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Soft commodity production impacts on the natural environment in Overseas Development Assistance eligible countries

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Summary

This report was undertaken to develop a methodology to assess subnational commodity production environmental impacts in Official Development Assistance (ODA) eligible countries, with a focus on linking this to UK commodity consumption. This work follows on from previous research investigating international links to UK consumption on a country-to-country level and develops a framework which can be used to find what subnational resolution data are available to investigate trade links, commodity production and related environmental impacts. This is important as currently the UK has a large overseas footprint, and the UK government has committed to reducing its global environmental impacts, particularly regarding deforestation. Data are available to hotspot the commodities and production countries associated with high environmental impacts from UK consumption (https://www.commodityfootprints.earth/). However, data are not readily available to assess such impacts at a subnational scale, which would be necessary to identify areas of high impact, to validate estimates of impact, and to improve the usability of the data to inform conservation action or to build sustainable production capacity. Therefore, investigating the availability of subnational datasets to pinpoint areas of high impact at a local/regional scale has direct policy relevance.

This report aimed to create a generalisable methodology which could be applied to any country (with a particular focus on ODA-eligible countries). This methodology was generated by a series of literature reviews and searches to build on existing research. It focused on how to obtain trade and commodity data at a subnational level and investigated biodiversity, deforestation and water stress as indicators of environmental impact. The resulting methodology is a decision tree which helps the user to identify the highest resolution data available and if no subnational data are available, it provides alternative global datasets. These global datasets are available in an accompanying dataset which includes details of commodity maps, notes on various indicators covering biodiversity, deforestation and water stress, and the recommended choice of indicator. Examples of subnational level data are also included in a separate accompanying dataset, which is focused on Brazil. It should be noted that these datasets are the result of time-limited reviews, due to the three-month length of the project, and as such they will not be exhaustive. The methodology resulting from this report can be used to rapidly assess the environmental impact of a country of choice and provides a useful baseline which could be expanded on in future work.

Contents

1 Introduction

1.1 Overview

This report comprises the results of a three-month Natural Environment Research Council (NERC) policy internship which investigated how soft commodity production impacts could be assessed in Official Development Assistance (ODA) eligible countries. The project aimed to investigate how subnational level impacts of agricultural and forest products, linked to UK consumption, could be assessed. It focused on biodiversity, deforestation, and water stress as indicators of these impacts. A proposed methodology was developed to guide users to find the best sources of high-resolution data per country and used a hierarchical flow chart approach to determine which level of data resolution is appropriate based on data availability (i.e. country-level or subnational-level information). This report focused on literature reviews and searches investigating:

- Spatial commodity maps around the world at various global, regional, national, and subnational scales.
- Indicators of biodiversity, deforestation and water stress that could be linked (directly or indirectly) to commodity production.
- Global trade data and its availability at a subnational level.

The outcomes of these time-limited literature reviews informed the methodology and provide a dataset which accompanies the report. This dataset provides links to indicator and commodity resources which can be used to analyse the impacts of UK consumption; examples of subnational data (Brazil) are also provided. This work builds on previous reports from the JNCC, notably the UK Consumption Indicator work.

1.2 Commodity Impacts

Soft commodity products are those commodities which are grown rather than extracted or mined and include many commodities which are linked with global environmental impacts (e.g. oil palm, soy, timber and livestock). For example, agricultural, pastural and tree plantation expansion are drivers of deforestation across the tropics, estimated to cause emissions of 2.6 gigatonnes carbon dioxide per year with up to 39% of these emissions associated with international trade (Pendrill *et al.* 2019). This deforestation is often linked with biodiversity loss (e.g. Koh & Wilcove 2008; Chaudhary *et al.* 2016) and further expansion of commodity production, such as palm oil, is expected to threaten increasing numbers of species into the future (Vijay *et al.* 2016). Furthermore, increasing commodity production is often intrinsically linked to increased water stress and water deficits (Dolganova *et al.* 2019) which can have detrimental impacts on crop yields, local biodiversity and drinking water availability. Agriculture can be linked to a multitude of other impacts from high levels of phosphorous (P) and nitrogen (N) pollution causing a high risk to the stability of the Earth system by exceeding the planetary boundary framework (Steffen *et al.* 2015), to soil erosion removing 17 Pg/year of soil from cropland globally (Borelli *et al.* 2013). These effects combined can affect ecosystem services, defined as the benefits people and society gain from the environment, with essential regulatory effects, such as flood prevention, pollination, water purification, and cultural benefits possibly degraded or lost altogether. With global resource use and consumption expected to double by 2050 (Bringezu *et al.* 2017) it is of key importance to minimise the negative impacts of commodity production on biodiversity and the environment. The UK government has committed to “leaving a lighter footprint on the global environment” in the 25 Year Environment Plan, in particular focusing on developing deforestation-free sustainable supply chains and minimising potential negative impacts overseas (Defra 2018).

