Climate Change and Land Degradation:

Identification of High-Risk Value Chains

THE GLOBAL MECHANISM
United Nations Convention to Combat Desertification

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Author

Gijs Simons (FutureWater)

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FutureWater is a research and consulting organization that works throughout the world to combine scientific research with practical solutions for water management. FutureWater works at both global, national and local levels with partners on projects addressing water for food, irrigation, water excess, water shortage, climate change, and river basin management. FutureWater's key expertise is in the field of quantitative methods, based on simulation models, geographic information systems and satellite observations. Important clients and collaborators include International Financial Institutions (IFIs), national and local governments, river basin organizations, knowledge institutes, and NGOs. In addition to carrying out research and providing advice on request to clients, FutureWater frequently initiates state-of-the-art scientific and applied research projects.

Website: www.unccd.int

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Platz der Vereinten Nationen 1, 53113 Bonn, Germany
Postal Address: PO Box 260129, 53153 Bonn, Germany

Tel. +49 (0) 228 815 2800
Fax: +49 (0) 228 815 2898/99
E-mail: globalmechanism@unccd.int

Executive summary

The way we produce food has changed significantly in recent decades. These changes are driven by demographics, growing urbanization, changing patterns of consumption worldwide, technological innovations and trends towards onshoring and near-shoring. However, increasingly systemic threats from climate change and land degradation impact on global production systems, with some regions expected to witness high degrees of loss of productivity for traditional crops as demonstrated by the well-known case of cocoa in the northern cocoa belt (Goetz et al. 2016). This loss of productivity driven by degraded land poses a systemic risk which countries and producers must address.

This report analysis climate change as a driver of land degradation and highlights potential impacts in a few selected high-risk geographical areas to stress, in more general terms, risks that many global commodities will face. Soils are an important tool in the fight against climate change and for resilient food systems, the further degradation of soils will accelerate the vulnerability of communities and global food systems.

The report undertakes a global-scale forward-looking assessment of the potential impact of climate change on land degradation based on changes as projected by Global Circulation Models (GCMs) for the 2035-2065 time horizon. From the global-scale analysis, the report zooms to high-risk areas to highlight impact on important value chains in these areas, namely:

- Eastern Brazil (coffee)
- Malawi (maize)
- Morocco, Algeria and Tunisia (citrus)

For these geographical focus areas, a spatial land degradation vulnerability assessment was completed based on satellite remote sensing and GIS data. The results of the land degradation vulnerability assessment were integrated with the maps of potential climate change impact, in order to produce overall risk maps of increased climate-induced land degradation in dryland agriculture.

The report estimates that a total of 29% of coffee production in Brazil, 46% of maize production in Malawi, and 78% of citrus production in Morocco, Algeria and Tunisia are considered to be at high or very high risk of increased climate-induced land degradation due to changes in precipitation and temperature. In the past years, the production of each of these crops has already been impacted, evidenced both by longer-term trends (e.g. declining productivity of coffee in Brazil and maize in Malawi) and extreme events, particularly those related to drought and heat. While these three regions have been used as a case study because of the high potential impact of climate change on land degradation in productive systems, other regions are also expected to witness productivity losses concerning climate-sensitive value chains.

Considering the likelihood of reduced productivity in many geographical areas, an increased focus on alternative crops that are more suitable for changing local weather patterns, as well as crops that ensure healthier and resilient soils will be critical to ensure economic and environmental resilience.

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1 Introduction

1.1 Background

UNCCD is the sole legally binding international agreement linking environment and development to sustainable land management. As some of the most vulnerable ecosystems and peoples can be found in arid, semi-arid and dry sub-humid areas, UNCCD especially addresses these drylands. The loss of biodiversity in soils and the accompanying land degradation now threatens the livelihoods and security of over 3 billion people, with 75% of the world's ice-free land altered by human activities. Unless the impact on soil is reversed, it is estimated that only 10% of the land will be healthy, intact, and resilient by the year 2050 (IPBES, 2018). However, approximately 24 billion tons of fertile soils are lost every year in agricultural systems globally (GLO, 2017). Depleted soils are an existential threat not only to communities but also businesses as they reduce productivity. By 2050, global crop yields are estimated to decrease by 10% due to land degradation and climate change, with some regions suffering up to a 50% reduction (IPBES, 2018).

Productive capacities in drylands are affected by megatrends,[1] the drivers of which include climate change and land degradation, amongst others. Changing precipitation and temperature potentially exacerbate processes of degradation, and degraded lands make productive systems more vulnerable to impacts of climate change (e.g. Webb et al., 2017). UNCCD therefore aims to support the reorientation of productive capacities towards sustainable and resilient patterns, in order to reverse the impact of land degradation and mitigate climate change impact. To this end, this report assesses regions and crops at a particularly high risk of being affected by increased climate-induced land degradation. The report highlights the close interconnection between climate change and land degradation, as well as the need to better understand the risks global food systems face from the lens of land degradation and climate change.

The outcomes of this report demonstrate the need for national governments and producers to assess and understand the risk profiles of their main agricultural value chains and, subsequently, support identification of alternatives for value chains that are likely to be unproductive in the future. Subsequent work should link towards opportunities around other megatrends such as population changes, consumption patterns, energy and shifting geopolitical patterns present in the identification of new value chains.

1.2 Scope and objective

The main objective of the report is twofold:

1. to identify areas which are vulnerable to land degradation and with high potential impact of climate change on land degradation, within the drylands of Asia, Africa and Latin America, and

2. to identify high-risk value chains within these selected geographical focus areas.

[1] Megatrends are shifts that define the future of how we produce, consume and live. Drivers are the underlying forces to these shifts. Among others, climate change and land degradation are important drivers which have a systemic impact on the way we consume and produce. UNCCD (2021), Megatrends and foresighting productive capacities.

The report utilized an integrated approach based on (i) climate model outputs to map areas with a high potential impact of climate change on land degradation, as well as (ii) a satellite remote sensing and GIS-based assessment of land degradation vulnerability. Three geographical focus areas were selected from these analyses and important, high-risk value chains in these regions were identified based on socio-economic criteria and the sensitivity of the respective crops to climate patterns.

The report highlights the risks associated with key agricultural value chains in the three selected regions, and provides a general demonstration of how the applied methodology can inform decisions on risk mitigation and adaptation to climate-induced land degradation. It is beyond the scope of this report to provide a risk assessment that is representative of all crop types, agro-ecological zones and climate systems across the globe.

1.3 Reading guide

This report presents the identification of dryland regions at a high risk of land degradation exacerbated by a changing climate, and a risk assessment of their key value chains. The applied methodology is described in Chapter 2. Chapter 3 presents the results of the global mapping of potential impact of climate change on land degradation and justifies the selection of three high-impact areas for further analyses. Chapter 4, then, provides the results of the risk assessment of selected value chains for each of the three identified regions, including the value chain selection, cropland mapping, and a land degradation vulnerability assessment. Finally, Chapter 5 lists the key conclusions and recommendations that arise from the report's results.

2 Methodology

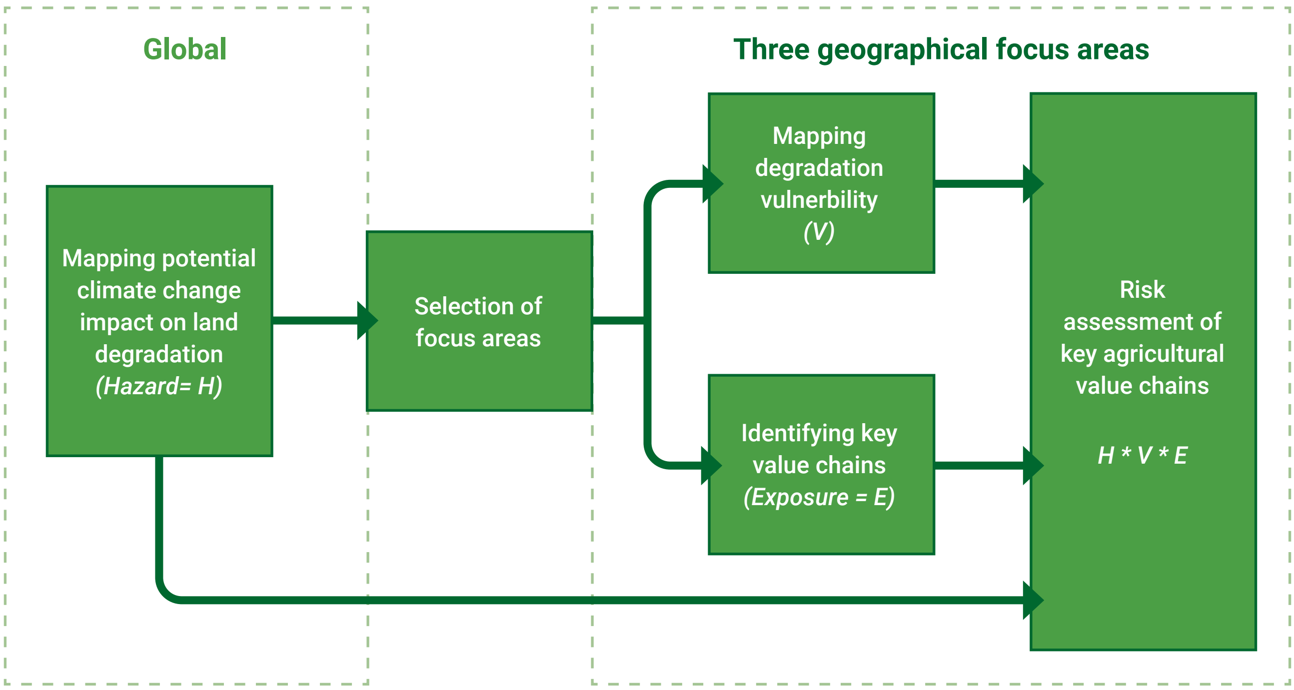
2.1 Conceptual approach

The applied methodology is based on the well-established definition of risk as the potential loss of life, injury, or destroyed or damaged assets which could occur to a system, society or a community in a specific period of time, determined probabilistically as a function of hazard, exposure and vulnerability (UNDRR, 2020). Risk, in general, is thus calculated as a function of the hazard occurrence probability and intensity (i.e., physical magnitude) in a particular location; the people and physical assets (infrastructure, housing, agricultural crops) situated in that location and therefore exposed to the hazard; and the level of vulnerability of the exposed people / physical assets to that hazard. Within the context of this report, the three components of risk are defined as follows:

- Hazard: increased climate-induced land degradation, i.e. accelerated or enhanced land degradation processes due to changes in precipitation and temperature patterns
- Exposure: cropland exposed to the hazard, in particular focusing on value chains that are of high socio-economic and/or nutritional importance
- Vulnerability: the vulnerability of the exposed cropland to land degradation, due to biophysical factors such as terrain, soil type, and vegetation cover.

Below sections describe the methodological steps for assessing each of these components and the subsequent overall risk assessment.

Figure 1: Flowchart of main activities, illustrating their interdependence, sequence of implementation (left to right), and geographical scale of implementation.



2.2 Hazard intensity: mapping of potential climate change impact on land degradation

2.2.1 General workflow

To evaluate the hazard component of risk, hazard intensity was mapped, defined as the potential impact of climate change on land degradation processes at the global level. For quantification of the potential impact of climate change on land degradation, a set of indicators was selected (see Section 2.2.3) that are indicative of the driving forces of climate-induced land degradation processes with detrimental impacts on agricultural production. These indicators capture drought, water availability, temperature stress, and erosion. Based on precipitation and temperature time series produced by General Circulation Models (GCMs), these indicators were quantified on the global scale for baseline as well as future climate conditions. The main output of this component was a map which integrates the projected changes to each of the five indicators into an overall assessment of potential impact of climate change on land degradation at the global level. Subsequently, this map was used to select a number of high-impact regions for an in-depth investigation of exposure and vulnerability.

