Methodological note

Trends in Population Exposure to Land Degradation

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1. Introduction

Land degradation continues expanding worldwide, affecting billions of people around the world [1–5]. Improving the living conditions of affected populations is at the core of the UNCCD 2018-2030 Strategic Framework[1]. Land degradation can impact populations in multiple forms, as it constrains the intertemporal supply of vital ecosystem services for human wellbeing, including the provision of food, energy, water, carbon sequestration capacity and biodiversity[1].

In decision 11/COP.14 Parties requested the Secretariat to align the reporting process for Strategic Objectives 1– 5 with gender-responsive indicators and guidelines, currently under development, and to ensure that the gender dimensions of land degradation are captured. In this context, the following progress indicator and underlying metrics are proposed to support the upcoming UNCCD 2021-2022 reporting cycle with gender-responsive indicators for Strategic Objectives 2 − to improve the living conditions of affected populations.

The purpose of this note is to develop a methodology for estimating the proportion of populations[2] exposed to land degradation disaggregated by sex. The proposed approach aims particularly at providing information about the proportion of male and female population exposed to land degradation, as a first step towards addressing the gender data gap on land degradation issues within the UNCCD reporting framework. While this information is critical and currently not available, sex-disaggregated data will not be sufficient to understand the gender dynamics and related issues in a specific region. Further socio-economic and demographic indicators will be necessary to conduct gender analysis in order to better understand how and why specific populations are affected by land degradation. [12].

Proposed indicator and metrics

Progress Indicator: Trends in the proportion of population exposed to land degradation disaggregated by sex.

Metric 1: Percentage of the *female* population exposed to land degradation.

Metric 2: Percentage of the *male* population exposed to land degradation.

Metric 3: Percentage of the *total* (female and male) population exposed to land degradation.

[1] https://www.unccd.int/sites/default/files/relevant-links/2018-08/cop21add1_SF_EN.pdf
[2] Henceforth, the term *'populations'* will be used interchangeably to refer to female, male and total population as described in Metrics 1-3.

2. Methodology and Datasets

Two key determinants for assessing the risk of natural hazards for a population are its exposure and vulnerability[6]. In general terms, the notion of *exposure* refers to the inventory of elements (e.g. population, assets, production, livelihoods, etc.) in the area where the adverse natural phenomenon, the hazard, takes place[6]; whereas *'vulnerability'* refers to the propensity of exposed elements to suffer adverse effects when impacted by a natural hazard[6]. Vulnerability includes factors that may exacerbate the negative impacts on the exposed elements such as predisposition, susceptibilities, fragilities, weaknesses, deficiencies, or lack of capacities[6]. For instance, socioeconomic conditions of the exposed populations, such as poverty, will aggravate or affect their vulnerability levels[6]. Like the case of adverse natural phenomena, understanding exposure and vulnerability is a prerequisite for determining the risk posed by land degradation to affected populations and their wellbeing.

Measurements of population exposure to environmental phenomena have been widely used, as for example in the context of drought [7,8], land degradation [1–5], sea-level rise and floods [9], and climate change[10]. In the specific case of drought, an indicator estimating '*trends in the proportion of the population exposed to drought'* has been adopted in decision 11/COP.14 as part of a tiered indicator and monitoring framework for Strategic Objective 3 (to mitigate, adapt to, and manage the effects of drought in order to enhance resilience of vulnerable populations and ecosystems). Several studies have also investigated the effects of land degradation for populations using the notion of exposure [1–5]. For instance, the IPBES Assessment Report on Land Degradation and Restoration estimates that the wellbeing of 3.2 billion people is affected by land degradation [1], based on the work of Le and colleagues 2015 [5] which also refers to the notion of population exposure. A UNCCD study furthermore shows that about three billion people are exposed to land degradation, out of which one third represents rural population [2]. Other works conclude that between 1.3 and 1.5 billion people are affected by land degradation, based on the notion of exposure in rural areas and using biomass productivity indicators as a proxy for land degradation [3,11].

As a first step in estimating the proportion of populations affected by land degradation, the notion of *exposure* is operationalized by building on the work of previous studies [1–5]. This proposed approach can be further enhanced by including vulnerability aspects of the populations exposed to land degradation as part of future methodological developments.