1.3 Trade links

These myriad impacts are heavily influenced by global trade with an estimated 23% of all food produced for human consumption traded globally (D'Odorico *et al.* 2014). The UK is no exception to this, with around 42% of direct UK food supply (based on the farm-gate value of unprocessed food) met from production in other countries (Defra, 2022). WWF have estimated that between 2016 and 2018, an area equal to 88% of the UK's total land area was used to grow just seven imported soft commodities (Jennings *et al.* 2020). The WWF report also indicated that the UK's overseas land footprint has been growing in recent years with the majority of cocoa, palm oil, rubber and soy sourced from countries considered to be high and very high risk, due to rates of deforestation, the rule of law and labour standards (Jennings *et al.* 2020). As a result, keeping track of these areas of risky commodity production is of key importance to be able to mitigate the UK's overseas environmental impact.

1.4 ODA-eligible countries

The focus of this report was on assessing the impact of commodities imported from individual ODA-eligible countries to the UK. All countries highlighted in Figure 1 are eligible for ODA from the UK government. Two of the central aims of ODA are "strengthening resilience and response to crises" and "promoting global prosperity" (FCDO 2020). These aims are intrinsically linked to sustainable commodity production in that sustainably managed agricultural and plantation land will maintain ecosystem services and lower the risk of extreme weather events and other economically damaging impacts, thereby developing long term sustainable economic activity. For example, the Dasgupta review (Dasgupta 2021) states that "sustainable production systems can effectively deliver multiple ecosystem services: regenerative agriculture, organic agriculture, agroforestry and low-trophic level aquaculture are examples of production systems capable of enhancing regulating services (such as pollination and air quality regulation) alongside provision of food." Therefore, it could be that ODA may be a useful policy lever to encourage change in a country or region's production practises if they are found to be causing negative environmental impacts which would contradict these aims. Furthermore, the UK government agreed to align UK ODA with the Paris agreement in June 2019 and has committed at least £11.6 billion of UK aid to climate finance until 2025-26. As a result, understanding where ODA could be spent to both reduce carbon emissions associated with agriculture and to encourage climate-resilient agricultural practise could be very valuable to this aim. Many other policy levers are available to influence commodity production from sustainable certification schemes (Harris *et al.* 2019), carbon pricing and emission trading schemes to ecosystem services protection schemes, such as REDD+, yet these are outside the scope of the report. Brazil is used as an example ODA-country later in this report due to both its strong trade links with the UK and unusually high level of easily accessible subnational data. While the focus of this report is on ODA eligible countries, the approach could be applied to any country to investigate subnational commodity impacts.

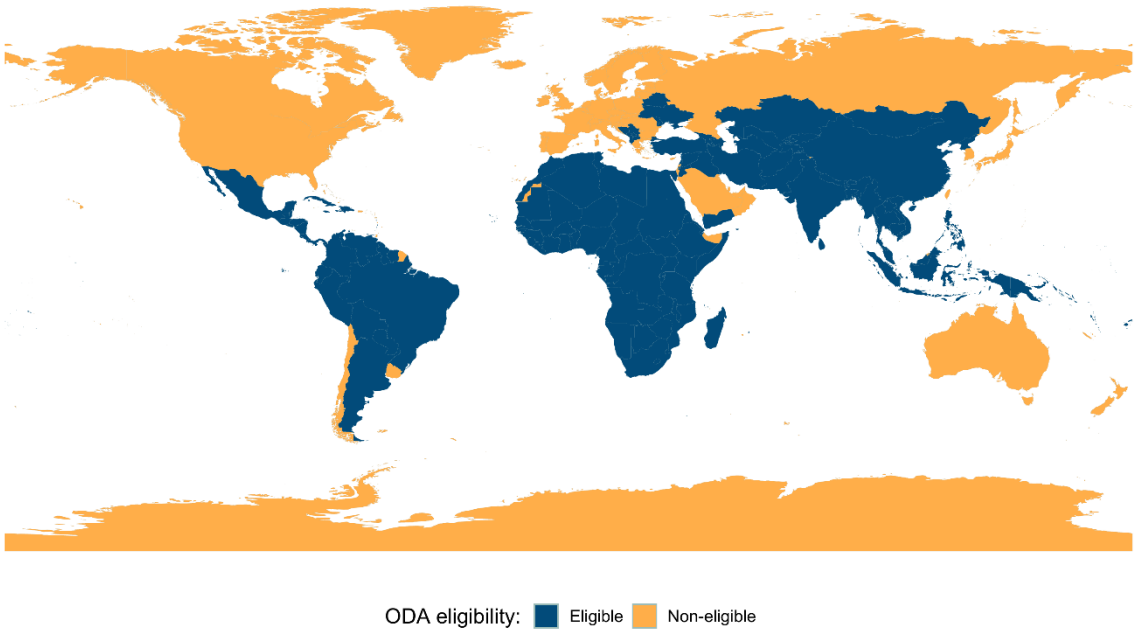

Figure 1. Map of Official Development Assistance (ODA) eligible countries (data sourced from OECD, map created in R version 4.2.1 (R Core Team 2022)).