2.2.2 Data collection and processing

A solid assessment of climate change impact requires an ensemble approach, including multiple GCMs. To build on the latest insights from the climate science community, the NASA Earth Exchange (NEX) Global Daily Downscaled Projections dataset (NEX-GDDP-CMIP6) was used for identifying areas with high potential climate change impact on land degradation. The NEX-GDDP-CMIP6 dataset is comprised of global downscaled climate scenarios derived from GCM runs conducted under the Coupled Model Intercomparison Project Phase 6 (CMIP6) and across greenhouse gas emissions scenarios called Shared Socioeconomic Pathways (SSPs). The

CMIP6 GCM runs were developed in support of the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR6). The dataset provides a set of global, high resolution, bias-corrected climate change projections.

For this work, the SSP245 used in CMIP6 model runs was selected, as it is considered a "middle of the road" scenario based on similar trends to present, with a slow shift towards sustainable development goals. As such, it provides an average scenario for analysis. It should be noted that under this scenario energy and resource utilization declines over time and global population growth is moderate and as such is an optimistic outlook (UNFCCC, 2016). Multi-level research involving the investigation of many SSPs was considered out of scope, as emphasis for this report is mainly on investigating spatial patterns based on trends that broadly follow their historical patterns rather than comparing a variety of climate scenarios.

Daily precipitation and temperature results from 35 GCMs included in the NEX-GDDP-CMIP6 dataset were downloaded, processed, and used to compute relevant indicators of climate change impact (see Section 2.1.3). Averages were computed from all GCMs. Baseline conditions were obtained from CMIP6 data for 1985 – 2015 and the future horizon was defined as 2035 – 2065 (i.e. a 30-year period centered around the year 2050). Assuming a 30-year period is common practice in this type of analysis to account for interannual climate variability.

2.2.3 Indicators of potential climate impact on land degradation

The regions identified as likely highly impacted were identified based on quantitative measures linked to potential climate impact on land degradation processes which affect agricultural productivity. The global scientific community has already established the main linkages between climate patterns, land degradation and agricultural productivity. As highlighted in the IPCC special report on Climate Change and Land (Shukla et al., 2019), climate change especially exacerbates land degradation, through increasing temperatures, altering precipitation patterns, and enhanced evapotranspiration. Key components of the overall hazard of increased climate-induced land degradation include drought (e.g. Hermans and McLeman, 2021), heat stress (e.g. Teixeira et al., 2013), water availability (annual rainfall) and the extent to which crop water requirements are met by this rainfall (e.g. Jägermeyr et al., 2021), and mass movements / erosive processes (e.g. Stoffel and Huggel, 2012). Multiple, or all, of these aspects have previously been integrated in assessments of climate-induced land degradation for specific value chains (e.g. Parker et al., 2019; Prager et al., 2020; Schroth et al., 2016; Trachsel et al., 2022).

When assessing impacts and risks associated with climate change, it is common practice to use the list of standardized indices included in the Climate Data Operator (CDO) software package.[2] Table 1 lists five CDO indices that were selected as indicators of potential climate impact on land degradation processes. These indicators were computed based on the CMIP6 GCM outputs. Since annual potential evapotranspiration (*ETp*) is not a standard output of GCMs, the $P - ETp$ indicator was calculated using the Hargreaves equation, similar to the approach used by Schroth et al. (2016). Global maps of each indicator were produced for both time periods (baseline and future horizon). Subsequently, change maps were computed for each of the selected indicators, mapping differences between the future time horizon and current conditions. The five individual indicators were integrated, with equal weighting, to produce an overall index of potential climate change impact on land degradation in 2035 – 2065.

Table 1: Selected indicators of potential climate impact on land degradation.

No.	Description of indicator	Code	Unit	Indicative of…
1	Number of hot days	TXge35	days	Heat stress
2	Max 1-day precipitation [%]	Rx1day	mm	Mass movement (e.g. mudslides), storm damage, splash erosion
3	Average annual precipitation	PRCPTOT	mm	Water availability
4	Longest dry spell (consecutive dry days)	CDD	days	Drought
5	Difference between annual rainfall and potential evapotranspiration (ETp)	P - ETp	mm	Water stress (extent to which water requirements are met by natural rainfall)

[2] Megatrends are shifts that define the future of how we produce, consume and live. Drivers are the underlying forces to these shifts. Among others, climate change and land degradation are important drivers which have a systemic impact on the way we consume and produce. UNCCD (2021), Megatrends and foresighting productive capacities.

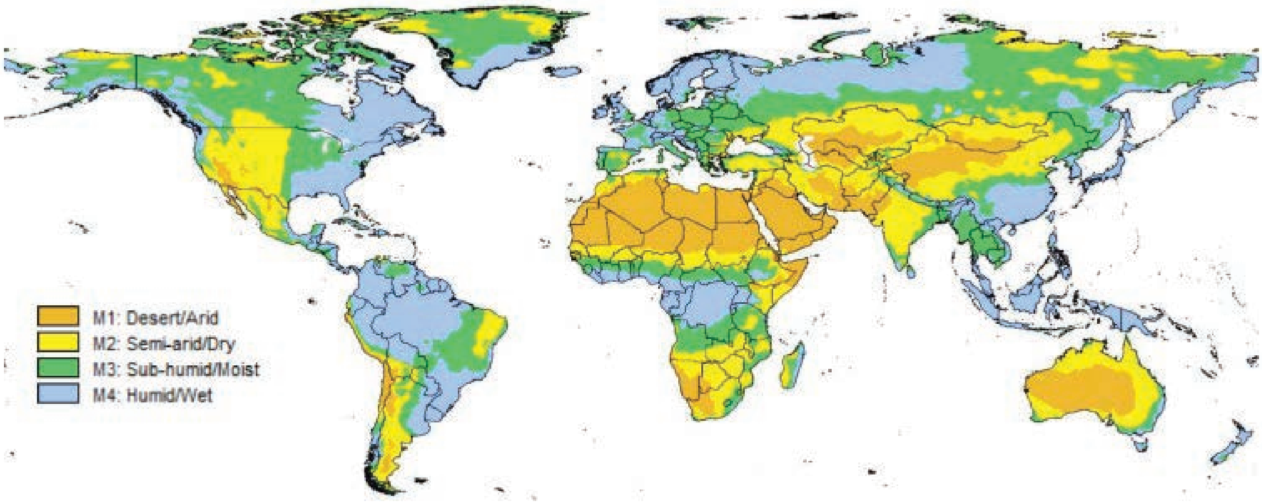
2.3 Exposure: mapping of global croplands and identification of important value chains

2.3.1 Identifying high-impact areas in drylands

To evaluate the exposure of cultivated areas to the hazard of increased climate-induced land degradation, global-scale mapping of cropland was required. The dataset used for this purpose was the FAO GLC-SHARE product, obtained from the updated Global Agro-Ecological Zones (GAEZ) v4 data portal[3]. GLC-SHARE was created by the Land and Water Division of FAO, and integrates high-resolution national, regional and sub-national land cover statistics with global satellite-derived data. As this report intends to focus on drylands in Africa, Asia, and Latin America, the boundaries of these regions were considered in the identification of high-impact areas. The FAO GAEZ v4 database includes a global classification of moisture regimes[4] (Figure 2). Overall, 57 agro-ecological zones were classified based on properties of climate, soil and terrain, of which 17 fall under arid, semi-arid, or dry moisture regimes.

The areas of dryland cropland under different categories of potential climate change impact on land degradation (low, medium, high, very high) were computed for each country. Based on the analysis of exposure, and in consultation with UNCCD, three focus regions (both within individual countries and transboundary) were identified for further analyses.

Figure 2: Global moisture regimes according to the zonation of Global Agro-Ecological Zones of FAO.



[3] FAO (https://gaez.fao.org/)

[4] Moisture regime classes are defined based on soil water balance calculations, accounting for actual evapotranspiration of a reference crop. More details can be obtained from the FAO GAEZ portal through https://gaez.fao.org/.

2.3.2 Selection of value chains and crop-specific mapping

For each of the focus regions, a value chain was selected with significant socio-economic importance. To illustrate the range of different types of value chains at risk, three crops were selected to ensure coverage of a (i) a global commodity, (ii) export-oriented agriculture, (iii) a staple crop that is key to food security. Selection of key crops from an economic perspective was performed based on their contribution to Gross Domestic Product (GDP), export value, and number of jobs in the value chain. In the food security context, dietary energy supply was considered as a main indicator. A literature review was conducted to collect the relevant data.

To evaluate the key production areas of the selected crop types within the focus regions, two global datasets were consulted:

- EarhStat (Monfreda et al., 2008) provides data of harvested areas and yields for 175 crop types, per 5 minute by 5 minute (~10 km by 10 km) grid cell. From this dataset, gridded yield files for each of the identified cash crops are downloaded and clipped to the boundaries of the three geographical focus areas.

- The FAO GAEZ v4 includes harvested area and production data at 10 x 10km, for the years 2000 and 2010. In this dataset, all global crops are categorized under 26 classes, comprising both individual crops and crop groups. In case a selected crop is considered individually in this dataset, the 2010 yield data are used for this analysis.

2.4 Mapping of land degradation vulnerability

2.4.1 General workflow

This component of the report comprised the mapping of land degradation vulnerability across the three selected focus regions. Factors concerning terrain, soil properties, and trends in vegetation cover were considered for this assessment. This component produced maps for each high-impact region, showing relative vulnerability to land degradation.

It should be noted that the implemented approach expands on the existing framework recommended for calculating the extent of land degradation for reporting on United Nations (UN) Sustainable Development Goal (SDG) Indicator 15.3.1, which relies primarily on assessing trends in land cover, land productivity, and soil organic carbon (Sims *et al.*, 2021). The use of additional indicators (see Table 2) allows for mapping of vulnerability, rather than focusing on monitoring of historical trends.

2.4.2 Data collection and processing

From the existing knowledge base on spatial land degradation vulnerability assessments, it can be concluded that the degree of significance of each of the determining factors differs between case studies. To ensure methodological consistency across the three focus regions in this report, it was required to adopt a shortlist of factors that can be assumed as generally influential in determining land degradation vulnerability. The following factors were taken into account:

1. trends in annual average Normalized Difference Vegetation Index (NDVI), where only negative trends are considered and significant negative trends can be indicative of already ongoing land degradation processes, i.e. loss of production (e.g. Sims et al., 2021)

2. average annual NDVI over the past 20 years, as a measure of vegetation cover (protection of the soil to erosion) (e.g. Tolche et al., 2021)
3. terrain slope, where higher values are assumed more vulnerable to soil loss through erosion and mass movements (e.g. Tolche et al., 2021)
4. soil organic carbon content, where lower values potentially indicate previous loss of fertile soil and a lower productive capacity overall (e.g. Prăvălie et al., 2021)
5. available water content of the soil, where lower values indicate a lower potential for water storage and thus for dealing with more erratic rainfall patterns (e.g. Kairis et al., 2014).

Table 2 lists the sources from which data were downloaded and processed for implementing this component. The 5 variables were mapped for each of the three selected geographical areas. A relative scaling between 0 and 1 was applied to combine the separate variables into an integrated land degradation vulnerability map. Here, zero values were assigned to conditions indicative of low land degradation vulnerability (e.g. a very high average NDVI, or a very low slope), and 1 to conditions indicating high vulnerability (e.g. a very low average NDVI, or a very high slope). Long-term NDVI trends were given higher weighting (50%) in this integration, as a clear negative trend can be considered as a sign that land degradation is already ongoing and affecting crop production. Equal weighting was applied to the other 4 factors (50%), to come to the calculation of an integrated land degradation vulnerability index. Given the spatial resolution of the various input datasets, the final land degradation vulnerability maps were computed with a pixel size of 250m.