In order to identify populations exposed to land degradation, spatial information on the distribution of populations as well as land degradation in the area of interest (e.g., at subnational, national, regional or global scale) is crucial. These data are relevant for identifying degraded areas and measuring the respective populations residing in these areas. The methodological procedure in this regard specifically entails intersecting spatial data on land degradation and populations in order to infer the proportion of the population residing on degraded land in a specific geographic area at a given resolution. These estimates serve as a proxy measure of the exposure of populations to land degradation.

The measurement of land degradation is specifically aligned with the methodology adopted to report on SDG Indicator 15.3.1 and follows version 2.0 of the Good Practice Guidance for SDG Indicator 15.3.1 [13] and the Scientific Conceptual Framework for LDN [14]. Changes in the state of land are assessed by analyzing temporal trends in three sub-indicators: land productivity, land cover and soil organic carbon stocks. The integration of these sub-indicators is carried out following the approach "one-out all-out", which states that if any of the sub-indicators shows a significant reduction or negative change with respect to the baseline (2001-2015), then the area under analysis is considered as degraded. For further details see references [13,14]. Default data on land degradation recommended in this note can be obtained from Trends.Earth [15] at the spatial resolution of 250 meters for land productivity and soil organic carbon and 300 meters for land cover. The result is a raster image with the following key values per grid cell: '-1' for degraded land; '0' stands for stable land condition; and '1' refers to improving land conditions.

Regarding the female and male population, the methodology exclusively refers to the respective population in the area of interest. Based on a recent review of global gridded datasets of population available for monitoring drought exposure[16,17], the dataset of the WorldPop Project (www.worldpop.org) is recommended as a default data source. This data source fulfills technical requirements such as temporal and global coverage, disaggregation by sex as well as a relatively high resolution. In particular, WorldPop produces gridded population count datasets in time series between 2000 and 2020 for all countries and at a spatial resolution of 100 meters [18]. These datasets were generated by gridding subnational information on age and sex structures, and overlaying them with the corresponding population count datasets [18,19]. The primary information source for these datasets are national population census, micro census and household surveys [18,19].

An alternative sex-disaggregated population dataset, the Gridded Population of the World (GPW) [20], has been developed based on population census, national geographic boundaries, protected areas and water bodies by the Centre for International Earth Science Information Network (CIESIN) at Columbia University. It is a gridded layer with an output resolution of 30 arc-seconds (approximately 1 km at the equator). The input data are weighted and extrapolated to produce population estimates (counts and densities) per grid cell for the year 2010 [15].

Combining the spatial datasets on populations and land degradation may require harmonization in terms of their coordinate reference system (CRS) and spatial resolution. In the case of the two suggested default datasets [13,16], the dataset on land degradation uses the World Geodetic System 1984 (WGS84); whereas the CRS of the populations' datasets in some cases differs from WGS84, as WorldPop uses a CRS more appropriate for individual countries. It may therefore be necessary to reproject the two datasets [13,16] into a common CRS for some countries.

A further issue concerns the different resolution of the default datasets: 100 meters in the case of populations and 250 meters for land degradation. As the grid resolution is different, the maps have to be resampled into a common grid size. The recommendation is to define the grid cell size for the analysis at the smallest resolution level of the data inputs; in this case the 100 meters resolution of the dataset of populations. Countries using national datasets should assess them in terms of their projection and resolution and standardize them as needed, in order to be able to combine them in the analysis of population exposure to land degradation. In the event that the population dataset needs to be resampled, it is important to consider whether the dataset is population density (people per unit of area) or population count (inhabitants per grid cell). If the dataset is population density, then resampling will not affect calculations. If the dataset is count, then the adjustment in grid cell size will need to be incorporated into the analysis for an accurate final population count. An additional and final harmonization procedure is the alignment of the population and land degradation grids. A common origin of the grids should be defined so that the grids are co-registered to one another and overlay perfectly.