2 Methodology

2.1 Overview

Previous work based on assessing the environmental impact of UK consumption from international trade at the JNCC has been carried out at country level in the form of the UK consumption indicator (see the interactive dashboard). This indicator estimates the global environmental impacts of UK consumption from agricultural, cattle-related and timber commodities with particular focus on commodity-related tropical deforestation (and related emissions). The indicator also examined biodiversity loss and scarcity weighted water use. This report aims to follow on from the UK consumption indicator by investigating similar indicators of environmental impacts (deforestation, biodiversity and water stress) but following these down to a subnational level where possible. This assessment of consumption focuses on the drivers of commodity production (i.e. trade, the pressures on the environment and the impact upon biodiversity, deforestation and water availability caused by commodity production).

The methodology developed in this report involves a series of decision trees identifying the availability of data, the data resolution and the usefulness of data at each stage – from choosing the country of interest to investigating trade, commodity and indicator data (Figure 2). Each decision tree (diamonds in Figure 2) involves carrying out a literature review to investigate what data are available, if the data are at a resolution which enables subnational level analyses to be performed, and, if this is not the case, it leads to global/regional data sources collated in the dataset. Each decision tree is explained in further detail below (Sections 2.2, 2.3 and 2.4).

Each step in the flowchart can be time consuming and so the level of ambition of each assessment of any country of interest's links to UK consumption must be considered before starting the assessment process. A number of factors will affect the time taken to complete the assessment:

- The experience of the assessor in working with ecological, economic, and spatial data, and modelling that data.
- The country being assessed – some countries will require more comprehensive literature reviews than others. For instance, some countries may have very little scientific or grey literature concerning certain commodities/indicators and the decision to use global data sources may be relatively quick, or the opposite could also be true.
- The timeline of commodity production being assessed – some assessments may wish to look at single time points whereas others may wish to analyse trends in indicators in relation to changing commodity production and export values.
- The level of detail required in the report, and if any additional steps need to be included, for instance including commodity yield data or production intensity (see Section 3.2).
- The resources allocated to the assessment – the European Commission report on assessing trade agreements for biodiversity and ecosystem impacts suggests that the biodiversity section of a report can cost between €1,000 and €3,000.

One example assessment looking at the impact of the EU free trade agreement with Colombia, focusing on biodiversity and deforestation change before and after the agreement, took an expert assessor approximately eight weeks of work (IEEP, Trinomics, IVM & UNEP-WCMC 2021). This assessment included some slightly different steps to the methodology we suggest, due to the different focus, but the length of time taken is likely similar and eight weeks should be considered to be a good estimate of how long the methodology takes to complete if a similarly comprehensive and detailed assessment is completed.

