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Development of a Soil Organic Carbon Baseline for Otjozondjupa, Namibia

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Abstract

Land Degradation Neutrality (LDN) has been piloted in 14 countries and will be scaled up to over 120 countries. As a LDN pilot country, Namibia developed sub-national LDN baselines in Otjozondjupa Region. In addition to the three LDN indicators (soil organic carbon, land productivity and land cover change), Namibia also regards bush encroachment as an important form of land degradation. We collected 219 soil profiles and used Random Forest modelling to develop the soil organic carbon stock baseline. Values range between 0.53 and 4.27 kg/m^2 in the sandy Otjozondjupa soils. LDN baselines were integrated into other national planning processes to add value to LDN products. Analyses of the relationship between soil carbon and land cover change, especially from grassland to bushland, increased the usefulness of soil carbon maps for the Integrated Regional Land Use Planning process. Local ownership of LDN baseline development, from data collection to digital soil mapping, was crucial for local stakeholders.

Keywords: LDN, soil organic carbon, Namibia, Otjozondjupa, bush encroachment, land use planning

Introduction, scope and main objectives

Land degradation is a global problem with serious economic, social and political consequences. The Economics of Land Degradation (http://www.eld-initiative.org/) project estimates that over 50% of the world's croplands and pasturelands are moderately to severely degraded. The United Nations (UN) estimates that 75% of forest lands are degraded and the rate of forest degradation is almost equal to that of deforestation (FAO Global Forest Resources Assessment, 2015)[1]. Economic losses from soil degradation are over $10 trillion, or around $1000 per capita, globally. As the global population increases by 2 billion in the coming 34 years and as diets change, the pressure on land resources will increase.

Given the severity of land degradation, there is renewed focus on restoration and sustainable land management (SLM) activities globally. Programs such as 20 by 20, which aims to restore 20 million hectares of degraded land by 2020 in Latin America, and AFR100, which aims to restore 100 million hectares of degraded land by 2030 in Africa, are working to mobilize resources and attract private sector investors for restoration activities. The Sustainable Development Goals (SDGs) also focus on this issue and SDG15.3 reads: By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.

The concept of Land Degradation Neutrality (LDN) receives much support from the UN Convention to Combat Desertification (UNCCD), and it has been piloted in 14 countries in 2015 while it is being scaled

[1] See: http://www.fao.org/3/a-i4808e.pdf

up to over 120 countries (that are parties to the Convention) in 2017. The geographic focus in Namibia, one of the 14 pilot countries that developed LDN baselines, was on the Otjozondjupa Region which has an area of approximately 105,000 square kilometres with a total population of less than 142,000 people. One of the reasons why this region was selected was because Namibia plans to integrate LDN into other national planning processes. The Integrated Regional Land Use Planning (IRLUP) process was planned to start in August 2016 which made the selection of Otjozondjupa ideal. This paper discusses the development of the Soil Organic Carbon (SOC) baseline, one of the three LDN indicators, focusing on method selection, capacity building, and key lessons learned.

Methodology

The process for LDN baseline development had two phases. During phase 1, a Synthesis Report (Nijbroek et al., forthcoming)[2] was written to provide a thorough review of methodologies currently available for the three LDN indicators: Soil Organic Carbon (SOC), Land Productivity or Net Primary Productivity (NPP) and Land Use and Land Cover Change (LUC). The LDN process also allows for countries to select a fourth indicator if land degradation is not sufficiently captured by these three indicators. In Namibia, Bush Encroachment (BE) is a problem with significant economic impacts. Therefore, a baseline for bush density was also developed. During a first workshop in Windhoek in February 2016, local stakeholders were guided through different exercises to define selection criteria for LDN methods (e.g. cost or accuracy), apply weights to these criteria, and make a final selection.

During Phase 2, a training workshop was held with potential field staff and representatives from local communities in Otjozondjupa focusing on sampling design and data collection. Participants were trained to collect soil samples at 0-30cm, 30-100cm and a bulk density core at 15cm. We used a freely available SOC map from ISRIC (www.soilgrids.org), Google maps, and local knowledge of the region to plan the data collection. We furthermore balanced data collection for SOC with data collection for the LUC and BE baselines.

