Interim Report

Trends of degradation and improvement in biomass productivity in target countries of CGIAR Initiative in Sustainable Intensification of Mixed Farming Systems

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ICARDA

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Trends of degradation and improvement in biomass productivity in target countries of CGIAR Initiative in Sustainable Intensification of Mixed Farming Systems

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INTRODUCTION

Degradation of land productivity is a profound problem seriously undermining livelihoods, especially of the poor, in all agro- ecologies across the world that includes different regions of mixed farming systems (Nkonya et al., 2011). Land productivity is the biological productive capacity of the land, the source of all the food, fiber and fuel that sustains humans. Net primary productivity (NPP), i.e. productivity of vegetation including crops and forages, has been widely used as a proxy of land productivity (Safriel et al. 2007, Vlek et al. 2010, Le et al. 2016).

Addressing land productivity degradation in sustainable intensification requires channelling substantial amounts of scarce resources and making long-term investments. These investments are likely to yield high levels of social returns and welfare improvements. However, all countries and involved communities have budgetary and human power constraints, necessitating the prioritization of such investments/interventions. Thus, spatial planning in sustainable intensification often need information about areas experienced degradation in order to prioritize national budgets and plan strategic interventions. To achieve this, accurate maps of land degradation hotspots – where land productivity degradation is most acute, are needed. Also, the mapping of productivity degradation level also a cost-effective approach for guiding the design of subsequent focal ground-based studies in sustainable intensification (Vlek et al. 2010, Le et al. 2016).

This document report the interim results of land productivity degradation/improvement mapping for Ethiopia, Malawi, Ghana and Laos which are of the target countries of the CGIAR Initiative in Sustainable Intensification of Mixed Farming Systems (SI-MFS). Further elaborations of the mapping work in these countries, and well as similar applications to the two other target countries, i.e. Nepal and Bangladesh will be the follow-up activities in 2023.

INPUT DATA AND METHODOLOGY

We use Trends.Earth tool (Trends.Earth 2022) for calculating and mapping land productivity degradation/improvement in the four target countries of CGIAR Initiative in SI-MFS (Ethiopia, Malawi, Ghana and Laos). Trends.Earth is a browser-based tool in addition to the plugin to desktop QGIS spatial-analytical software. The tool allows users to assess time series of key indicators of land change to produce maps and other graphics that can support monitoring and reporting, and to track the impact of sustainable land management. The tool supports monitoring progress on land degradation neutrality (SDG 15.3.1). For this purpose, the tool implemented the most up-to-date remote sensing time-series and analytical methods for calculating trends in NPP.

One of the most commonly used surrogates of NPP is the Normalized Difference Vegetation Index (NDVI), computed using information from the red and near infrared portions of the electromagnetic spectrum. Trends.Earth uses of bi-weekly products from MODIS for computing annual integrals of NDVI (computed as the mean annual NDVI for simplicity of interpretation of results). These annual integrals of NDVI are then used to compute each of the productivity sub-indicators that include: (i) productivity trend/trajectory, (ii) productivity performance and (iii) productivity state. Then, (iv) the final indicator of land productivity degradation/improvement is the combination of the three productivity sub-indicators.

Productivity Trend/Trajectory

The productivity trend/trajectory sub-indicator measures the rate of change in NPP over tim, given a defined period, Trends.Earth calculates a linear regression at the pixel level to identify areas experiencing changes in NPP over the considered period. Then, non-paremetric significance test (Mann-Kendall) is applied, and only significant changes at p-value ≤ 0.05 (confidence level at 95%) are considered. Positive significant trends in NDVI would indicate potential improvement in land condition, and negative significant trends potential degradation. Furthermore, the Trends.Earth tool applies most current methods for correcting the effects of climate changes on the inter-annual NPP trend. For this application, we use MODIS time-series from 2000 to 2015, with a spatial resolution of 250m.

Productivity State

The productivity state sub-indicator measures recent changes in NPP period in comparison to the baseline a baseline period. For each pixel, Trends.Earth uses the annual integrals of NDVI for the baseline period to compute a frequency distribution.

Productivity Performance

The productivity performance sub-indicator measures local productivity relative to other similar vegetation types in similar land cover types or bioclimatic regions throughout the study area. The tool combines soil units (soil taxonomy units using USDA system provided by SoilGrids at 250m resolution) and land cover (full 37 land cover classes provided by ESA CCI at 300m resolution) to define this areas of analysis.