Table 2: Input datasets for estimation and mapping of land degradation vulnerability.

Data	Resolution	Source	Reference
Slope	30m	SRTM	https://www2.jpl.nasa.gov/srtm/
Soil Organic Carbon	250m	SoilGrids	https://www.isric.org/explore/soilgrids
Available Water Content	250m	HIHydroSoil	https://www.futurewater.nl/projects/hihydrosoil-nl/
NDVI	250m	MODIS	https://modis.gsfc.nasa.gov/data/dataprod/mod13.php

2.5 Overall risk assessment

Finally, the results from the separate components on hazard, exposure, and vulnerability were integrated to provide an overall assessment of the risk of increased climate-induced land degradation for the identified crops in the three selected regions:

- Hazard intensity: the index of potential climate change impact on land degradation described in Section 2.2.3
- Exposure: production zones and harvested areas of the selected crop types (Section 2.3.2)
- Vulnerability: the integrated land degradation vulnerability index described in Section 2.4.2.

Since both the indices of hazard intensity and vulnerability are valued between 0 and 1, the average of both values was computed as an index of risk, which was categorized in four classes (low, medium, high, very high). This approach allowed for the estimation of the portions of crop production and harvested area that are considered at risk, compared to total crop production and harvested area at the national level.

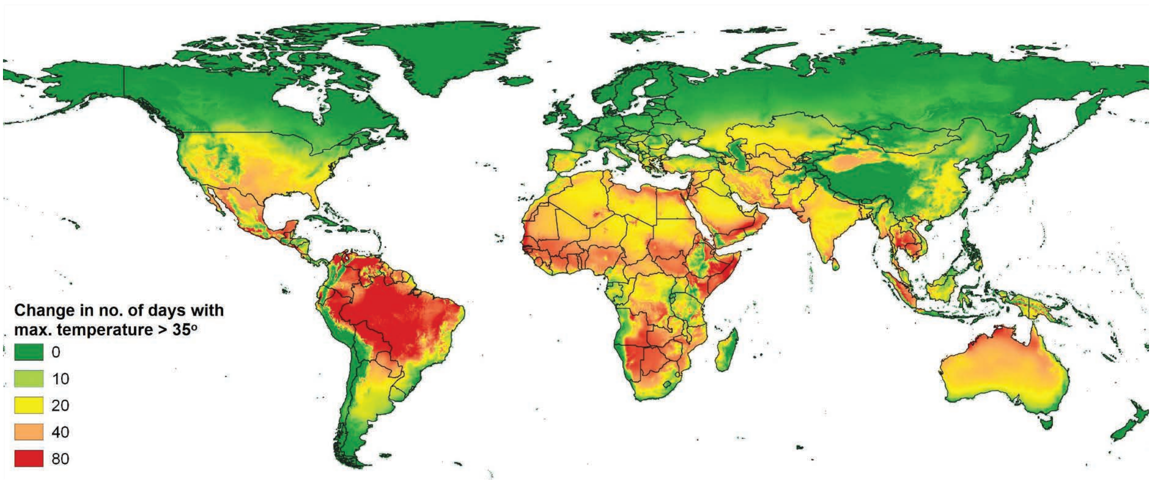
3 Potential impact of climate change on land degradation

3.1 Global-scale assessment

The indicators of potential climate change impact on land degradation listed in Table 1 were mapped on the global scale. Figure 3 shows the results for each indicator. Color scales are set in such a way that red colors are associated with expected amplification of land degradation processes.

Spatial patterns clearly vary between indicators. However, there are some regions of the world where all five climate change impact indicators (see Table 1) display a change that is associated with exacerbated land degradation (e.g. Brazil and the countries to its North, southern Africa, southern Spain, and Central America).

Figure 3: Projected changes in selected climate change impact indicators (time horizon 2035 – 2065, SSP245).



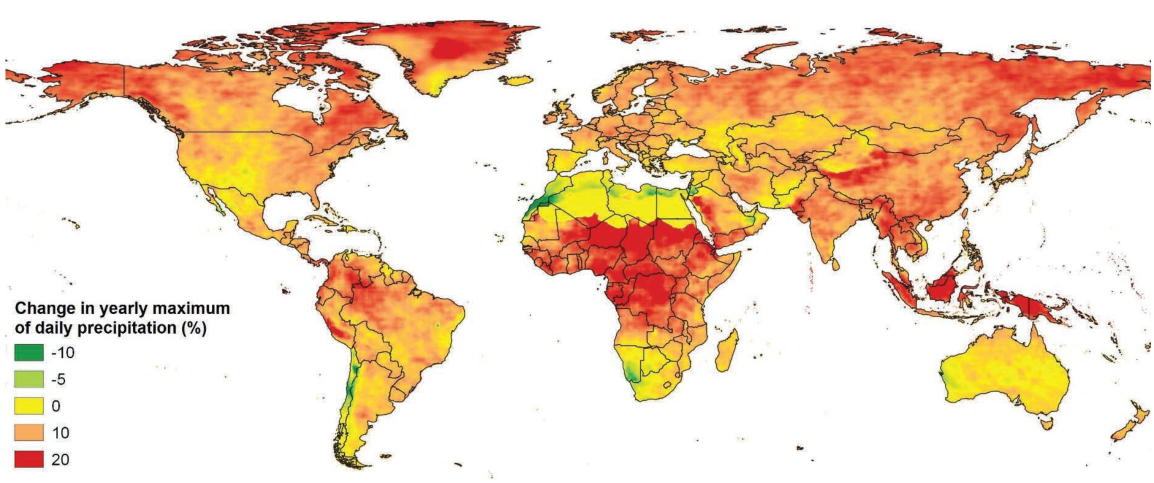
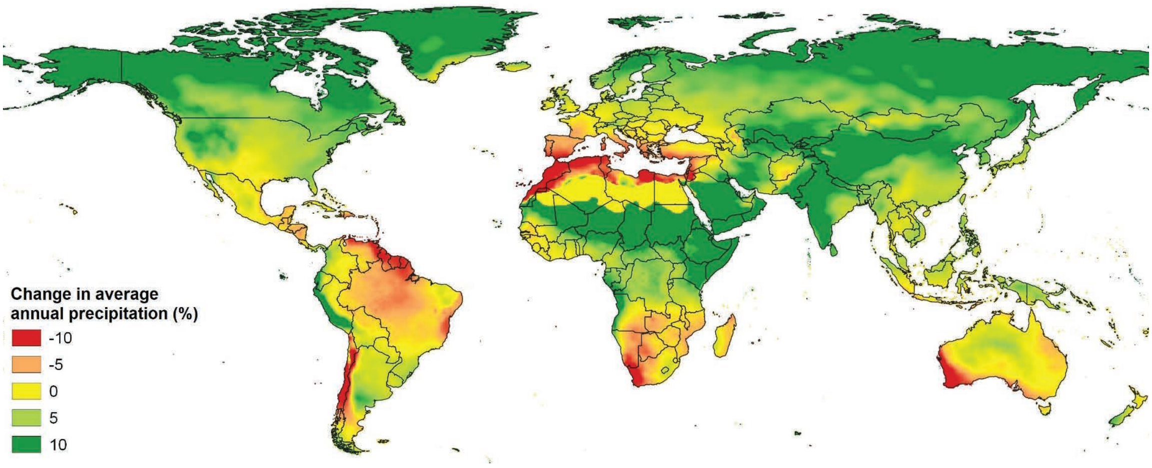
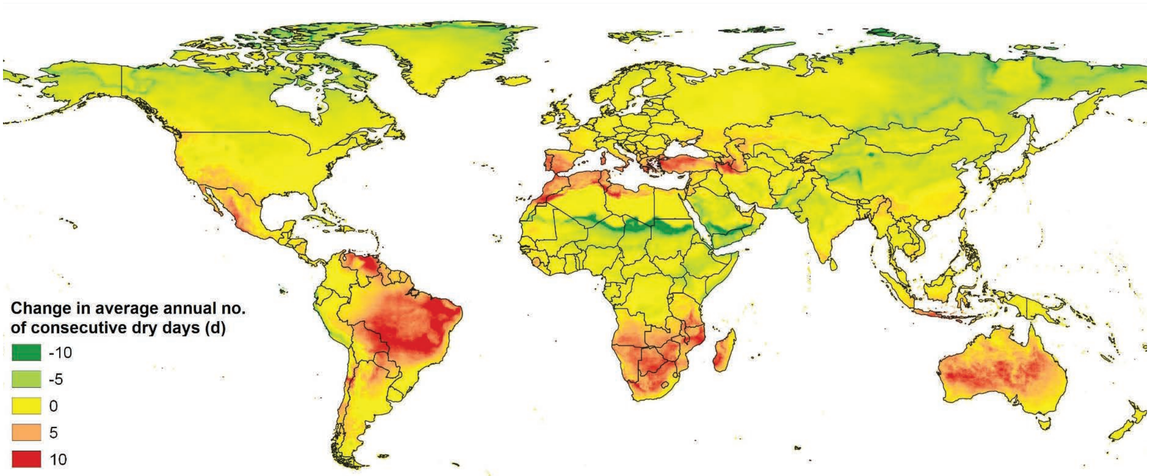
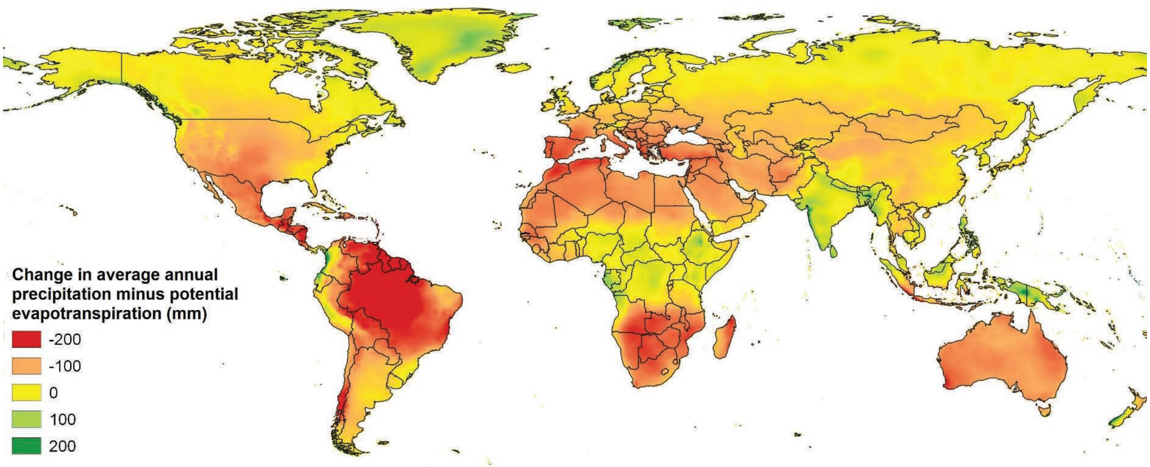


Figure 2 (cont.): Projected changes in selected climate change impact indicators (time horizon 2035 – 2065, SSP245).