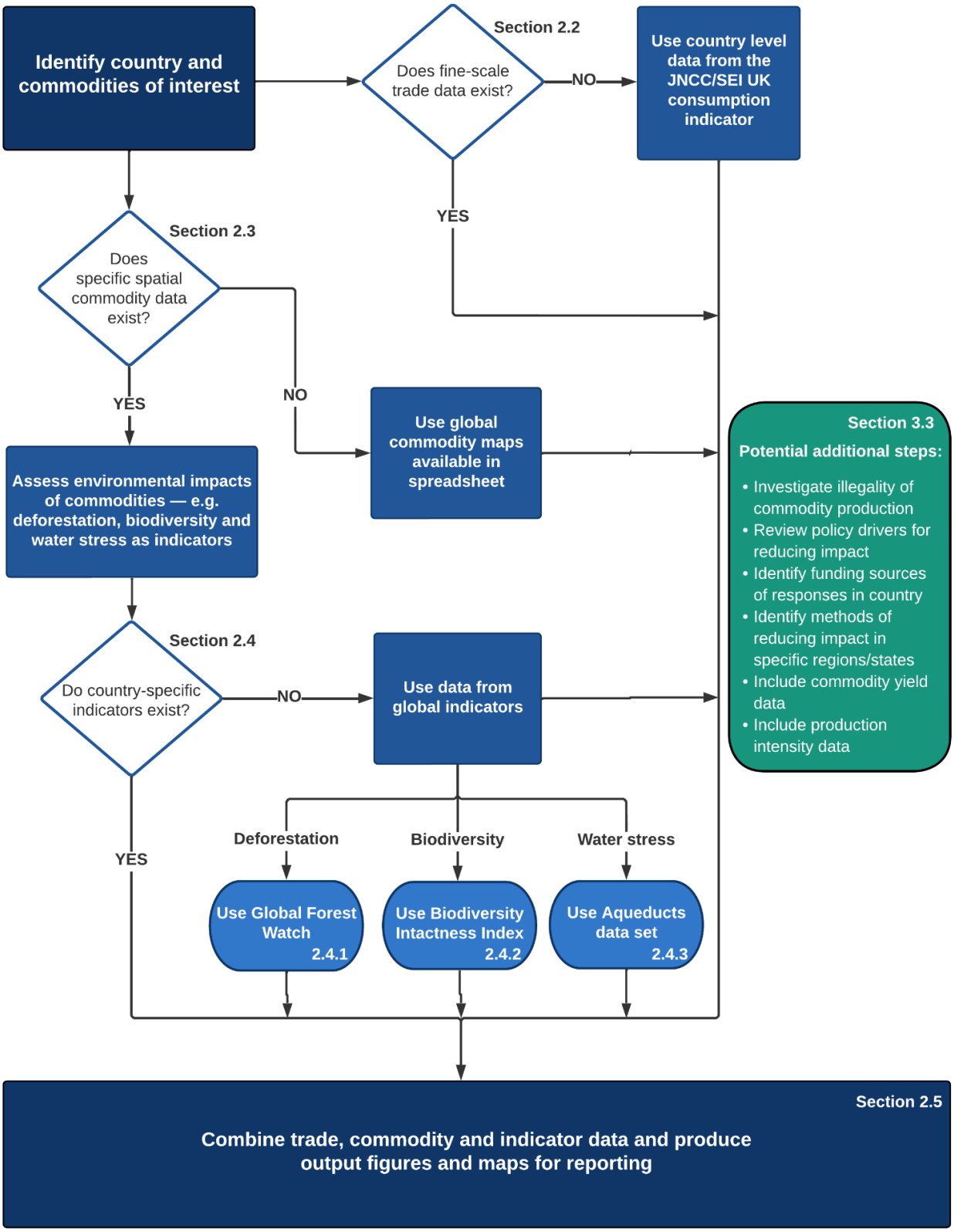

Figure 2. Flowchart methodology describing the process developed in this report to assess the environmental impact of UK consumption associated with a country of choice at a subnational level, taking into account the availability of trade, commodity and indicator data. Each diamond in the chart is a step which involves carrying out a literature review to assess data availability and if no country-specific data sources can be found, the next step is to utilise globally available sources of data (examples of which are provided in the accompanying dataset). See the numbered sections in the methodology for further information. This flowchart was created using the Lucidchart tool.

2.2 Trade data

Tracking commodity production from source to consumption is a difficult task which involves investigating inter-country trade data. The vast majority of trade data are reported at a country level. For instance, the Food and Agriculture Organisation of the UN (FAO) reports on trade in food and agricultural commodities between over 245 countries/territories, yet it does not provide subnational level trade data (e.g. trade exports between specific states/counties and a country) as most data received from national statistics offices is aggregated to a country level (FAOSTAT). Some initiatives are looking into hot spotting commodity production at a higher resolution. Trase is one example which maps supply chains to an unprecedented level of detail, allowing commodities to be followed from a county/municipality level to the companies which are exporting and importing the commodity, and through to the importing country. However, FAOSTAT and Trase only look at bilateral trade and as a result, commodities which are re-exported or embedded within other products can be missed from trade statistics. This can be an important data gap as, for example, palm oil can be found embedded in many common supermarket products, and the vast majority of soy production is used for animal feed and thus embedded in meat products. Therefore, it is necessary to take into account these indirect commodity flows. The UK consumption indicator dashboard provides this, resolved at a country-to-country level, with an approximate three-year lag, with all data available to download from the site. The following steps are recommended to obtain the trade data for the country of interest:

1. Download the UK Consumption Indicator trade dataset from JNCC's Resource Hub to obtain data on total trade volumes (and associated environmental impacts). These data account for cases where commodities are embedded into products, and cases where a commodity's supply chain involves re-export across a number of intermediate countries before reaching the final destination, allowing users to estimate the commodity's country of origin rather than simply the last country from which it was imported as many other datasets show.
2. Check if Trase has trade data for the country/commodities of interest at a subnational level. Trase is the premier data source for high-resolution trade data, however it currently only has data for a handful of countries. This is because of the large time investment it takes to add even one commodity from one country to the Trase tool, an estimated 6–9 months (West, pers. Comm.). This time investment is the reason why the report does not advocate for a Trase-style analysis of all a country's agricultural commodity trade.
3. Look for government agencies and departments which might report data in further detail to that collated by the FAO. For example, IBGE (the Brazilian Institute of Geography and Statistics) reports crop production data by region and state, and these data could be cross referenced with the FAOSTAT trade data to hotspot states of high production. These data can also be useful when searching for subnational commodity data. Subnational data resolution is unlikely to be obtained for many countries/commodities, as countries are only required to report trade data at a country-to-country level, but the Foreign Agricultural Service from the US Department of Agriculture (USDA) can be a useful service to search for such data.
4. The reviewer may wish to use the trade data to focus analysis on particular commodities that form a significant part of the UK's demand for produce from that country; to inform your literature reviews for the impact metrics and ensure inclusion of search terms for particular subnational regions linked to high UK demand; or to simply set the context for results from subsequent sections (e.g. comparing UK demand to total production within the country, and thereby giving context to the more detailed environmental indicators as assessed in total against total production).

2.3 Commodities

Numerous different soft commodity products might be of interest to policy makers and researchers. For instance, the WWF riskier business report which focuses on the UK commodity footprint examines timber, palm oil, pulp and paper, soy, beef and leather, cocoa and rubber as commodities of interest, with particular emphasis on cocoa, palm oil and soy. Moreover, the UK Environment Act 2021 includes provisions to address illegal deforestation by making large UK-based businesses implement due diligence schemes to prevent illegally produced forest risk commodities being part of their supply chains, meaning many agricultural commodities used commonly in UK products will likely be affected. Therefore, this methodology is developed to be flexible, and the user may focus on one or many commodities throughout the flowchart.