The detailed pseudo algorithm for calculating productivity state and performance sub-indicators can be found at:
https://docs.trends.earth/en/latest/for_users/features/landdegradation.html#sub-indicators

Productivity Degradation/Improvement Indicator

The three productivity sub-indicators are then combined to yield the productivity degradation/improvement Indicator as indicated in Figure 1. The indictor can be obtained in two measuring scales: 3 classes or 5 classes of productivity degradation or improvement. In this application study, we select the measuring scale of 5 classes.

Trend	State	Performance
Improving	Improving	Stable
Improving	Improving	Degrading
Improving	Stable	Stable
Improving	Stable	Degrading
Improving	Degrading	Stable
Improving	Degrading	Degrading
Stable	Improving	Stable
Stable	Improving	Degrading
Stable	Stable	Stable
Stable	Stable	Degrading
Stable	Degrading	Stable
Stable	Degrading	Degrading
Degrading	Improving	Stable
Degrading	Improving	Degrading
Degrading	Stable	Stable
Degrading	Stable	Degrading
Degrading	Degrading	Stable
Degrading	Degrading	Degrading

5 Classes	3 Classes
Improving	Improving
Improving	Improving
Improving	Improving
Improving	Improving
Improving	Improving
Moderate decline	Degrading
Stable	Stable
Stable	Stable
Stable	Stable
Stressed	Stable
Moderate decline	Degrading
Degrading	Degrading
Degrading	Degrading
Degrading	Degrading
Degrading	Degrading
Degrading	Degrading
Degrading	Degrading
Degrading	Degrading

Figure 1. Aggregating land productivity degradation/improvement (5 classes or 3 classes on the right) based on three productivity sub-indicators (productivity trend/trajectory, state and performance on the left). Source: Trends.Earth (2022).

INTERIM RESULTS

The map of land productivity degradation/improvement over the 2000-2015 period for Ethiopia, Malawi, Ghana and Laos are showed in Figure 2, 3, 4 and 5, respectively. GIS raster data (ESRI ASCII) underlying the presented maps are downloadable using the sharepoint links provided in the figure captions.