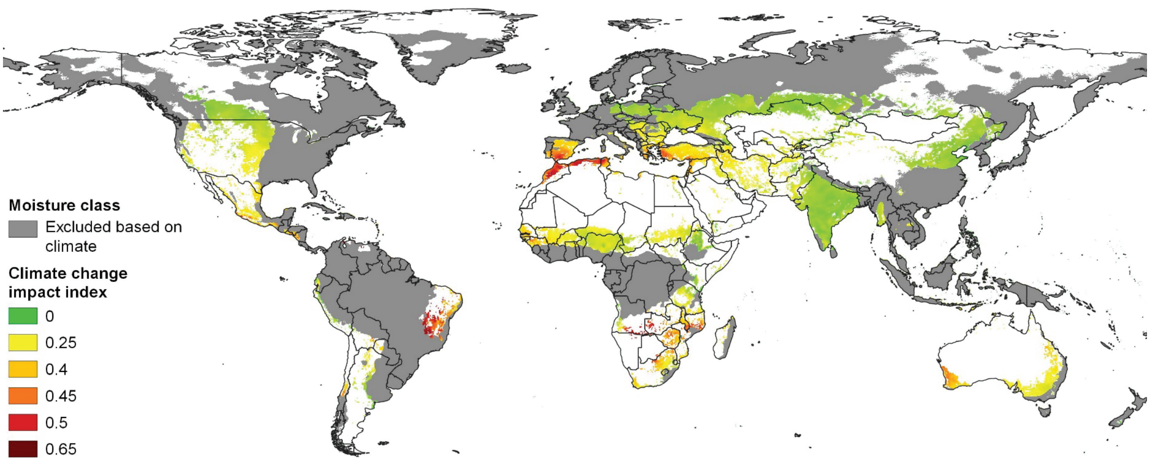




3.2 Potential impact of climate change on land degradation in dryland agriculture

As described in Section 2.2.3, the five individual climate change impact indicators were combined to map the potential impact of climate change on land degradation in croplands in 2035 – 2065 (SSP245). Figure 4 shows the resulting map, only displaying grid cells containing >10% of cropland according to the GLC-SHARE product, and which are located in moisture regimes between "hyper-arid" and "moist semi-arid" according to the GAEZ classification. Several regions with particularly high values can be distinguished, such as North Africa, Southeast Africa, eastern Brazil, southern Spain, western Turkey, and Southwest Australia. As can be seen in Figure 3, these are parts of the world where most of the indicators (both temperature- and water-related) are projected to aggravate land degradation processes.

Figure 4: Potential climate change impact on land degradation in croplands (time horizon 2035 – 2065, SSP245).[1]



[5] The potential climate change impact is expressed as a unitless index, based on the integration of the change maps produced for each of the five indicators (see Section 2.2.3). A value of 0 implies no change to the baseline situation regarding the potential for climate-induced land degradation. A value of 1 for a certain location, though not present in practice, would indicate that the maximum occurring change values for all five indicators are projected on this particular location.

3.3 Identification of high-impact regions

For deriving per-country statistics, the results presented in Figure 4 were categorized into four classes of potential impact of climate change on agricultural land degradation: low (< 0.15), medium (0.15 – 0.35), high (0.35 - 0.45), and very high (> 0.45). Annex 1 lists the cropland area per country falling into each of these classes. Countries are ranked in the table according to the relative portion of cropland falling in the very high impact class. For the 20 countries ranked highest according to this criterion, Figure 5 visualizes the cropland extents in each of the four classes.

Based on the results presented in Annex 1, three areas with potential high impact were selected for further analyses. The following criteria were taken into account:

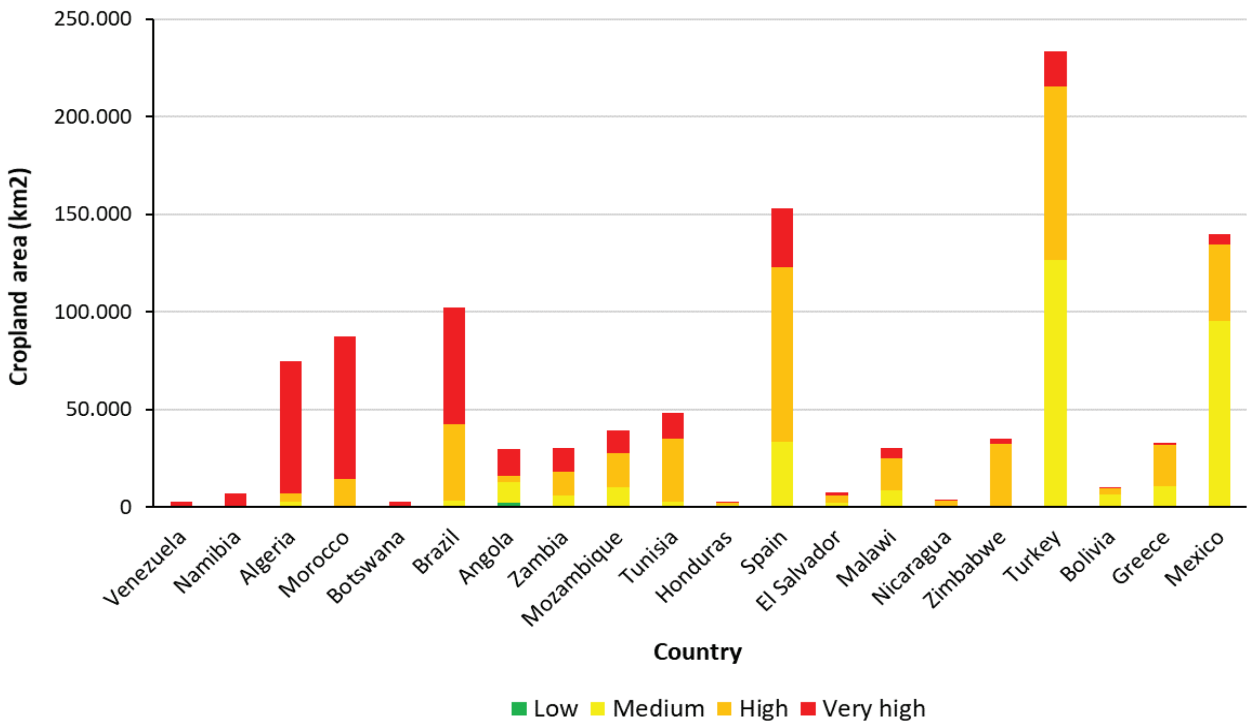
- The relative portion of dryland cropland located in the very high and high impact classes, presented in Annex 1
- The total surface area of cropland in dryland climate zones at high or very high risk
- The extent of dryland cropland relative to the total country surface area
- Geographical location, with the aim to obtain geographically diverse areas located in either South America, Africa, or Asia.

The following high-impact regions were identified in this manner:

- The **eastern part of Brazil**, encompassing 15 states
- The entire country of **Malawi**
- A transboundary region spanning the northern parts of **Morocco, Algeria** and **Tunisia**.

Chapter 4 presents the results of the risk assessment of selected value chains in these three regions.

Figure 5: Cropland area in each of the climate change impact classes for the 20 countries ranked highest according to their relative cropland portions in the very high impact class.



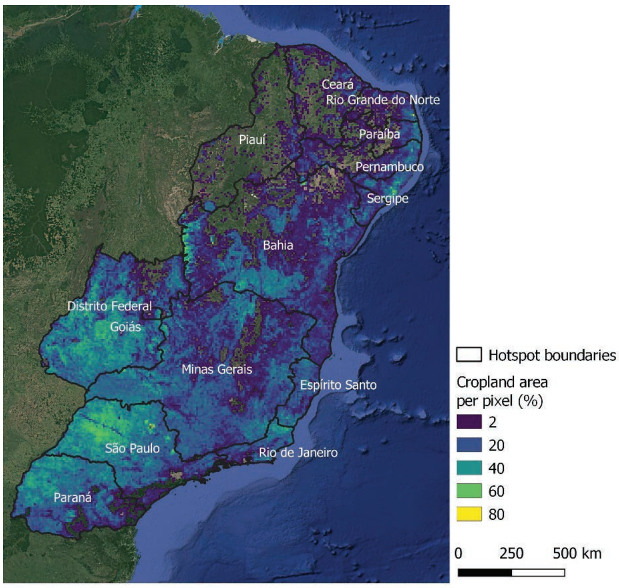
4 Risk assessment of focus regions

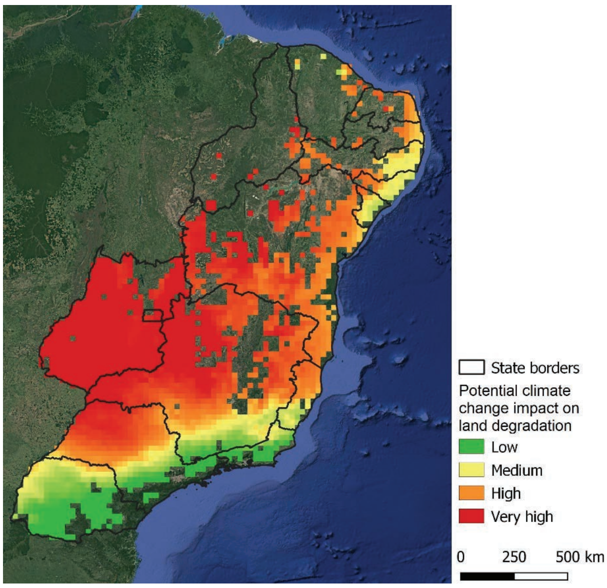
4.1 Eastern Brazil

4.1.1 Potential impact of climate change on land degradation

Eastern Brazil was identified as one of the regions globally where the potential impact of climate change on land degradation in dryland croplands is considered the highest. Figure 5 shows the spatial distribution of cropland, as well as the classification of potential climate change impacted on degradation of these croplands in 2035 – 2065. Especially large portions of cultivated land in the states of Minas Gerais, Goiás, São Paulo and Bahia are located in the high- to very high-impact categories. Overall, the potential climate change impact on land degradation shows an increasing trend with distance to coast.

Figure 6: Cropland area in each of the climate change impact classes for the 20 countries ranked highest according to their relative cropland portions in the very high impact class.





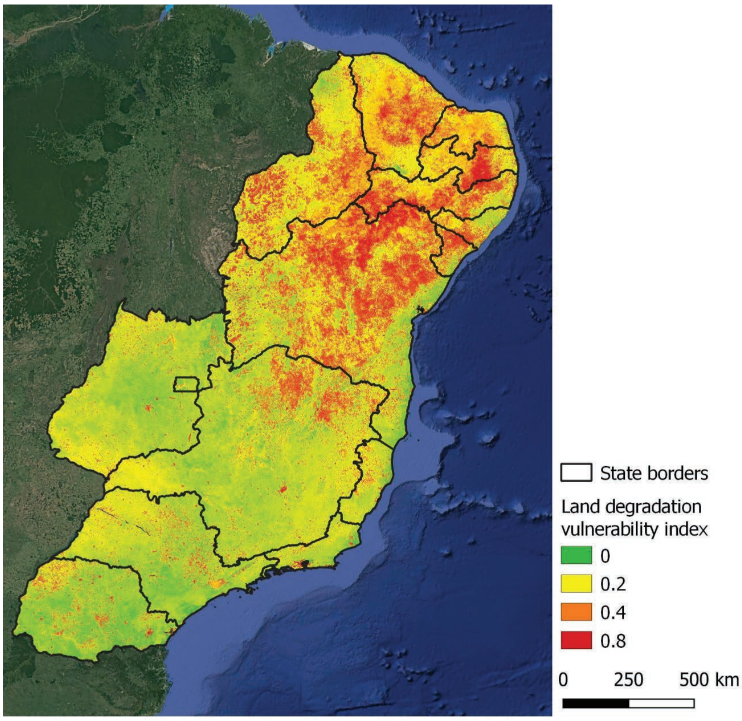
4.1.2 Land degradation vulnerability

An integrated land degradation vulnerability index was computed based on the methodology outlined in Section 2.4. Figure 7 presents the resulting map. Clearly, the northern half of the region is considered more vulnerable than the southern portion, according to the criteria listed in Section 2.4.2. It is interesting to compare the spatial patterns of land degradation vulnerability to the spatial distribution of cropland and the map of projected climate change impact in Figure 6. Cropland areas with high vulnerability to land degradation can be found particularly in the center of the region, in the north of Minas Gerais. The greatest extents of cultivated area are located in the southwest, where land degradation vulnerability is considered moderate. However, at the same time this is a region where the projected change in the selected climate indicators (Table 1), and thus the potential impact on land degradation, is very high.