The first step, after choosing which commodities to examine, is to begin a literature search to find out if country-specific commodity maps are available, and if these are higher resolution than global maps for the same commodity. These commodity maps are important to understanding the impact their production as they will later be used in spatial analyses to relate to the environmental impact indicators. Steps to take in the commodity map literature review:

1. Start by searching local government websites and agencies for production data by state/county/region. Where available, these data can later be tied to environmental indicators and in some cases subnational trade data. The Foreign Agricultural Service from USDA is a useful resource to find these data sources. The USDA provide commodity maps for many countries and commodities globally, and although the maps cannot be directly downloaded and used for analyses, the data sources are reported in each map so that they can be replicated.
2. Conduct a review of relevant scientific publications investigating the commodity of choice as these may have published commodity maps at a high resolution. Search engines such as Google Scholar and Dataset Search are useful, as are websites such as Web of Science which provide the ability to search multiple databases of scientific journals comprehensively. At this stage the nature of the review must be considered. Time-limited reviews to obtain the majority of information can be carried out, as can comprehensive reviews, with appropriate Boolean search terms, to find all potentially relevant papers. The type of review depends on the time dedicated to the project and whether longer reviews are expected, or required, to bring back necessary results. For example, if it is quickly apparent that no country/region specific commodity maps exist then time may be better allocated in other sections of the analysis.
3. Each potential data source should be reported in a spreadsheet and assessed for suitability. The suitability of a spatial commodity map depends on:
    - The scale of the data – are the data available for the whole country, part of the country (e.g. one biome, or at a regional level)?
    - The data resolution – how high resolution are the data? Are they available in grid cells or per administrative area (e.g. state)?
    - Does the dataset span the years that the user wishes to examine or is it from a single time point?
    - When were the data last updated? Is this comparable to the environmental indicators and trade data being used? Will this dataset be updated in the future?
    - How were the data collected – are they based on on-the-ground monitoring data or are they all derived from remote sensing data?
    - The limitations associated with that product or method of data production.
    - Are the data publicly available?

4. The country-specific commodity maps should then be compared with global maps available in the attached dataset and screened for suitability based on the previous criteria.

2.4 Indicators

There are many potential indicators which could be used to assess the environmental impact of soft commodities. This report focuses mainly on deforestation, biodiversity and water stress as these were the indicators prioritised by the UK consumption indicator and they are often the focus of global conservation goals. For instance, the UN Global Forest Goals report states the aim to "reverse the loss of forest cover worldwide … and increase efforts to prevent forest degradation" and Sustainable Development Goal 15 of the 2030 Agenda for Sustainable Development is focused on improving sustainable use of terrestrial ecosystems and halting biodiversity loss. The following steps are recommended to investigate subnational indicators:

1. Generate a baseline understanding of the current state of biodiversity, forest cover and deforestation, and water scarcity in the country of choice (similarly recommended by IEEP, Trinomics, IVM & UNEP-WCMC (2021)). This is important as it gives the user prior knowledge as to how severe agricultural commodity impacts are likely to be and allows results produced by the assessment to be sense checked against existing knowledge. The Convention on Biological Diversity (CBD) National Reports are a good way of obtaining this baseline understanding.
2. CBD reports are also the first place to look for country-level indicators. For instance, Brazil's Sixth National Report provides useful information about how Brazil derives indicators (e.g. for deforestation), and links to the programs and schemes related to these indicators (in this case the PRODES program for assessing deforestation in each unique Brazilian biome).
3. Conduct literature reviews separately for each indicator using the same principles described in Section 2.3. Additionally, to the previous criteria:indicators should be:
    i. Indicators should be easy to interpret for non-experts who are likely to read the output of any report.
    ii. The units of the indicator should have a readily understandable meaning which explains the commodity impact (e.g. for biodiversity this could be numbers of species lost per region, or for deforestation this could be hectares of forest lost).
    iii. Indicators should be easy to link to specific commodities or production systems which are the drivers of the change seen in the indicator.
4. Any country-/region-specific subnational-level indicators found during the literature review should be compared to the global indicators with strengths, weaknesses and caveats noted. Suggested global indicators are:
    - Global Forest Change dataset, associated with Global Forest Watch, for deforestation.
    - Biodiversity Intactness Index described in Newbold *et al.* (2016) for biodiversity change.
    - Aqueducts dataset for water stress.

Global indicators are described in further detail in the subsequent sections. These can be used in cases where country-specific indicators are not as useful or cannot be found through literature reviews.

2.4.1 Deforestation

The Global Forest Change dataset is suggested as the global indicator for deforestation due to its widespread usage (the original paper has over 7,500 citations) and regularly updated

nature. This dataset is an updated version of the Hansen *et al.* (2013) global forest change dataset and it includes forest loss data from 2000 to2020, with further updates anticipated. The forest loss data are available at 30 m pixel resolution globally and are derived from remotely sensed data obtained by Landsat 5, 7 and 8 (with Landsat 8 used for the data since 2013). The dataset identifies areas where forest cover has been lost per year, meaning the land cover type has changed from forest to non-forest. This is based on defining tree cover as all vegetation > 5 m in height, and as such can include tree plantations in the dataset. Forest gain and forest extent data can also be obtained from the same source. The dataset continues to be improved through time, however due to the different satellites and methods of acquiring data there are inconsistencies between data obtained prior to 2011 and more recent years (Global Forest Change Usage Notes). Therefore, it is recommended to avoid comparing data between these time periods where possible, although an update is planned to resolve some of these issues (Global Forest Change Usage Notes).