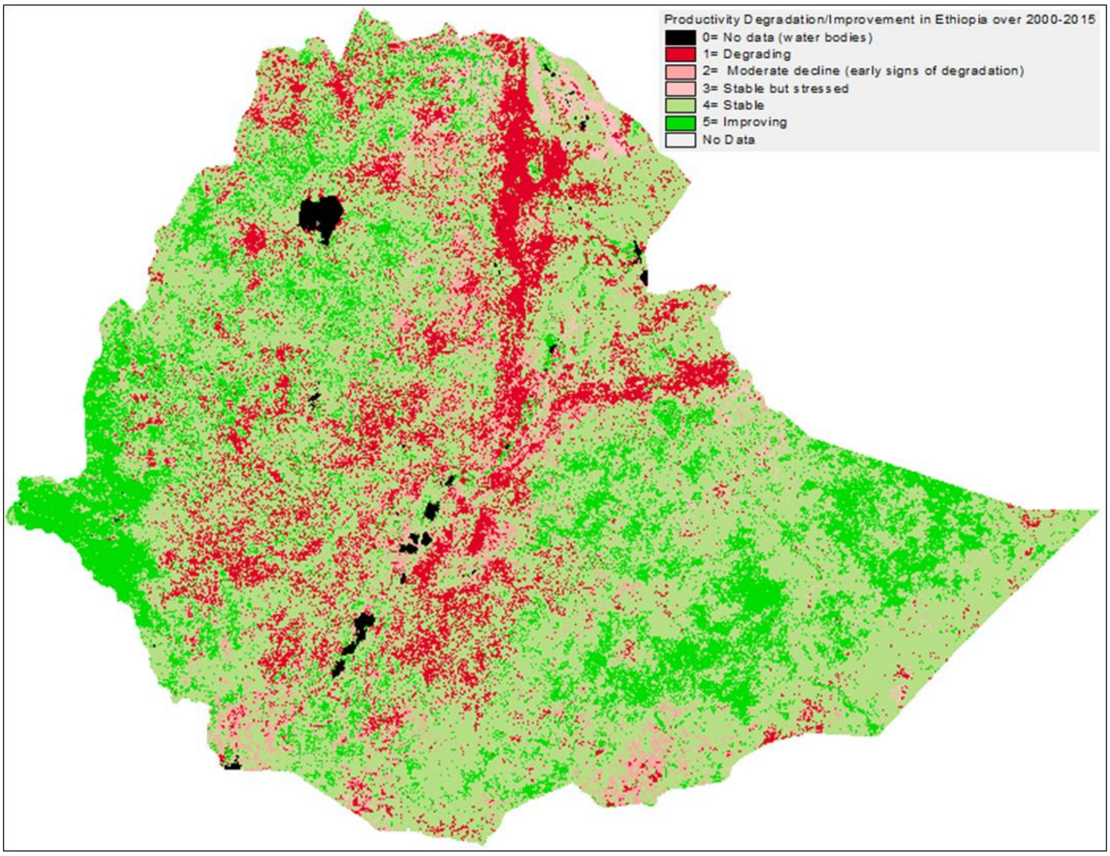

Figure 2. Land productivity degradation/improvement in Ethiopia over the 2000-2015 period. Note: GIS raster data for the map is downloadable in this link.