4.1.3 Value chain selection

A major crop grown in the eastern part of Brazil is coffee. With a contribution of approximately 10% to the country's GDP and a total export value of US$ 52.5 billion in 2020, the coffee value chain is of high importance to the Brazilian economy.[6] Over 8 million jobs are associated with the coffee value chain in Brazil.[7] Six of the states included in the focus area (Minas Gerais, Bahia, Espirito Santo, Sao Paulo, and Parana) together contribute 95% of all coffee produced in the country (Barros et al., 2019). Figure 8 illustrates the spatial distribution of coffee production. Another reason for focusing on coffee is its importance as a commodity on the international market, with Brazil producing over one-third of the world's coffee.[8]

Figure 7: Land degradation vulnerability map of eastern Brazil.

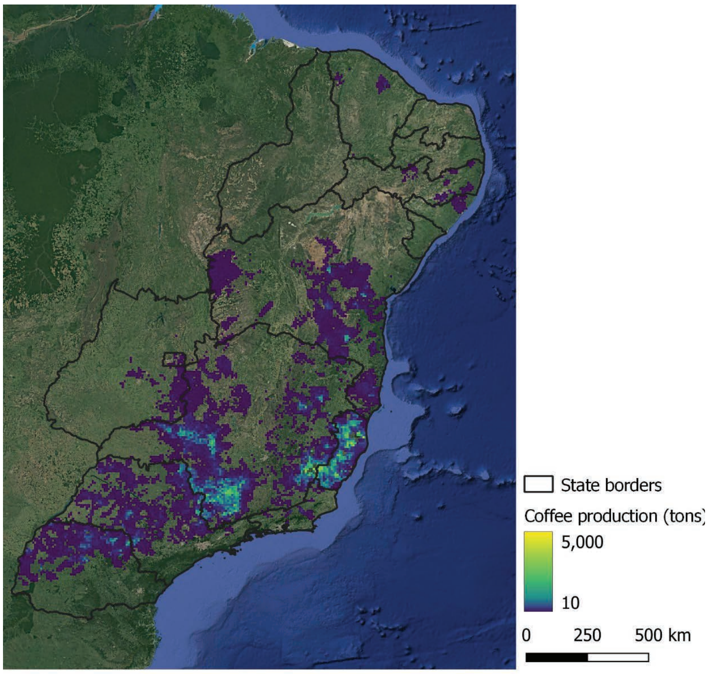


[6] ITC Trade Map (https://www.trademap.org/)

[7] Embrapa (https://www2.camara.leg.br/atividade-legislativa/comissoes/comissoes-permanentes/capadr/apresentacoes-em-eventos/eventos-de-2021/audiencia-publica-01-de-setembro-de-2021-embrapa/view)

[8] International Coffee Organization (ICO): https://www.ico.org/prices/po-production.pdf

Figure 8: Coffee production in eastern Brazil in the year 2000 (source: EarthStat).



4.1.4 Overall risk assessment

Figure 9 presents the overall risk map which integrates potential impact of climate change on agricultural land degradation with land degradation vulnerability. As can be seen in Figure 8, most coffee cultivation is practiced outside the areas considered at highest risk. Still, 29% of national coffee production falls in at least the high-risk class within the focus area (Table 4), and should therefore be considered at high risk of experiencing productivity losses over the next decades.

The actual impact of recent historical climate change gives a sense of the nature and magnitude of such productivity losses. Especially increasing temperatures and decreasing water availability are factors which negatively affect coffee production. A recent study by Koh et al. (2020) shows that climate change already resulted in reductions in coffee yield by more than 20% in the Southeast of Brazil, which is attributed to increased temperatures in the focus region[9] by over 1.2 °C between 1974 and 2017 and large decreases in annual rainfall (>10% decrease) in a major part of the area. For a case study in Espirito Santo, the 2015/2016 record-low harvest (41% below normal) coincided with an annual rainfall of 40% below average and an average temperature of +/- 1 °C above average (Venancio et al., 2020). The trend of declining productivity is expected to continue towards the 2035 – 2065 period, particularly in the high- and very high-risk zones depicted in Figure 9. Considering the likely impact on productivity reinforcement measures against land degradation and climate change impact within the coffee value chain, as well as other value chain in the high and very high-risk geographical areas need to be considered. In the geographical areas that are classified as very high-risk, crops supporting land restoration while at the same time able to withstand climate change induced changes should be considered to ensure greater resilience in local productive capacities.

[9] In the cited study defined as the states of Goiás, Mato Grosso do Sul, Paraná, Minas Gerais, São Paulo, Rio de Janeiro, Bahia, and Distrito Federal.

Figure 9: Risk map of exacerbated land degradation due to climate change in eastern Brazil (2035 – 2065).

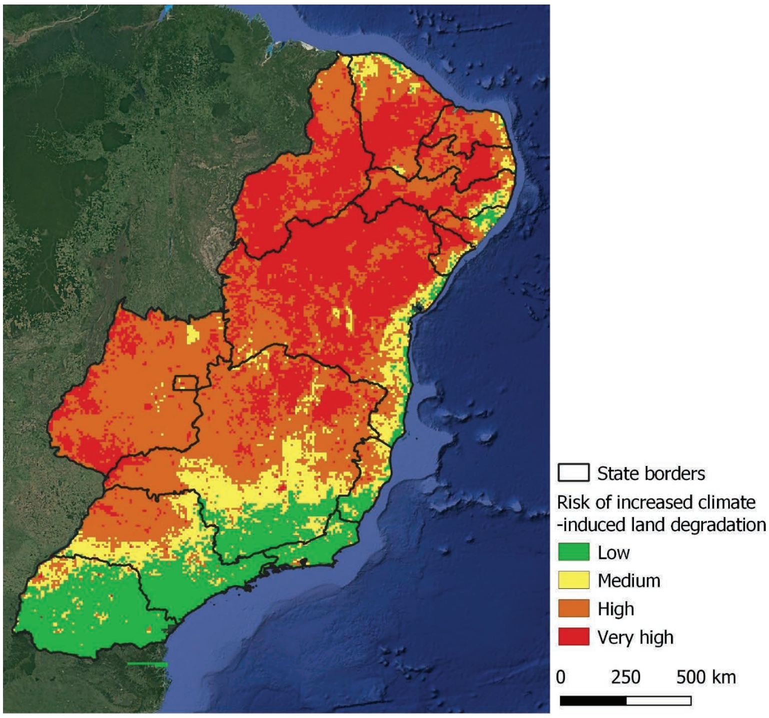


Table 3: Coffee production and harvested area in Brazil in the year 2000, for each of the risk classes.

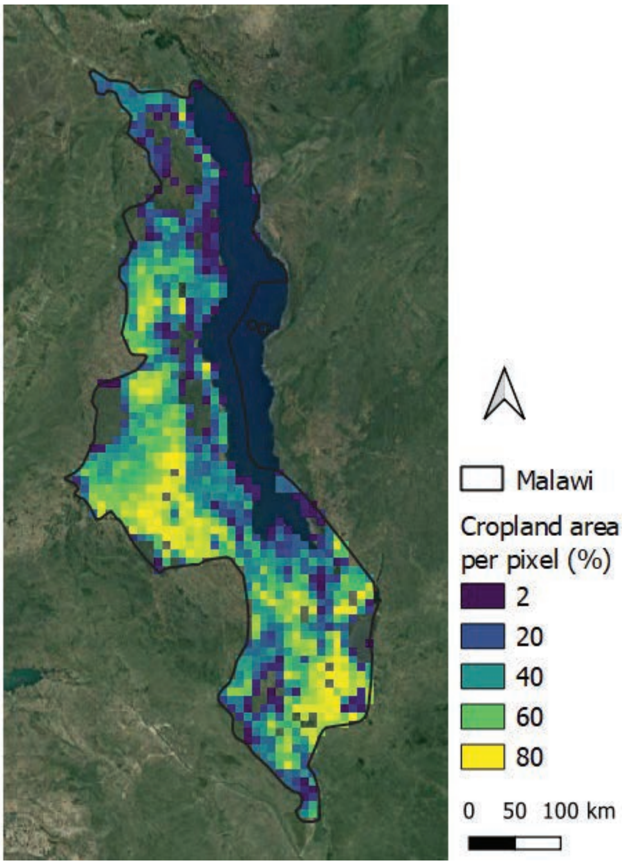
Risk class	Production (tons)	Harvested area (km²)	% of national production	% of national harvested area
Low	653,743	8,161	38%	37%
Medium	430,828	5,512	25%	25%
High	426,806	5,111	25%	23%
Very high	63,457	915	4%	4%
Total	**1,574,834**	**19,699**	**91%**	**90%**
Total (national)	**1,732,632**	**21,830**	**100%**	**100%**

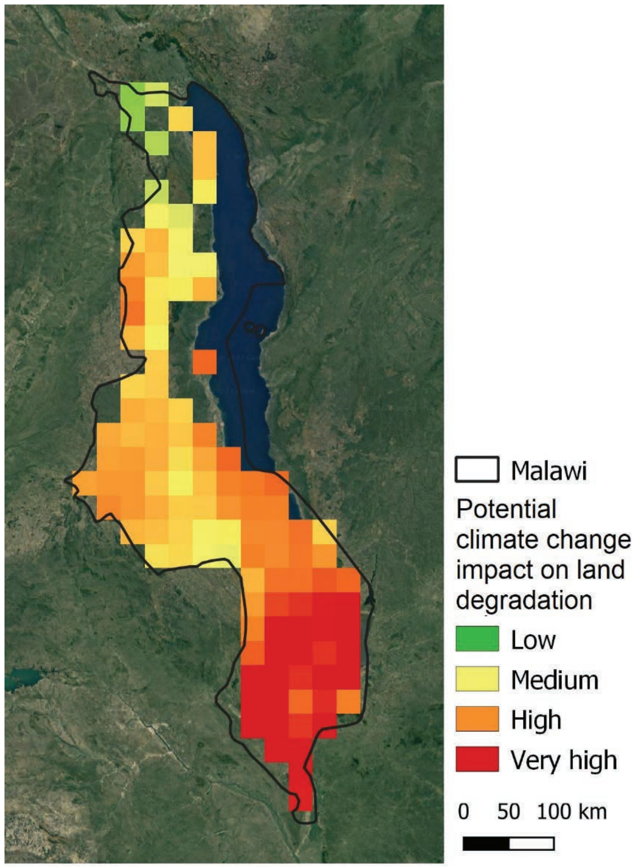
4.2 Malawi

4.2.1 Potential impact of climate change on land degradation

The country of Malawi was identified as a second geographical focus area. Figure 10 shows the spatial distribution of cropland in Malawi, as well as the classification of potential climate change impacts on land degradation. Agricultural land clearly makes up a significant portion of the country, and contributes significantly to employment, economic growth, poverty reduction and food security in Malawi (World Bank, 2021). As shown in Figure 10, severity of climate change impact is projected to increase with a southward direction, with the south of the country already located in a drier and hotter climate zone than the north.

Figure 10: Maps of cropland (left) and projected climate change impact on land degradation in cropland (right) in Malawi.





