region in December of 2016 (dry season) to develop evidence of pastoralists' local ecological knowledge relevant to land degradation. The Ferlo is considered the heart of Senegal's pastoral zone and is representative of the Sahelian climatic zone with its short, irregular rainy season (mean annual rainfall: 300-500mm), a mix of herbaceous vegetation and scattered shrubs and trees, and only marginal dry farming potential (Tappan et al., 2004). The region is sensitive to drought impacts and primarily used for grazing.

We selected three sites (pastoral communities) in the vicinity of the town of Linguère from the diversity of landscapes in the Ferlo (Fig.1): (1) Barkedji in the Southern Sandy Pastoral Region, (2) Yangyang in the Northern Sandy Pastoral Region, and (3) Dodji in the Ferruginous Pastoral Region. In each site, with the help of local facilitators, we assembled a focus group of 4 to 10 pastoralists who had been residents of the area for a long time and were considered among the most knowledgeable of pastoralist issues and the environment.

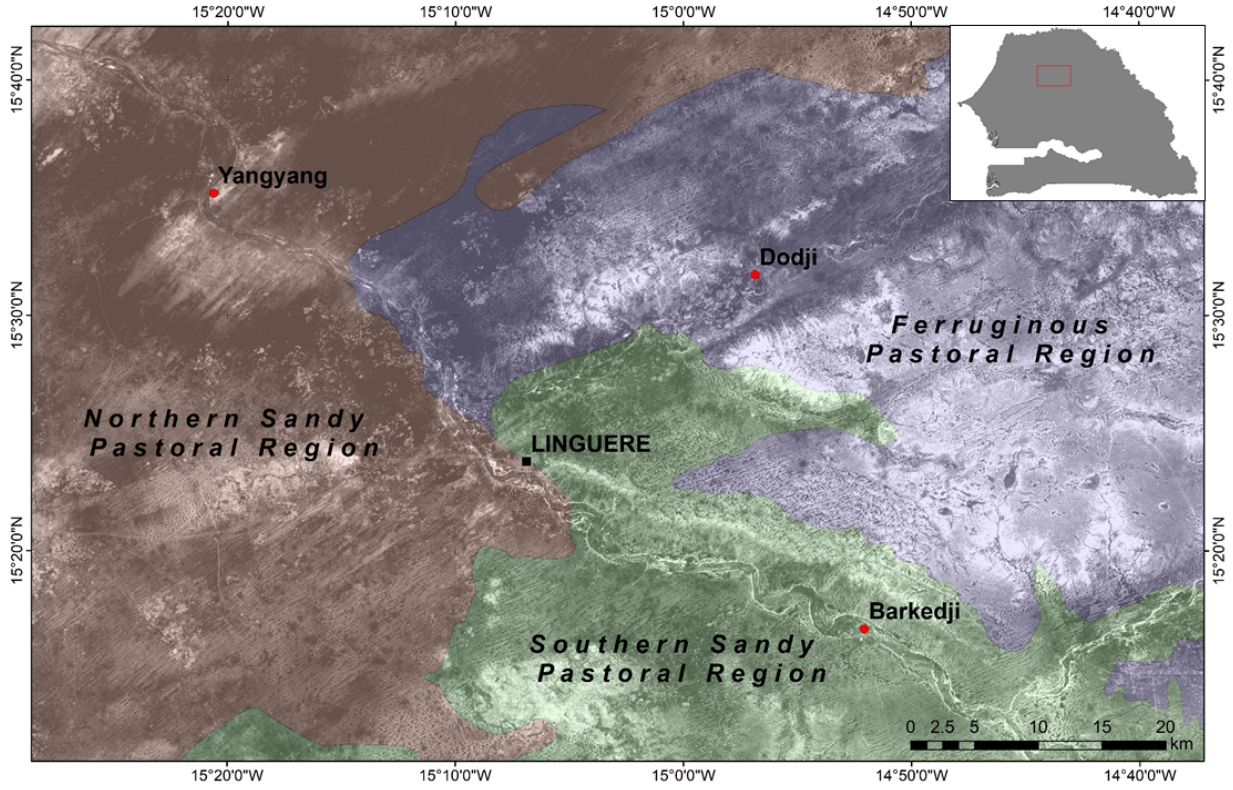

Figure 1: Location of the three field sites in different ecological regions (Tappan et al., 2004) around the town of Linguère in the Senegalese Ferlo, superimposed on a Landsat 8 OLI image from October 2, 2016.