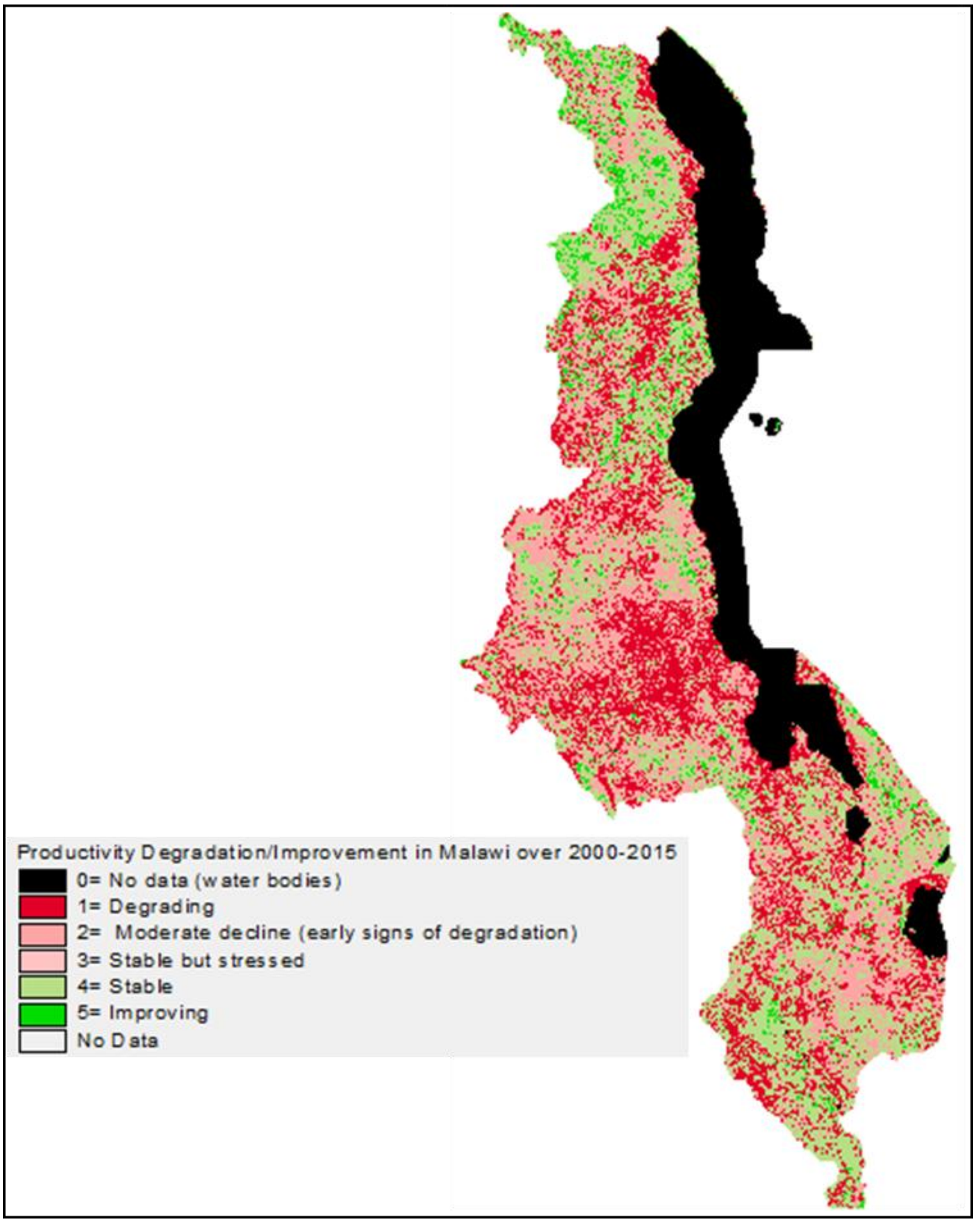

Figure 3. Land productivity degradation/improvement in Malawi over the 2000-2015 period.
Note: GIS raster data for the map is downloadable in this link.

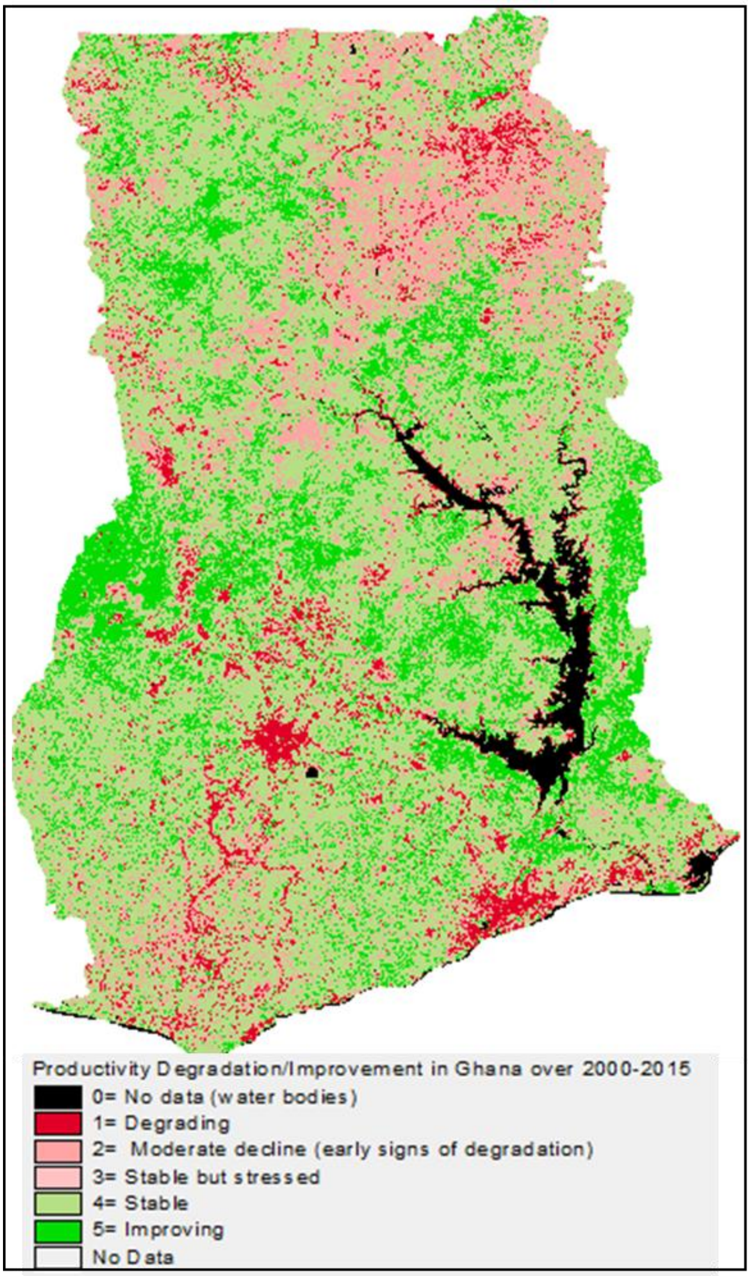

Figure 4. Land productivity degradation/improvement in Ghana over the 2000-2015 period.
Note: GIS raster data for the map is downloadable in [this link].