4.2.2 Land degradation vulnerability

The map of land degradation vulnerability for Malawi is shown in Figure 11. Spatial patterns of vulnerability are quite similar to the distribution of agricultural area (Figure 10), which is partly due to the fact that croplands are relatively sparsely covered by vegetation (i.e. more exposed to potential erosive processes) than other land cover types in the country. Also, negative trends in annual NDVI values over the 2000 – 2020 were computed, which is consistent with declining productivity trends observed in remote sensing analyses and farmer surveys over roughly the same period (Mungai et al., 2020). At least part of this ongoing decline can be attributed to land degradation and climate change.

4.2.3 Value chain selection

Given Malawi's vulnerability to food-insecure conditions, the risk assessment focuses on maize, which is by far the most important food staple in Malawi (Fisher and Lewin, 2013). Maize production accounts for over 60% of all food production in the country (Mazunda and Droppelmann, 2012). Dietary energy supply of Malawi's population attributed to maize amounts to 1,069 kcal / capita / day, with an average intake of 337 grams per capita (Galani et al., 2022). Figure 12 shows the spatial distribution of maize production in Malawi in the year 2010, which is concentrated in the southern and western parts of the country.

Figure 11: Land degradation vulnerability map of Malawi.

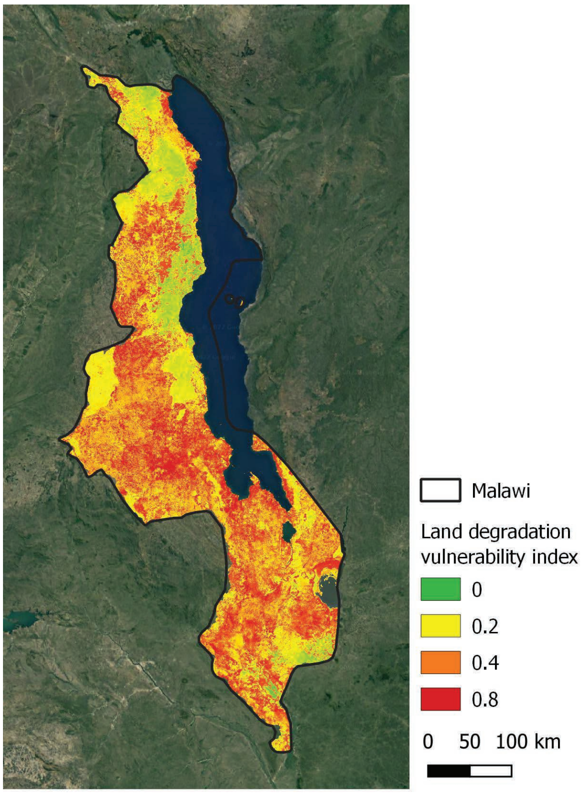
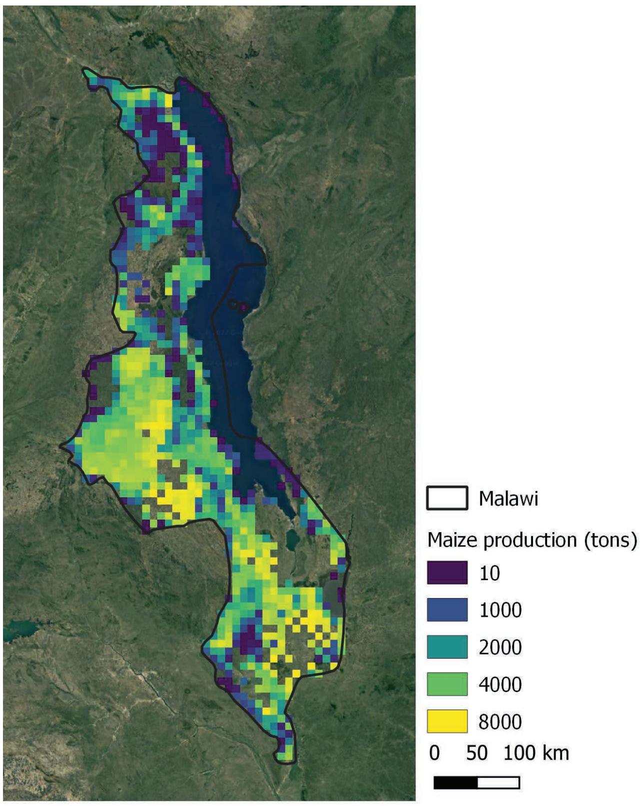


Figure 12: Maize production in Malawi in 2010 (source: FAO GAEZ v4).



4.2.4 Overall risk assessment

Figure 13 presents the risk of increased land degradation due to climate change in Malawi. Table 5 summarizes the statistics of maize production and harvested area in each of the four risk classes. In total, 46% of national production is considered at either high or very high risk of being negatively impacted by aggravated land degradation as a consequence of climate change.

Cultivation of maize in Malawi is known to be sensitive to climate change, expected to be negatively impacted by increased temperatures and reduced or delayed rainfall (Hunter et al., 2020; Msowoya et al., 2016). In this regard, the 2015-2016 drought event can be viewed as illustrative of a hazard more likely to occur in the future, with an observed maize production loss of 32-34% (McCarthy et al., 2021). Considering the risk profile for this crop in important geographical production areas, diversification towards nutrient-dense and land-friendly consumption crops to ensure greater resilience is important.

Figure 13: Risk map of exacerbated land degradation due to climate change in Malawi (2035 – 2065).

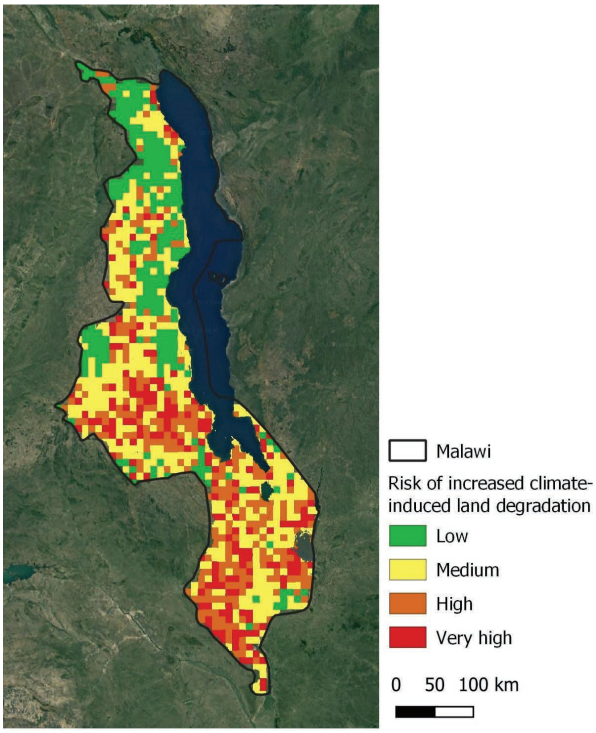


Table 4: Maize production and harvested area in Malawi in the year 2010, for each of the risk classes.

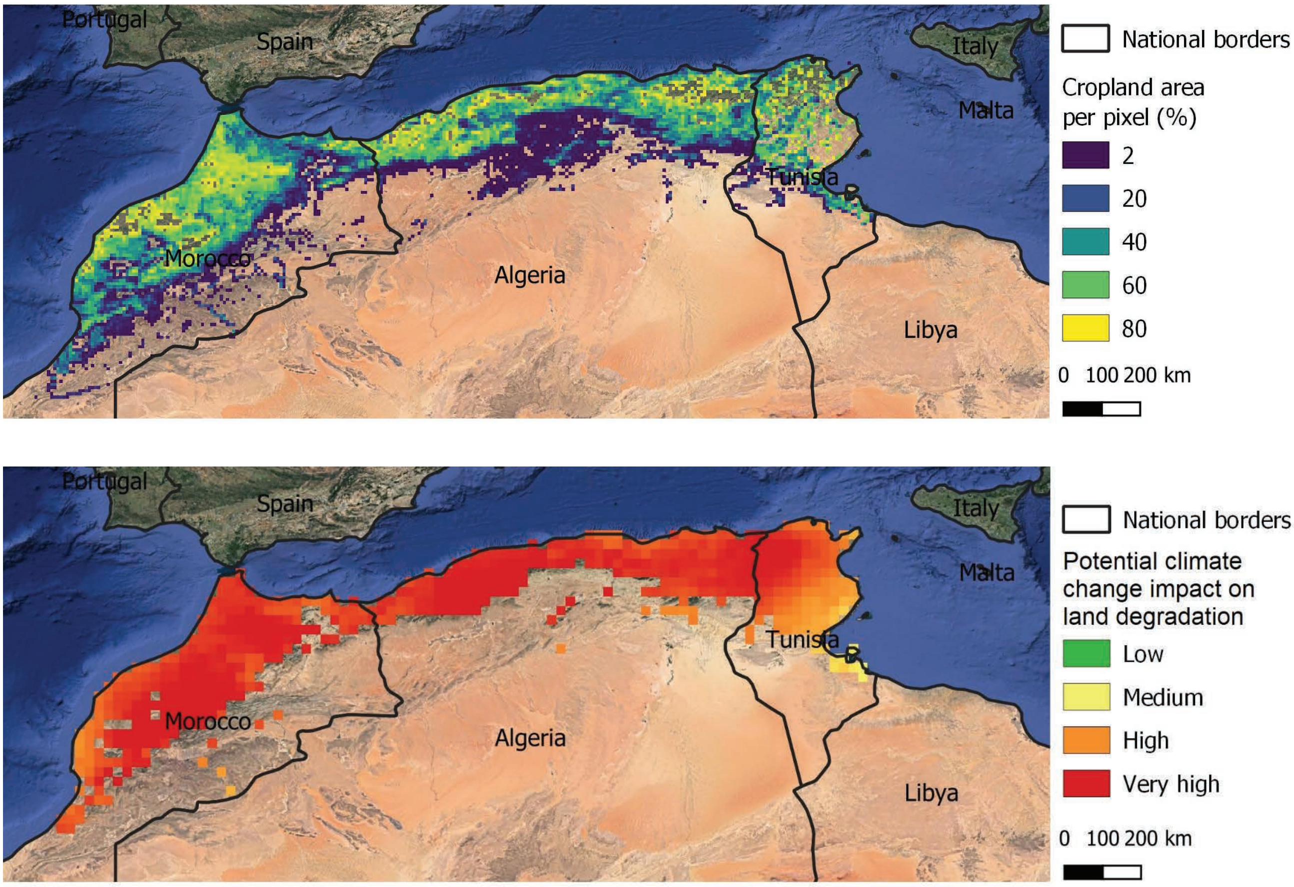
Risk class	Production (tons)	Harvested area (km^2)	% of country Production	% of country harvested area
Low	375,559	1,951	11%	12%
Medium	1,532,193	6,935	44%	43%
High	927,195	4,335	27%	27%
Very high	663,269	3,014	19%	19%
Malawi	**3,498,216**	**16,235**	**100%**	**100%**

4.3 Morocco, Algeria and Tunisia

4.3.1 Potential impact of climate change on land degradation

A transboundary region of Morocco, Algeria and Tunisia was selected as the third region with high potential climate change impact on land degradation in agriculture. The area encompasses the northern regions of these countries that are known for extensive agriculture, both rainfed and irrigated. Figure 14 shows the spatial distribution of cropland, as well as the classification of projected climate change impacted on land degradation in croplands (GLC-SHARE grid cells with >10% cropland area are shown).