2.4.2 Biodiversity

The Biodiversity Intactness Index (BII) is suggested as the global indicator for biodiversity due to its widespread usage in other national and international reports (e.g. 2019 IPBES Global Assessment Report on Biodiversity and Ecosystem Services), and its basis on a vast volume of on-the-ground ecological data – BII is based on the PREDICTS database which has over 3.6 million biodiversity records from more than 32,000 sites around the globe. BII is a measure of how much biodiversity, on average, remains in a region after human disturbance and is reported as an estimated percentage of undisturbed species' richness and abundance, with values > 90 % indicative of a well-functioning ecosystem and values < 30 % indicating ecosystem collapse. Since BII is a proportional estimate of intactness, it does not indicate absolute species' richness or abundance, so caution should be used when comparing between countries. However, this is unlikely to be a consideration when analysing at the subnational level. BII is generated by modelling the impacts of human disturbance on species' abundance in the site of interest against the species' community composition (i.e. the number and abundance of species) at nearby undisturbed sites. For information about the modelling see the R script tutorial. BII can be used at any spatial scale and is being continually updated which makes it a useful indicator into the future. The Biodiversity Intactness Index is still a work in progress, however, and Martin *et al.* (2019) suggest that BII overestimates how intact ecosystems are, when cross referencing the indicator with other metrics. (For further information about PREDICTS and the BII see Hudson *et al.* 2016; LeClere *et al.* 2020; Hill *et al.* 2018.)

2.4.3 Water Stress

The Aqueducts dataset for water stress is suggested as the global indicator due to the data being regularly updated and high resolution, available at the sub-basin level. Water stress is defined as the "ratio of total water withdrawals to available renewable surface and ground water supplies" and is calculated at a sub-basin level, either in monthly or yearly intervals (Hofste *et al.* 2019). This water stress value is compared to a baseline water stress value and either a raw percentage or an assigned score (0 to5) can be calculated, which indicates how risky the current rate of water use is. The water stress calculations in the Aqueducts dataset are based on the PCR_GLOBWB 2 global hydrological model (Sutanudjaja *et al.* 2018) and HydroBASINS 6 hydrological sub-basins (Lehner and Grill 2013) and any limitations noted in those publications therefore apply to this dataset. Moreover, the Aqueducts dataset is noted to be tailored to large scale comparisons and so local applications of the water risk indicator are described as having "limited added value" (Hofste *et al.* 2019). This should not be an issue as trade data are unlikely to be fine scale enough to warrant a local examination of water stress related issues. Moreover, ideally other sources of

water stress related indicator data could be found in the literature reviews which are more appropriate at a local scale.

2.5 Analyses

The next steps in conducting this review of soft commodity impacts are to collate all the data, analyse the trends and output graphs and maps to hotspot areas of high impact at a subnational level. It is worth noting that these analyses have not been completed by the authors of this report and as such these are suggestions, which can be built upon. Future work could investigate the best steps in how to analyse, collate and present the outputs of this report.

1. All commodity maps, trade and indicator data need to be downloaded.
2. Summary values from indicators should be generated on a country/state level for the years of interest in the analysis to create baseline data against which the impacts of individual commodities can be measured.
3. Following on from the summary values, the impact of either individual commodities or all commodities on the indicators needs to be assessed. This can be done by spatial analyses overlaying the commodity maps with indicator maps and assuming the impacts measured by the indicators are caused by the commodity in a small buffer region around that commodity. If performing time series analysis, it may be worth considering that the impact of commodity production likely spans the planting/harvesting date, as the land will first likely have to be converted beforehand to be suitable and then there will be a lag effect before the impact of that commodity is fully realised on the surrounding environment. Thus, to fully analyse a commodity's impact, indicators should be examined in the years before and after commodity production begins.
4. Outputs should be generated which show the environmental impact per subnational region, the trade flows between the UK and the country of interest, and time series graphs showing how the impact changes through time. These can be in the form of chloropleth maps of the country of choice subdivided based on the spatial resolution being examined (e.g. region/state/biome, etc.) and bar graphs showing changing indicators through time, subdivided by commodity.
5. This analysis will require coding ability in R/Python/similar and/or GIS knowledge. The greater the user's familiarity with these software, the quicker the analysis will be.

2.6 Example subnational data

This report was time-limited and there was not time for a full case study and subsequent analysis. However, examples of subnational data were gathered for Brazil to show the availability of different data sources and how good the data from some sources can be. Those data are available as an accompanying dataset. Brazil was chosen for this brief exploration, due to it being an important agricultural trade partner with the UK and being known for high data availability. Other countries would likely have varied subnational data availability, based on the amount of scientific research taking place in the country, the country's environment and agricultural departments' infrastructure and the accessibility of any data reported by that country. An example of state-level crop-level data can be seen in Figure 3, which identifies the state of Mato Grosso as a hotspot of crop production. This level of data resolution could be used to inform future analyses or research, knowing that Mato Grosso is likely an area of high environmental impact, simply due to the many times higher levels of commodity production than some of the other states.