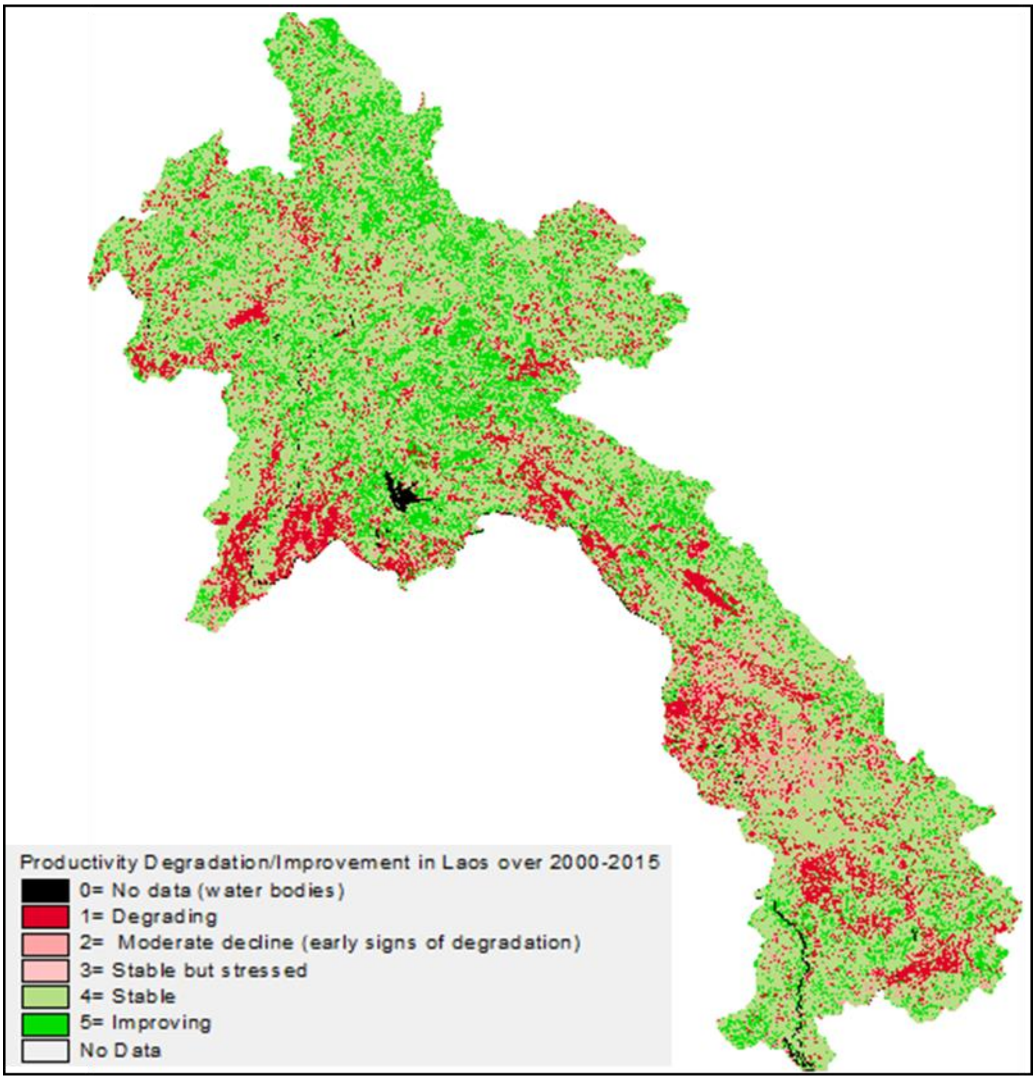

Figure 5. Land productivity degradation/improvement in Laos over the 2000-2015 period. Note: GIS raster data for the map is downloadable in this link.

NEXT STEPS

Similar mapping of land productivity degradation/improvement should be applied to the two other target countries of SI-MFS (i.e. Nepal and Bangladesh)

For target countries having sufficient GIS data on potential socio-ecological drivers , the following activities will be done in 2023:

- The national maps of land productivity degradation/improvement will be overlaid with the map of mixed farming system (MFS) types (results of separated companion studies) to have a systematic overview of productivity trend against different MFS typologies
- The GIS rasters of land productivity degradation/improvement can be merged with rasters of potential socio-ecological contextual factors to form cross-sectional, pixel-

based datasets. These data will allow the application of inferential multi-variate statiscs (e.g. different kind of spatial regression analyses) for inferring significant drivers of land degradation/improvement in MFS at national and global scales. In these studies, the dependent variable should be the land productivity trend, and the explanatory variables are the potential socio-ecological drivers of land productivity degradation/improvement (see Vu et al. 2014a,b).

The above follow-up research activities would contribute substantially to key expected outputs of WP1 of SI-MFS

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