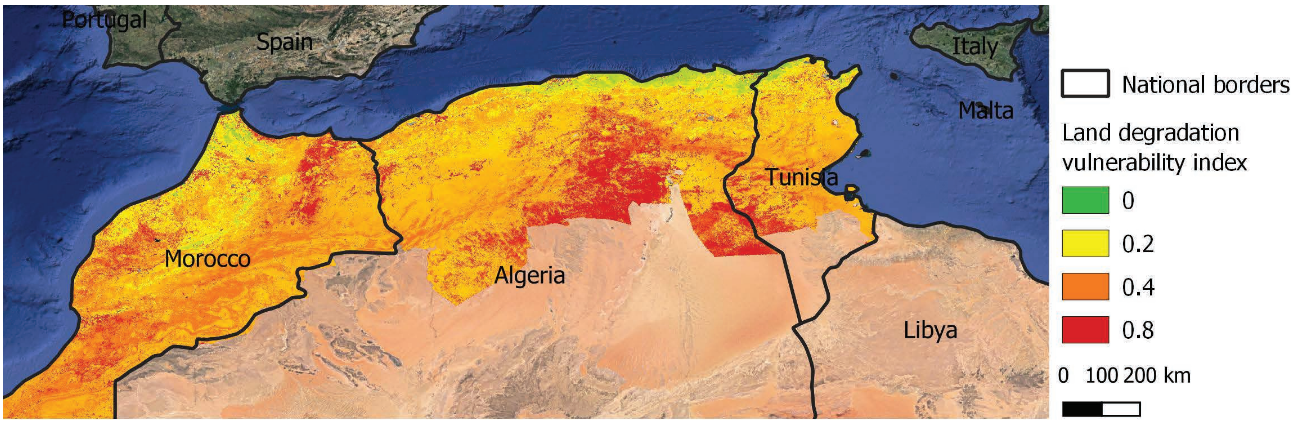
Figure 14: Maps of cropland (top) and projected climate change impact on land degradation in cropland (bottom) in Morocco, Algeria, and Tunisia.



4.3.2 Land degradation vulnerability

Figure 15 shows the land degradation vulnerability map of Morocco, Algeria and Tunisia. Here, the relationship between spatial patterns of vulnerability and cropland distribution (Figure 14) is quite different to e.g. in Malawi, as the cultivated areas in North Africa are associated with denser vegetation cover, more advantageous soil properties, and less rugged terrain than in other parts of the three countries.

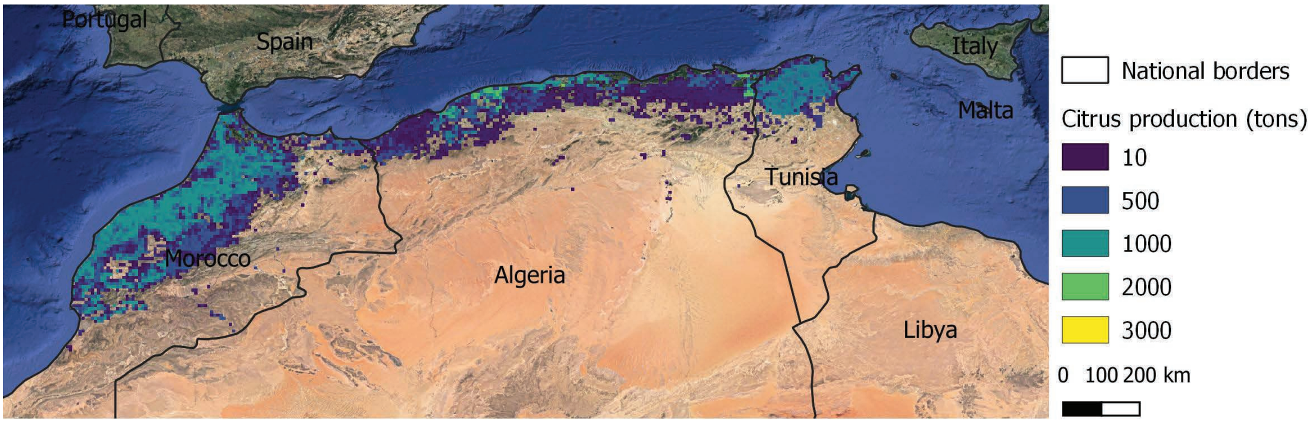
Figure 15: Land degradation vulnerability map of Morocco, Algeria and Tunisia.



4.3.3 Value chain selection

Citrus crops are grown extensively in Morocco, Algeria and Tunisia (Figure 16). Oranges, tangerines, grapefruits and other citrus fruits are particularly grown for export purposes. Over the period 2013 – 2018, on average 607,180 tons and 20,558 tons were exported annually from Morocco and Tunisia, respectively (ONAGRI, 2018). In 2018, the export value of Moroccan citrus amounted to US$ 1.14 billion, with around 90,000 permanent jobs provided by the citrus industry . Citrus was therefore selected in this report as an emerging export-oriented crop.

Figure 16: Citrus production in Morocco, Algeria and Tunisia in 2000 (source: EarthStat). The map presents a summation of production of orange, grapefruit, tangerine, lemon lime, and "citrus NES" – Not Elsewhere Specified.



[10] ONAGRI Tunisie (2018), Notes de Veille (http://www.onagri.nat.tn/notes-veille)

[11] MEYS Emerging Markets Research (https://meys.eu/media/1245/presentation-citrus-production-morocco-vs2.pdf)

[12] GIZ (https://www.climate-expert.org/fileadmin/user_upload/Case_Study_Summary_Agrumar_Souss_EN.pdf)

4.3.4 Overall risk assessment

Figure 17 presents the risk map of aggravated land degradation due to climate change in the northern regions of Morocco, Algeria and Tunisia. The high risk class is dominant in all three countries, while especially in Morocco various stretches of (agricultural) land are classified as being at very high risk. Table 7 lists total citrus production and harvested area located in each of the four risk classes. Overall, 78% of national citrus production in the three countries is considered at least at high risk of being seriously affected by land degradation due to climate change by 2035 - 2065.

Climate change can negatively affect citrus production in various ways. An increase in temperature and water stress at critical phenological stages results in decreased fruit growth rates and sizes, increased fruit acidity, and low tree yields, among others (Shafqat et al., 2021). For example, the heatwaves of 2015 and 2016 saw drops of 30% to 40% in citrus tree blossoms in Souss Massa, Morocco . Over the past years, citrus production in the region has already fluctuated considerably due to varying weather conditions. Drought and elevated temperatures contributed to a 38% reduction in 2017/2018 citrus production in Tunisia, and a 15-20% reduction in Morocco, compared to the preceding year (ONAGRI, 2018). As shown in Figure 3, the annual number of hot days and lengths of drought episodes are expected to increase over the next decades. Considering the risk profile citrus trees face, as well as the fact that returns on investment of tree crops are directly linked to tree maturation (i.e. time for the tree to bear fruits), investments towards tree crops or crops that can withstand climate change impact as well as contribute towards land restoration would increase the resilience of the export basket.

Figure 17: Classification of risks associated with climate change-induced land degradation in Morocco, Algeria, and Tunisia (2035 – 2065).

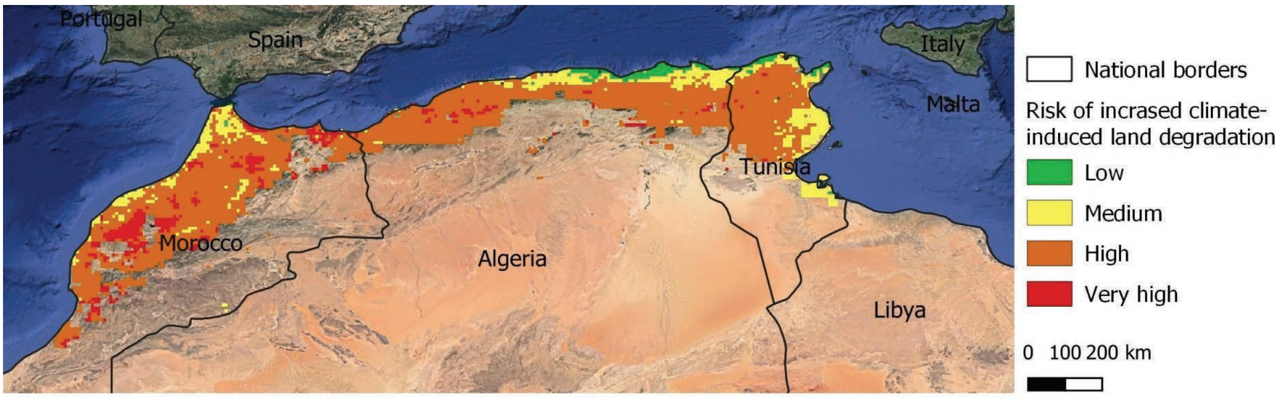


Table 5: Citrus production and harvested area in the Morocco, Algeria and Tunisia region in the year 2000, for each of the risk classes.

Risk class	Production (tons)	Harvested area (km^2)	% of national production	% of national harvested area
Low	17,643	16	1	1
Medium	298,055	245	16	17
High	1,310,631	1,011	71	71
Very high	135,350	89	7	6
Total	**1,761,679**	**1,361**	**96**	**96**
Total (national)	**1,834,786**	**1,419**	**100**	**100**

5 Conclusions and recommendations

This report started with a global assessment of potential climate change impact on land degradation in dryland agriculture. Based on the global-level results, three focus regions were selected for an in-depth risk assessment of key value chains, based on potential climate change impact on land degradation, vulnerability to land degradation, and spatial mapping of the relevant crops. A methodology based on international standards was applied for all focus regions, relying on global circulation model outputs, satellite-based remote sensing, and GIS datasets.

The assessment highlighted that for 30 countries, at least 50% of their dryland cropland is situated in either the *high* or *very high* impact classes of potential climate change impact on land degradation. Depending on crop-specific sensitivity to climate change and land degradation and sustainability of local land management practices, these croplands are likely to face increasing vulnerabilities to degradation and subsequent productivity loss. Particularly in these 30 countries, shifts in climatic and agro-ecological suitability need to be anticipated and climate-adaptive measures need to be considered. Productivity of traditional crops - especially those vulnerable to land degradation – may be considerably affected in the future.

With regard to the three selected geographical focus areas, at least an estimated total of 29% of coffee production in Brazil, 46% of maize production in Malawi, and 78% of citrus production in Morocco, Algeria and Tunisia are considered to be at high or very high risk of increased climate-induced land degradation due to changes in precipitation and temperature. In the past years, the production of each of these crops has already been affected, evidenced both by longer-term trends (e.g. declining productivity of coffee in Brazil and maize in Malawi) and impacts of extreme events, particularly those related to drought and heat. The results of this report show that both the severity and frequency of such events is expected to increase in the future. This is not only the case in these three regions, but also in dryland agriculture in many other parts of the world, including North Africa, Southeast Africa, southern Spain, western Turkey, and Southwest Australia.

The three regions selected in this report represent pathways of risks for other regions. Loss of productivity due to declining soil health is expected to be accelerated in many regions through climate change. Some value chains are likely to be no longer productive in the near future. These risks are increasing, and countries need to prepare and think of resilience and diversification as a matter of systemic risk, especially as these risks are likely to be compounded by other global megatrends around energy prices, the 4th Industrial Revolution (IR) and the rise of the megacity. Some geographical regions will have to completely redefine their productive capacities approaches. Concrete recommendations for the adaptation to these risks include:

- Develop national-level hazard and vulnerability assessment to build forward-looking risk maps that can provide a basis for evidence-based and future-proof policy recommendations and investment decisions
- Assess exposure of key productive systems and develop concrete adaptation measures, including assessing alternative higher returns productive systems. This should also include land restoration measures to ensure greater resilience to climate change, ideally through land friendly crops and production systems
- Ensure megatrends around population growth and consumption patterns, but also around on-shoring and near-shoring, are integrated in policy-making to ensure that productive systems adapt to emerging patterns of needs.

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Annex 1: Assessment of potential climate change impact on land degradation in croplands

The table below lists all countries with over 100 km2 of cropland according to the FAO GLC-SHARE product. Areas and percentages of cropland in each of the four climate change impact classes are listed. Countries are ranked according to the percentage of total national cropland falling in the "very high" impact class. Countries listed in bold are part of the focus regions selected in this report. Only cropland located in dryland climate zones is considered in the table.