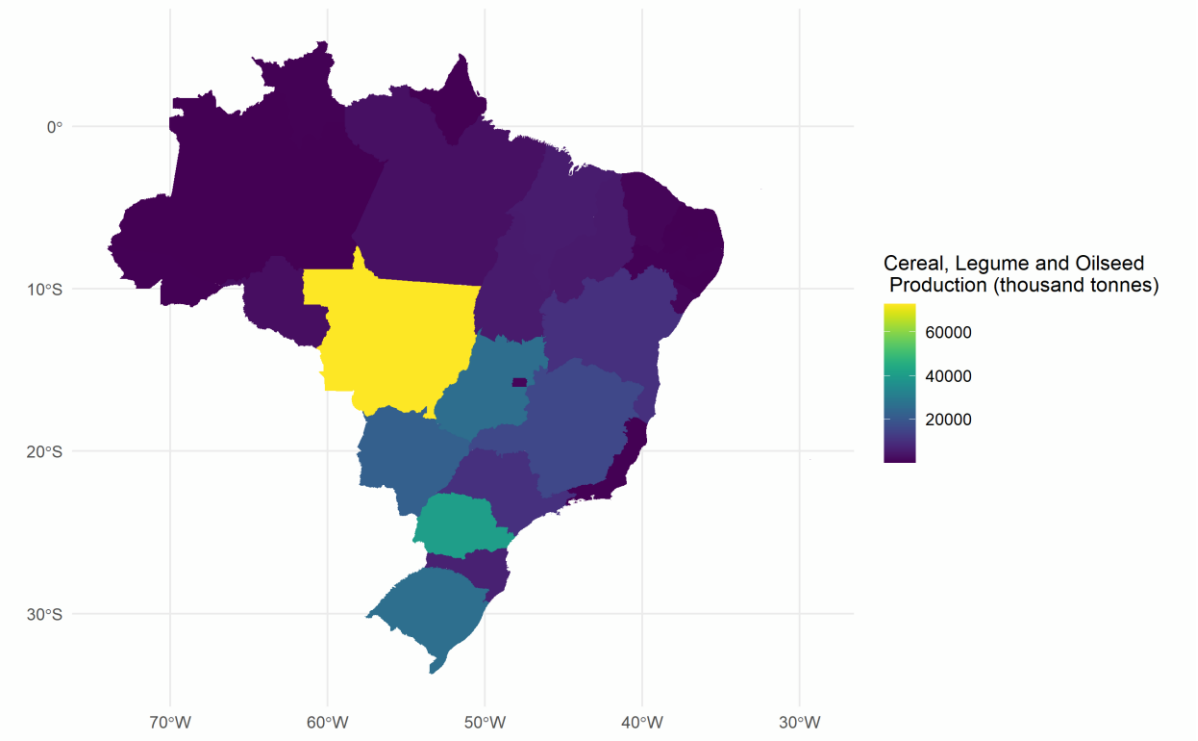

Figure 3. Choropleth map showing the production quantity of various cereal, legume and oilseed crops across Brazil. Map created using R version 4.2.1 (R Core Team 2022) using data from the Brazilian Institute of Geography and Statistics.

3 Discussion

3.1 Potential applications and implications

The framework this project has developed provides an approach for obtaining the highest resolution data available on the environmental impacts of UK trade in any given country. Whilst previous work, such as development of the UK consumption indicator, has focused on comparability between countries, this work focuses on obtaining the most detailed and accurate information possible. This is particularly useful for cases where better data are available and the application relates to a single country, as it does not require users to rely on less accurate data for the sake of comparability with other countries. For example, if assessing the implications of ODA spend across different projects within a single country, use of subnational data where available could greatly aid in optimising spend for environmental mitigation. For countries or commodities that do not have additional data available, it nonetheless provides a consistent method for searching for more detailed data rather than simply relying on coarser-scale data by default.

The framework has many potential uses. These include:

- Narrowing the location of environmental impacts estimated from sources such as the UK consumption indicator.
- Validating estimates of impact.
- Improving the tractability of using data on the environmental impacts of consumption to inform local action to reduce impacts or build sustainable production capacity.
- Adding detail to the environmental chapters of free trade agreements.
- Informing ODA spend.

3.2 Limitations

The methodology has several limitations which should be noted before carrying out the analysis.