It is additionally important to highlight two aspects related to the temporality of the analysis. The first concerns the fact that the land degradation map covers a certain number of years (and not a specific year) as it captures temporal trends in the three sub-indicators mentioned above; whereas population reflect the populations in one specific year. For instance, the land degradation dataset could represent trends in the three sub-indicators for the time period between 2001 and 2015; while population data represent the year 2015. The second aspect refers to the relevance of carrying out this analysis over at least two time periods in the case of populations in order to measure changes over time. It is important to note, however, that the changes in the proportion of population exposure to land degradation may not be only due to the expansion of land degradation but also because of population growth, among other factors.

2.1. Key steps in estimating population exposure to land degradation

The following subsection provides a brief guidance of the key steps for estimating population exposure to land degradation disaggregated by sex.

1. Identify national sources of spatial datasets for populations (i.e. female and male population) and land degradation. In the case of missing data from national sources, default datasets should be used. [13,16].

2. Standardize the selected datasets in order to harmonize their resolution and reproject and co-register if needed.

3. Intersect each of the selected spatial maps of populations − that is the selected dataset for female and male population − with the maps on land degradation. Then add the population residing on degraded land across grid cells by identifying the intersection of these datasets. This can be represented by the following formulation:

   $SPE_k = \sum_{i=1}^{n} PE_{ik}$ Equation (1)

   SPE: sum of population *'k'* exposed to degraded land, with *'k'* representing female and male population in the area of interest.

   PE: population exposed to land degradation in the respective grid cell *'i'*.

   Where *'i'* characterizes a spatial grid cell that shows signs of degraded land in the area of interest. '*k*' stands for the different types of populations, namely female and male population, residing on the degraded grid cell *'i'*. 'n' represents the total number of degraded grid cells in the area of interest.

   Equation (1) renders the female and male population exposed to land degradation. In order to derive the total population exposed to land degradation, the sum of female and male population exposed to degraded land that was derived from Equation (1) should be carried out. Alternatively, employ a dataset for the *total* population in the areas of interest and use Equation (1).

4. Estimate the percentage of the populations exposed to land degradation over the respective total population. The formulation is the following:

   $PPE_k = \frac{SPE_k}{TP_k} \times 100$ Equation (2)

   Where:

   TP: total population of the type 'k' in the area of interest, with 'k' taking three values in this occasion to represent female, male and total population.

PPE: Proportion of population exposure of class *'k'*.

Thus, Equation (2) renders the three metrics recommended in section 1.

5. Consider running the analysis for two or more time periods in order to measure changes over time in the proportion of populations exposed to land degradation.

3. Final remarks

This note describes a methodology to quantify the exposure of populations to land degradation disaggregated by sex, as a first approximation to support Strategic Objectives 2 with gender-responsive indicators in the context of the upcoming UNCCD 2021-2022 reporting process.

As a first approach, a measure of female, male and total population *exposure* to land degradation is proposed based on previous studies and related scientific literature. In general, on-site exposed populations to land degradation may produce lower-bound estimates of the exposure of populations to land degradation because land degradation in a specific area impact not only populations residing on degraded land, but also – through environmental, economic and social linkages – populations elsewhere.

Other consideration to take into account in the proposed approach regards the exposure of populations to land degradation as a consequence of the expansion of cities, that is when land is being degraded due to urban expansion. As the exposed populations to land degradation are potentially at risk due to the loss of key land-based ecosystem services, this is less likely to occur on degraded land that result from the expansion of cities, because populations residing in the expanded areas of cities may be less dependent on direct land-based ecosystem services due to the generally better access to goods and services in urban areas. Nonetheless, urban populations may also be affected by land degradation in an indirect manner, as for example by food shortages and associated higher food prices affecting urban population welfare[2]. As part of a future methodological research agenda on exposure metrics to land degradation, the complementarity of Metric 1-3 with estimates of *'rural'* populations exposed to land degradation should also be considered; this integration would render metrics of population exposure to land degradation excluding populations residing in land recently converted into urban areas.

In order to have a more comprehensive measure of populations that are affected by land degradation, the availability and inclusion of further data and indicators will need to be explored. A key recommendation is to quantify vulnerability aspects of populations exposed to land degradation, considering socioeconomic conditions, land tenure systems, migration and displacement, age, marital status, among other dimensions.

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