Rank	Country	Low impact		Medium impact		High impact		Very high impact		Total area (km^2)
		Area (km^2)	%	Area (km2)	%	Area (km2)	%	Area (km2)	%	
1	Venezuela	0	0.0	0	0.0	137	4.6	2828	95	2965
2	Namibia	0	0.0	355	5.1	111	1.6	6440	93	6906
3	**Algeria**	**0**	**0.0**	**2720**	**3.6**	**4369**	**5.8**	**67847**	**91**	**74937**
4	**Morocco**	**1**	**0.0**	**14**	**0.0**	**14536**	**16.6**	**72873**	**83**	**87424**
5	Botswana	0	0.0	0	0.0	863	33.3	1727	67	2590
6	**Brazil**	**0**	**0.0**	**3104**	**3.0**	**39494**	**38.7**	**59528**	**58**	**102126**
7	Angola	2475	8.2	10302	34.3	3084	10.3	14174	47	30035
8	Zambia	0	0.0	5785	19.2	12402	41.3	11875	40	30062
9	Mozambique	0	0.0	9991	25.4	17711	45.1	11591	29	39293
10	**Tunisia**	**0**	**0.0**	**2820**	**5.8**	**32189**	**66.4**	**13453**	**28**	**48462**
11	Honduras	0	0.0	1107	40.8	1023	37.7	582	21	2713
12	Spain	0	0.0	33397	21.9	89499	58.6	29885	20	152781
13	El Salvador	0	0.0	2411	32.6	3651	49.4	1327	18	7389
14	**Malawi**	**0**	**0.0**	**8469**	**28.1**	**16354**	**54.2**	**5348**	**18**	**30171**
15	Nicaragua	0	0.0	496	12.0	3084	74.4	566	14	4146
16	Zimbabwe	0	0.0	770	2.2	31410	89.5	2927	8	35107
17	Turkey	0	0.0	126444	54.2	88817	38.1	17885	8	233146

Rank	Country	Low impact		Medium impact		High impact		Very high impact		Total area (km²)
		Area (km²)	%	Area (km2)	%	Area (km2)	%	Area (km2)	%	
18	Bolivia	5	0.1	6553	65.3	3045	30.3	432	4	10035
19	Greece	0	0.0	10958	33.3	20793	63.1	1199	4	32950
20	Mexico	103	0.1	95477	68.4	39034	28.0	5013	4	139627
21	South Africa	165	0.2	47851	50.8	43048	45.7	3179	3	94243
22	Guinea	0	0.0	9390	43.1	11784	54.0	638	3	21812
23	Libya	0	0.0	15201	79.0	3918	20.4	131	1	19250
24	Syria	0	0.0	13655	27.6	35584	71.9	269	1	49508
25	Paraguay	0	0.0	2391	35.8	4260	63.9	21	0	6672
26	Australia	4	0.0	266177	72.8	98285	26.9	1115	0	365582
27	Mauritania	7	0.2	3451	99.3	15	0.4	3	0	3475
28	Jordan	0	0.0	375	14.5	2207	85.5	0	0	2583
29	Sierra Leone	0	0.0	0	0.0	258	100.0	0	0	258
30	Portugal	0	0.0	67	0.7	9543	99.3	0	0	9609
31	Gambia	40	1.2	266	7.8	3092	91.0	0	0	3398
32	Israel	0	0.0	534	11.7	4022	88.3	0	0	4556
33	Chile	308	3.0	1576	15.3	8391	81.7	0	0	10275
34	Guinea-Bissau	6	0.1	1144	27.7	2974	72.1	0	0	4124
35	Lebanon	0	0.0	906	33.9	1762	66.1	0	0	2668
36	Palestine	0	0.0	367	37.6	610	62.4	0	0	977
37	Senegal	378	1.3	11068	36.9	18571	61.9	0	0	30017
38	Italy	0	0.0	6551	54.3	5513	45.7	0	0	12064
39	Democratic Republic of the Congo	0	0.0	3705	58.8	2599	41.2	0	0	6304
40	Guatemala	0	0.0	2244	72.5	853	27.5	0	0	3097
41	Northern Cyprus	0	0.0	443	78.0	125	22.0	0	0	568
42	Egypt	0	0.0	27410	80.3	6738	19.7	0	0	34148
43	Madagascar	0	0.0	11673	93.0	875	7.0	0	0	12548
44	Albania	0	0.0	337	95.1	17	4.9	0	0	355

Rank	Country	Low impact		Medium impact		High impact		Very high impact		Total area (km^2)
		Area (km^2)	%	Area (km2)	%	Area (km2)	%	Area (km2)	%	
45	Mali	0	0.0	54867	96.2	2141	3.8	0	0	57008
46	Iran	0	0.0	177988	97.6	4380	2.4	0	0	182368
47	United Republic of Tanzania	4761	5.8	75423	92.1	1685	2.1	0	0	81870
48	Saudi Arabia	352	1.6	21651	96.4	459	2.0	0	0	22462
49	Azerbaijan	0	0.0	21920	98.9	246	1.1	0	0	22166
50	Macedonia	0	0.0	4336	99.0	44	1.0	0	0	4380
51	Iraq	0	0.0	43908	99.1	396	0.9	0	0	44304
52	Argentina	15202	19.5	62256	79.9	433	0.6	0	0	77892
53	Eritrea	1078	17.9	4910	81.5	33	0.6	0	0	6022
54	Sudan	151	0.1	163727	99.7	358	0.2	0	0	164237
55	United States of America	11094	1.5	723128	98.4	557	0.1	0	0	734779
56	Chad	0	0.0	39910	100.0	12	0.0	0	0	39922
57	Niger	0	0.0	108798	100.0	16	0.0	0	0	108814
58	Yemen	3440	26.8	9399	73.2	1	0.0	0	0	12840
59	India	977718	70.9	401179	29.1	0	0.0	0	0	1378896
60	Russia	580813	43.1	766353	56.9	0	0.0	0	0	1347166
61	China	311305	44.0	396222	56.0	0	0.0	0	0	707527
62	Canada	351518	63.8	199184	36.2	0	0.0	0	0	550701
63	Ukraine	2502	0.7	362918	99.3	0	0.0	0	0	365420
64	Kazakhstan	212312	70.3	89851	29.7	0	0.0	0	0	302163
65	Nigeria	1281	0.5	261572	99.5	0	0.0	0	0	262853
66	Pakistan	40040	20.0	159667	80.0	0	0.0	0	0	199706
67	Poland	34262	33.4	68165	66.6	0	0.0	0	0	102426
68	Romania	0	0.0	95326	100.0	0	0.0	0	0	95326
69	Afghanistan	8054	10.3	69923	89.7	0	0.0	0	0	77977
70	Ethiopia	48086	65.3	25560	34.7	0	0.0	0	0	73646

Rank	Country	Low impact		Medium impact		High impact		Very high impact		Total area (km^2)
		Area (km^2)	%	Area (km2)	%	Area (km2)	%	Area (km2)	%	
71	Myanmar	2411	3.4	68367	96.6	0	0.0	0	0	70778
72	Uzbekistan	263	0.5	49300	99.5	0	0.0	0	0	49563
73	Burkina Faso	0	0.0	49448	100.0	0	0.0	0	0	49448
74	Hungary	0	0.0	48995	100.0	0	0.0	0	0	48995
75	Bulgaria	0	0.0	37931	100.0	0	0.0	0	0	37931
76	Republic of Serbia	0	0.0	30200	100.0	0	0.0	0	0	30200
77	Germany	16690	56.6	12821	43.4	0	0.0	0	0	29512
78	Cameroon	0	0.0	26950	100.0	0	0.0	0	0	26950
79	Moldova	0	0.0	24857	100.0	0	0.0	0	0	24857
80	Kenya	14809	60.1	9821	39.9	0	0.0	0	0	24630
81	Belarus	15458	63.5	8890	36.5	0	0.0	0	0	24349
82	Turkmenistan	0	0.0	23034	100.0	0	0.0	0	0	23034
83	Peru	8083	36.3	14190	63.7	0	0.0	0	0	22273
84	Czechia	160	0.9	17037	99.1	0	0.0	0	0	17197
85	Ghana	0	0.0	14398	100.0	0	0.0	0	0	14398
86	Kyrgyzstan	6463	45.2	7823	54.8	0	0.0	0	0	14286
87	Benin	0	0.0	13614	100.0	0	0.0	0	0	13614
88	South Sudan	0	0.0	12930	100.0	0	0.0	0	0	12930
89	Slovakia	0	0.0	11419	100.0	0	0.0	0	0	11419
90	Nepal	1825	16.3	9392	83.7	0	0.0	0	0	11218
91	Tajikistan	641	6.2	9685	93.8	0	0.0	0	0	10326
92	Bangladesh	4301	44.2	5437	55.8	0	0.0	0	0	9738
93	Ecuador	1899	20.4	7404	79.6	0	0.0	0	0	9303
94	Somalia	549	6.6	7798	93.4	0	0.0	0	0	8347
95	Indonesia	0	0.0	8149	100.0	0	0.0	0	0	8149
96	Mongolia	5020	63.2	2922	36.8	0	0.0	0	0	7942
97	Thailand	0	0.0	7375	100.0	0	0.0	0	0	7375

Rank	Country	Low impact		Medium impact		High impact		Very high impact		Total area (km^2)
		Area (km^2)	%	Area (km2)	%	Area (km2)	%	Area (km2)	%	
98	Central African Republic	0	0.0	6206	100.0	0	0.0	0	0	6206
99	Togo	0	0.0	5731	100.0	0	0.0	0	0	5731
100	Armenia	0	0.0	5524	100.0	0	0.0	0	0	5524
101	Ivory Coast	0	0.0	4791	100.0	0	0.0	0	0	4791
102	Austria	0	0.0	4710	100.0	0	0.0	0	0	4710
103	Uganda	279	6.9	3741	93.1	0	0.0	0	0	4020
104	Georgia	0	0.0	3763	100.0	0	0.0	0	0	3763
105	Sri Lanka	1865	76.1	585	23.9	0	0.0	0	0	2451
106	Lesotho	0	0.0	2237	100.0	0	0.0	0	0	2237
107	Kosovo	0	0.0	2168	100.0	0	0.0	0	0	2168
108	North Korea	1799	100.0	0	0.0	0	0.0	0	0	1799
109	Croatia	0	0.0	1789	100.0	0	0.0	0	0	1789
110	Laos	0	0.0	1532	100.0	0	0.0	0	0	1532
111	eSwatini	0	0.0	1359	100.0	0	0.0	0	0	1359
112	Somaliland	391	47.9	426	52.1	0	0.0	0	0	817
113	United Arab Emirates	0	0.0	816	100.0	0	0.0	0	0	816
114	Cyprus	0	0.0	796	100.0	0	0.0	0	0	796
115	New Zealand	722	100.0	0	0.0	0	0.0	0	0	722
116	Oman	43	6.5	615	93.5	0	0.0	0	0	658
117	East Timor	0	0.0	627	100.0	0	0.0	0	0	627
118	Dominican Republic	0	0.0	617	100.0	0	0.0	0	0	617
119	Sweden	243	100.0	0	0.0	0	0.0	0	0	243
120	Kuwait	0	0.0	150	100.0	0	0.0	0	0	150
121	Qatar	0	0.0	144	100.0	0	0.0	0	0	144
122	Haiti	0	0.0	125	100.0	0	0.0	0	0	125

**United Nations Convention
to Combat Desertification**

P.O. Box 260129
D-53153 Bonn, Germany

Tel: 00 49 228 815 2800
Email: secretariat@unccd.int

www.unccd.int

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