4.2. Photo elicitation

In the context of this pilot study, we used the photo elicitation method – a qualitative research method that empowers participants to document and share their perspective by capturing their observations in photographs (Collier and Collier, 1986; Kong et al., 2015) – to give a voice to the pastoralists as the experts on their environment based on their long presence in the region and intimate familiarity with their natural surroundings. In each of the three focus groups, an initial visit introduced the background and goals of the pilot study, garnered the pastoralists' interest in participating, and instructed participants in the use of and what to document with the camera that was left with them.

A second visit took place 2-3 days after the first and gave participants the opportunity to show and explain the photos they had taken (Fig. 2), which were projected onto a wall where electricity was available or otherwise displayed on a laptop screen. The presentations were led by the pastoralists and allowed us to learn about their environmental concerns through their eyes. It was followed by a discussion of possibilities of, and interest in, systematically collecting and disseminating locally relevant degradation indicators as well as an assessment of the mobile technology currently available to pastoralists. Each meeting was facilitated by a local facilitator in the pulaar language spoken in the region, and recorded by the co-authors.

4.3. Degradation indicators

The focus group discussions were centered on the topic of pasture quality and its characteristics and determinants. A simple question about different types of pastures and which pastures are good, bad, or worsening provided an entry point, and a "how do you know?" then prompted a conversation about indicators.

From the perspective of the pastoralists, indicators of pasture quality are in the first place related to livestock performance and health, rather than environmental markers. Thus, the quantity and quality of the milk (e.g., smell, taste), as well as the appearance of the skin or fur of the animals all were mentioned as indicators of pasture quality. While highly relevant to pastoralists from an economic or livelihood perspective, these indicators are arguably difficult to monitor and map. Only when directly asked about ways to tell whether a pasture is good or bad *before* the animals are grazed did the pastoralists produce the kind of environmental indicators that we had been expecting. These were the indicators, and broader environmental concerns, that the pastoralists documented in the photo elicitation exercise, including a loss of forage quantity as well as quality of the vegetation cover.