After the data were analyzed, several digital soil mapping methods were tested to find the best possible fit for a SOC baseline at 250m resolution. By using the existing SoilGrids map for designing data collection as well as using it as a covariate in the modeling, we wanted to test different ways to easily improve on the freely available SoilGrids with minimal cost. A third workshop was completed with participants from the private sector, local universities and different government offices, all people who had been identified as most likely to provide support to the Ministry of Environment and Tourism (MET) in future monitoring and reporting for LDN. In addition, we took part in IRLUP planning meetings to explain how the LDN baselines could be used for this process.

Results

During the first workshop, participants stressed that the selected LDN methodology needed to be locally "owned". This requirement for local ownership implied several things. First, soil data were analyzed at the Ministry of Agriculture, Water and Forestry (MAWF) in Windhoek. This meant that the Walkley-Black method was used rather than a more precise alternative, such as infrared spectroscopy, which was not locally available. Second, the digital soil mapping technique needed to match local capacities or these capacities needed to be developed. We tested Regression Kriging, Random Forest and Gradient Boosting to develop the final SOC and a survey of workshop participants revealed that capacity was lacking. We provided a one-week training in these approaches, as well as a training in R and GIS. Last, participants of the first workshop wanted the LDN baselines to be useful for the IRLUP process. The proposal we made to the MET was discussed with members of the IRLUP process before it was approved.

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[2] Nijbroek et al., forthcoming, Review of Methodologies of Land Degradation neutrality Baselines: Sub-national case studies from Costa Rica and Namibia, CIAT Report, Nairobi, Kenya

The task of planning field work was especially challenging due to the size of the area, time and budget constraints, and a lack of available data on existing road networks. Data were collected during the dry season from April 11 to June 3, 2016. A field team of Namibian nationals aimed to collect 325 soil profiles and were able to reach 237 locations, resulting in 219 useable soil profiles. The final SOC baseline map (Figure 1) was produced using Random Forest modeling and shows a range of values from 0.53 - 4.27 kg/m^2 in Otjozondjupa.

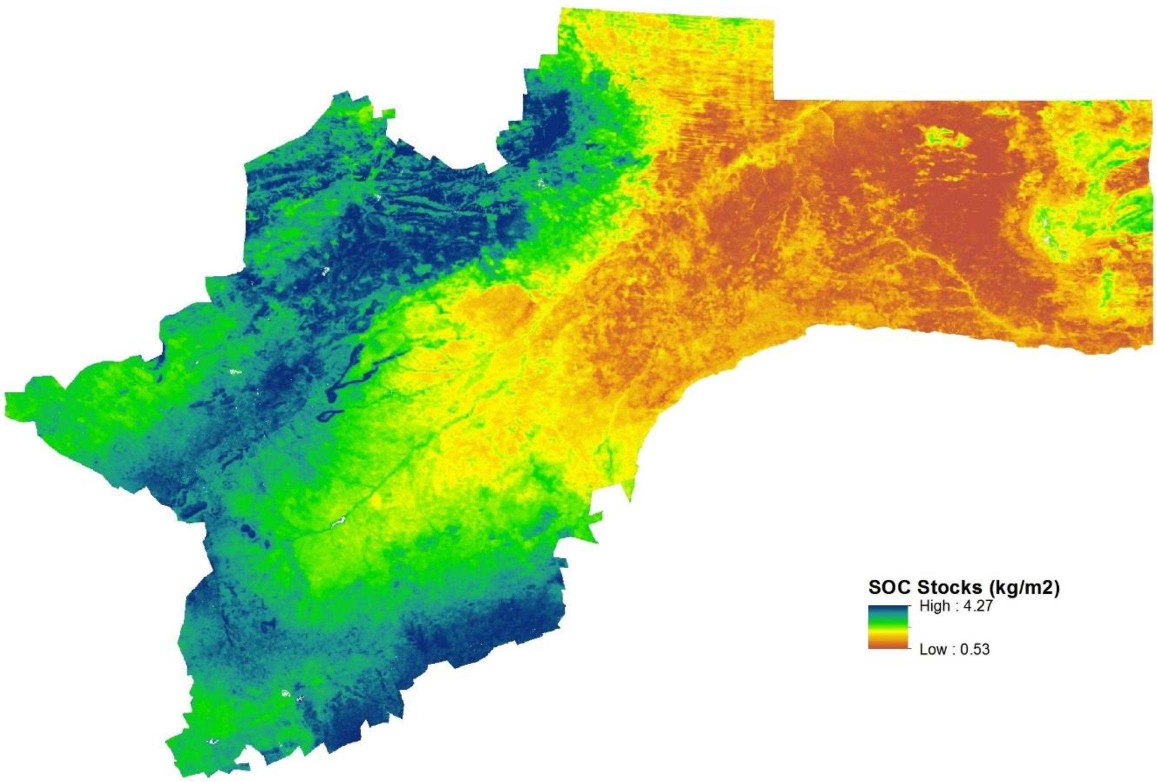

Fig. 1: Soil Organic Carbon stocks (0 – 30cm) for Otjozondjupa, Namibia. Total stock = 2,835 tons.