- The assessment of one country will by design not be directly comparable between an assessment of a different country. This is because the assessment aims to obtain the highest resolution data available in order to best inform the environmental impacts of trade and commodity production in each country. This means that some countries may be more data poor than others and as such they would be assessed at a lower resolution (e.g. country level), than others which could be assessed subnationally. The indicators used may also vary between assessments if certain countries have more suitable indicators, in terms of data resolution and availability, than others.
- Any assessment carried out will necessarily be limited by the availability of commodity, trade and indicator data. It may be that for certain countries no subnational-level assessments will be able to be carried out, due to the lack of data. However, this cannot be known until the literature review and search process has been carried out.
- Due to the time-limited nature of the data review carried out for this report, it could be that there are additional global data sources, for commodities and indicators, which have not been considered in the dataset.
- The focus of this report is specifically soft commodities over hard commodities. This means that by default the negative environmental impacts of hard commodities, such as oil (O'Rourke & Connolly 2003) or coal (Giam *et al.* 2018), are not included. Moreover, this report primarily focuses on terrestrial commodities and not marine/freshwater commodities. This is because some indices, such as deforestation and water stress, are not suited for a marine environment and further work would have to be carried out to investigate appropriate indices to assess (e.g. marine fishing/aquaculture).
- It may be that searches only in English will bias the search results in the literature reviews. For instance, it is known in the ecological literature that monolingual searches can introduce bias and limit the results (Nuñez & Amano 2021) and additionally there may be difficulties in accessing government websites, if they are primarily written in another language. Moreover, even finding webpages in other languages is more difficult when the search terms are not translated. Therefore, searches only in English can limit the accessibility of data and information, and thus the scope of any reviews.
- Care must be taken to align commodity maps with trade and indicator data from similar timeframes. This is important because having data from different timeframes could add uncertainties into the modelling and outputs from those models, as spatial commodity data may not align with the indicator data or export values from the region may not be well represented by the commodity maps.
- Inconsistencies are present in the Global Forest Change dataset due to: data being collected using different satellites between 2000 and 2012 and 2013 and 2020, changing numbers of image acquisitions for analysis, and algorithmic changes. This may make time series comparisons inaccurate, and care has to be taken in analyses spanning 2012 to 2013. Moreover, due to the forest loss dataset including tree plantations, some areas with high plantation turnover (e.g. an oil palm plantation at the end of its lifecycle could be falsely identified as forest loss). This issue could be addressed by masking tree plantations out from the forest loss data using existing commodity maps (e.g. the global map of oil palm plantations (Descals *et al.* 2021)).

3.3 Future Work

This methodology was limited by the time constraints of the NERC-policy internship. Multiple other aspects of international trade and UK consumption impacts could be considered and added into the methodology at future date. Example areas of interest include:

- Identifying illegal commodity production. This is especially relevant due to the UK Environment Bill provision to prevent illegal deforestation in the supply chain and any work done to identify data sources which track illegal deforestation would be of key interest to policy makers and industry stakeholders. A number of methods currently exist, for instance the Rainforest Foundation UK have produced an app which allows local community members to report illegal logging and mining, Rainforest Connection creates acoustic monitoring systems to monitor illegal logging, and remote sensing imagery can be used to track deforestation almost daily, at high resolutions (e.g. Diniz *et al.* 2015). However, globally tracking illegal deforestation is difficult due to the vast amount of data needing to be processed and the legality of the logging needing to be known. Further research would be necessary to find out if there are data sources available which could be useful to incorporate analysis of illegal commodity production at a global scale.
- Reviewing the policy drivers available for reducing the impact of overseas trade. This would involve further literature reviews to detail which UK policies and international agreements best apply to commodity production overseas and how the UK should be following them to best reduce its environmental impact (e.g. in terms of deforestation or biodiversity loss). The review could also focus on how other countries/institutions are mitigating their overseas impacts and any solutions/issues identified could be noted. Workshops/consultations could be useful to bring together stakeholders (e.g. representatives from government, non-governmental organisations, commodity importers and producers), to identify policy levers which could instigate changes in production practises.
- Including commodity yield data. This would allow the results to investigate whether intensively produced high-yield areas have higher environmental impacts than lower-yield areas and would contribute to the land-sparing vs land-sharing debate (Phalan *et al.* 2011).
- Including production method and intensity information. The addition of this information into the methodology would allow a comparison within commodities of different production methods, for example shade-grown coffee vs sun-grown coffee, where shade-grown coffee is known to be less environmentally damaging (Perfecto *et al.* 1996). This could have important links to UK consumption and would enable UK consumers to be more confident in their choice of product (if the different production methods are reported). However, this wasn't included in the current report due to much of the data being remotely sensed and within-commodity differences were not found to be reported often in spatial commodity maps.
- Development/addition of further indicators. Additional indicators could be useful in cases where the existing indicators don't cover the breadth of environmental impact fully. For instance, the UK only has 13.2 % forest cover and lost most of its forests years ago, meaning that deforestation would currently be a poor indicator for UK agricultural impact as any existing forest is unlikely to be cut down to make way for fields/pasture. Other indicators such as looking at nutrient pollution (phosphorous and nitrogen) may be more appropriate in these cases (e.g. 55 % of England is currently described as a "Nitrate Vulnerable Zone" by the Environment Agency (2019)). The addition of further indicators to the methodology could also be linked to expanding the indicator to look at non-ODA eligible countries, as these are the most likely to be less well covered by the assessment's existing indicators.

- A valuable addition to this work would be a full case study being completed, following the methodology from start to finish. This would enable steps in the flowchart to be fine-tuned and validated and would also enable a complete assessment of the time requirements of an analysis like this. A case study would also provide valuable information on the data availability of subnational-level data, although this is likely to vary considerably between countries.

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