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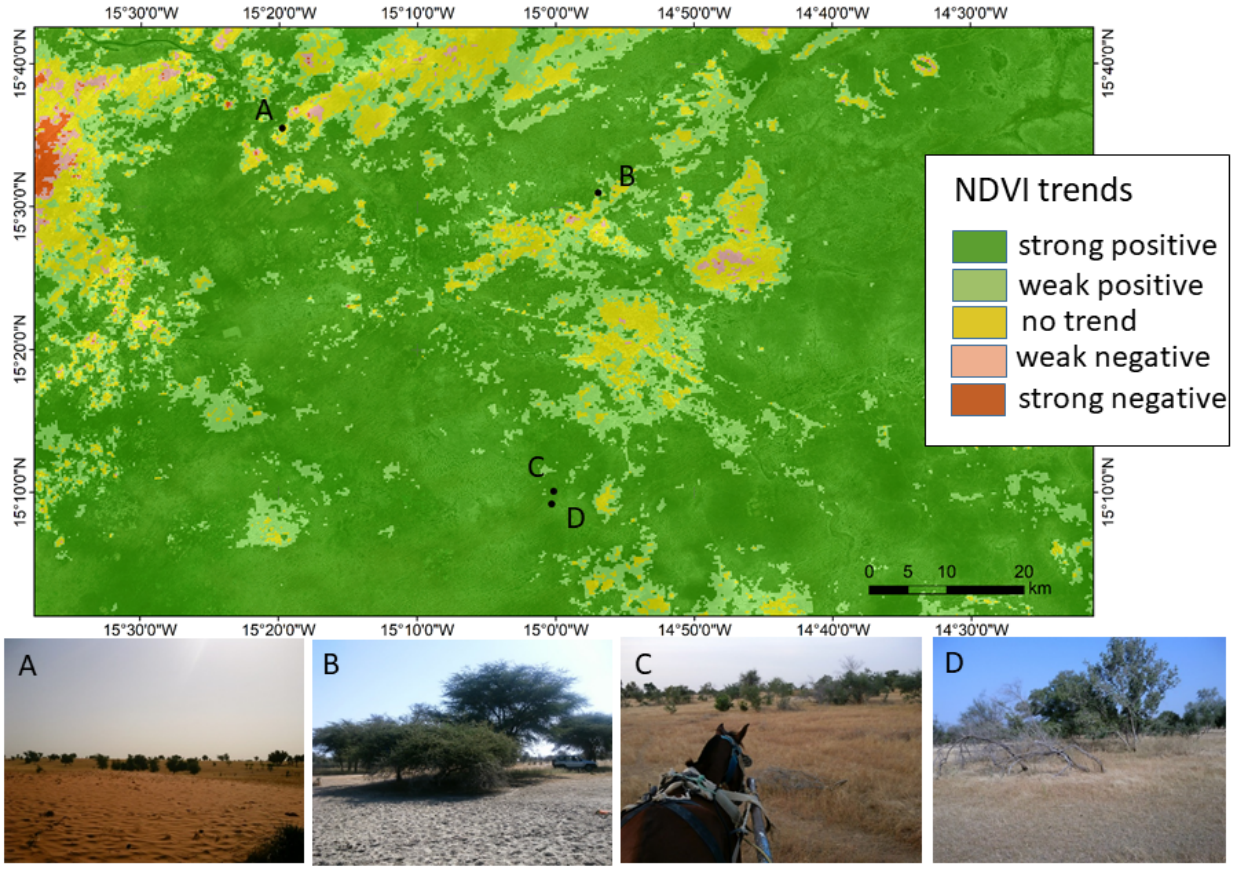

Figure 2: Selection of photos taken and explained by the study participants, and their approximate location on a map of mean annual MODIS NDVI trends 2001-2015: A) Mobilization of sand; B) Decrease in tree species diversity, especially around temporary ponds ("mares"); C) Propagation of an invasive red grass ("demba yabal"); D) Tree mortality and lack of natural regeneration of young trees.

In the discussion of the photos they had taken, pastoralists pointed out a decrease of overall tree cover over the years, which they attribute to a combination of precipitation shortfalls, pests and cutting. They are particularly concerned about a lack of natural regeneration of the semi-evergreen Sahelian native *Guiera senegalensis*, which leaves open spaces when mature trees die or are cut down (Figure 2a).

A decrease in the diversity of tree species was also reported, especially around the seasonal ponds forming in depressions ("mares"), where dense stands of tamarind, baobab and other trees used to be found. The pastoralists attribute this to a lack of water in the depressions. According to them, good rainy seasons occur only once every 3-4 years, and the surface water that seasonally inundates the depression now lasts shorter than it used to in the past (Figure 2b).

Pastoralists were not only concerned about the loss of tree density, but also about the herbaceous vegetation cover becoming sparser in places. As a result, sand dunes formerly stabilized by vegetation have become mobile (Figure 2c). And where the grass cover is still dense, some of it is reportedly due to the proliferation of an invasive grass species, which they call "demba yabal" (red grass) and which most likely belongs to the *Rubiaceae* family (oral

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communication, CSE) (Figure 2d). Its provenance disputed, the grass was observed first in the area a few years ago and has expanded very quickly, outcompeting native species such as *Zornia glochidiata*, *Schoenefeldia gracilis*, *Eragrostis tremula*, and others. According to the pastoralists, the red grass is not palatable to the livestock, especially cattle. Sheep can digest it only when it is dry. Pastoralists therefore avoid pastures taken over by the grass. Invasive species research is indeed a topic that is thought to benefit from integrating local pastoral knowledge, as also shown at the example of the discovery of an invasive rubber vine (*Cryptostegia grandiflora*) in northeastern Ethiopia previously unknown to researchers and others working in the region (Luizza et al., 2016).