Discussion

Participants in Namibia were much more concerned with local ownership of the LDN process then we expected. The synthesis study, for example, includes the following criteria that need to be evaluated in the selection of a methodology:

- Ability to assess the indicator of interest at a relevant spatial scale that capture landscape variabilities
- Ability to detect changes in indicators at appropriate spatial scale, and with appropriate temporal resolution
- Cost-effectiveness
- Transparency of methods, high accuracy, consistency, and reliability
- Accessibility, now and in the future, for monitoring and evaluation
- Comparability between regions and nations
- Capacity and acceptance of local and national partners to implement the methodology and integrate with ongoing national processes

Only the last point in this list mentions local acceptance but here it is formulated more with regards to finding agreement or consensus, not necessarily with respect to acceptance for ownership. This point also combines the ability of the method to be integrated with ingoing national processes, and this should probably be a point in itself given the importance in Namibia.

During the digital soil mapping training, for which participants reported that they had a background in GIS, R, statistics or a combination, we conducted a survey to gage whether participants understood what is meant by the fourth bullet: transparency of methods, high accuracy, consistency, and reliability. The answers showed that there was a wide range in understanding of these concepts. This is another indication that understanding of methodologies for developing LDN baselines, including the SOC baseline, requires further investigation in terms of how criteria or communicated and explained.

While there has been much debate regarding the selection of the three LDN indicators (LUC, NPP and SOC), our experience in Namibia shows that it is crucial that the value of these indicators is understood beyond the LDN process in order transition towards a degradation-neutral world. Showing the value and practicality of SOC is especially difficult due to the slow nature of the variable. This is further exacerbated by the relatively low SOC values in sandy soils.

In Namibia, for example, it was important to link SOC, as well as the other LDN indicators, to the locally more important concern for bush encroachment to show the value of the LDN indicators. One approach was to show that areas that converted from the more desirable grassland to bushland had lower SOC values (1.28 kg/m^2) then either areas that converted from bushland to grassland (1.59 kg/m^2) or areas that remained grassland (1.67 kg/m^2) from 2000 to 2016. We also showed that areas which are becoming bush encroached (measured by the density of small bushes less than 1.5m in height) are actively replacing grasslands and have a negative correlation with SOC. On the other hand, once land is encroached by mature bushes (greater than 1.5m), SOC tends to increase again probably due to density of the root system. While this is seemingly desirable in terms of carbon sequestration, in Namibia this has the unfortunate effect of much higher transpiration from deeper roots that can lower the water table compared to grassland systems (Colin Christian & Associates, 2010)[3].

Conclusions

The LDN framework provides a good opportunity to take stock of the world's soil carbon resources, and work within national environments to stop the loss of soil carbon and reverse land degradation more generally. Many countries lack good data on soil carbon stocks and we successfully developed a SOC baseline at the sub-national level in Namibia. The baseline was just the first step however. It was critical to then link this baseline to other national planning processes, in our case the politically supported Integrated Regional Land Use Planning process. By showing the relationship between land cover change and soil carbon, especially with respect to areas that are converting from more desirable grasslands to bush encroached lands, we captured the attention of the IRLUP team.

There are many factors that influence the development of a SOC baseline including sampling design and cost of data collection, laboratory methods for analyzing soil samples, digital soil mapping techniques, etc. Further research is needed to make sure that relevant decision makers understand the nuance of the differences in choices. Even if this is clear, however, it may be the case that the most important criterion is that the process can be locally controlled from start to finish, and this requires a much greater investment in capacity building.

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[3] Colin Christian & Associates, 2010. The effect of bush encroachment on groundwater resources in Namibia: a desk study. A report commissioned by the Namibia Agricultural Union. 126 pp.