Of the environmental indicators brought up by the local populations (Table 1), many are not directly related to bioproductivity or the remote sensing-based Normalized Difference Vegetation Index (NDVI). The table also shows that the list of indicators mentioned differed already between three relatively close sites, illustrating the importance of local context in the assessment of degradation. Hence, the involvement of a local land users from a number of communities in the definition of indicators is a step that should not be skipped. Furthermore, it would be beneficial to take into account the temporal dynamics of degradation indicators by seeking observations from different times of year. It is expected, though, that a few common indicators would emerge that are representative of a larger area and could be prioritized.

Table 1: Indicators of environmental degradation mentioned and documented by the pastoralists in the three study sites.

Indicator mentioned	Barkedji	Yangyang	Dodji
Tree die-off	×	×	×
Fewer tree and shrub species present	×	×	
Lack of young trees and shrubs	×		
Shorter duration of water in ponds	×	×	×
Water becoming salty		×	
Declining amount of fodder grass		×	×
Proliferation of a "red grass"	×	×	×
Only short grasses present	×		
Fewer pasture species present	×	×	
Soils becoming sandier		×	
Soils becoming less productive		×	
Brighter soil color		×	
Erosion gullies present			×
Poor rainfall	×		×

5. Conclusions and outlook

This qualitative pilot study from the Senegalese Ferlo showed that land degradation is of concern to local pastoralist populations primarily because of its impact on livestock production. This perspective is reflected in their ways of identifying and characterizing degradation. Overall bioproductivity is only one aspect of rangeland health. Other environmental aspects include the composition and quality of the herbaceous and woody vegetation, which is where remote sensing has so far fallen short of providing locally relevant assessments.

Not all degradation indicators brought up by local pastoralists are easily measurable, let alone mappable. Locally identified indicators also vary in their relevance across communities and regions. Any larger-scale effort of systematic and spatially explicit data collection with the goal of a field-based geospatial representation of locally relevant degradation indicators should therefore focus on indicators identified independently by a number of communities, for example the proliferation of an invasive species. Such a dataset could serve as an input to a decision support tool to local land managers, or guide the development of remote sensing metrics that better capture local concerns, thus linking the research and development agendas. While some indicators, such as tree cover, might be detectable using remote sensing at finer resolutions, others, like species composition, would be entirely complementary to remote sensing, but equally valuable. Remote sensing provides the larger context and offers systematic and highly reproducible measurements, which however often miss features of concern to local land users, whereas the local indicators capture the idiosyncrasies of a location.

The next step to take this work forward would be implementing a data collection system that is flexible enough to incorporate these locally identified indicators, provided interest by the pastoralists in participating in such an endeavor. Involving citizens in science observations has seen an upsurge in the past decade with the growth of cloud computing and collaborative cyberinfrastructure, which has reached the developing world (Hoedjes, 2014). With the widespread use of cell phones for information exchange (confirmed by our study participants) as well as rapid improvements in mobile network coverage, there is an important potential not only for delivering information to pastoralists (Rasmussen et al., 2015), but also for pastoralists to actively contribute environmental observations in a systematic way. Our pilot study participants expressed their interest in sharing observations through mobile apps, provided appropriate technology be available to them, and hope to in turn receive information that would help them better manage livestock movement and address their environmental concerns. A larger field-based dataset would allow us to better assess the compatibility of the locally defined indicators with the range of available remote sensing data products.

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