

Linking local production impacts with consumption

Implementation for Assessment of Impact on
Drivers of Biodiversity Loss

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Presentation Overview

1. Project Background
2. Approach to the Project
3. Methods applied
4. Results extract
5. Discussion (limitations, extensions)

Project Background

- Project Duration: Nov 2011 – April 2013
- Funder: Department for Environment Food and Rural Affairs, UK
- **The Issue**
 - Growing consumption, continued reliance on imports
 - Complex supply chains
 - Indirect and direct impacts of consumption
 - Overseas biodiversity impacts
- **Project Aim**
 - *provide a database-driven methodology for linking UK imports to geographically-defined impacts on biodiversity*

Policy Drivers

- Convention on Biodiversity Diversity (CBD) 1992
- Most recent targets for signatories are Aichi
- Aichi target 4 states:
 - *“By 2020, at the latest, Governments, business and stakeholders at all levels have taken steps to achieve or have implemented plans for sustainable production and consumption and have kept the impacts of use of natural resources well within safe ecological limits”*
- Defra want to find ways to measure and monitor this, this project contributes to research. We focus on the sustainable consumption

Approach to Classify and Prioritise Impacts

- Standard trade data do not capture indirect impacts of consumption via supply chains
- Full consumption assessment requires supply chain data
- Need to identify the location of production to assess local impacts
- Focus on drivers of biodiversity loss from production activities, rather than trying to quantify the impacts on individual species

WP1: Existing Studies

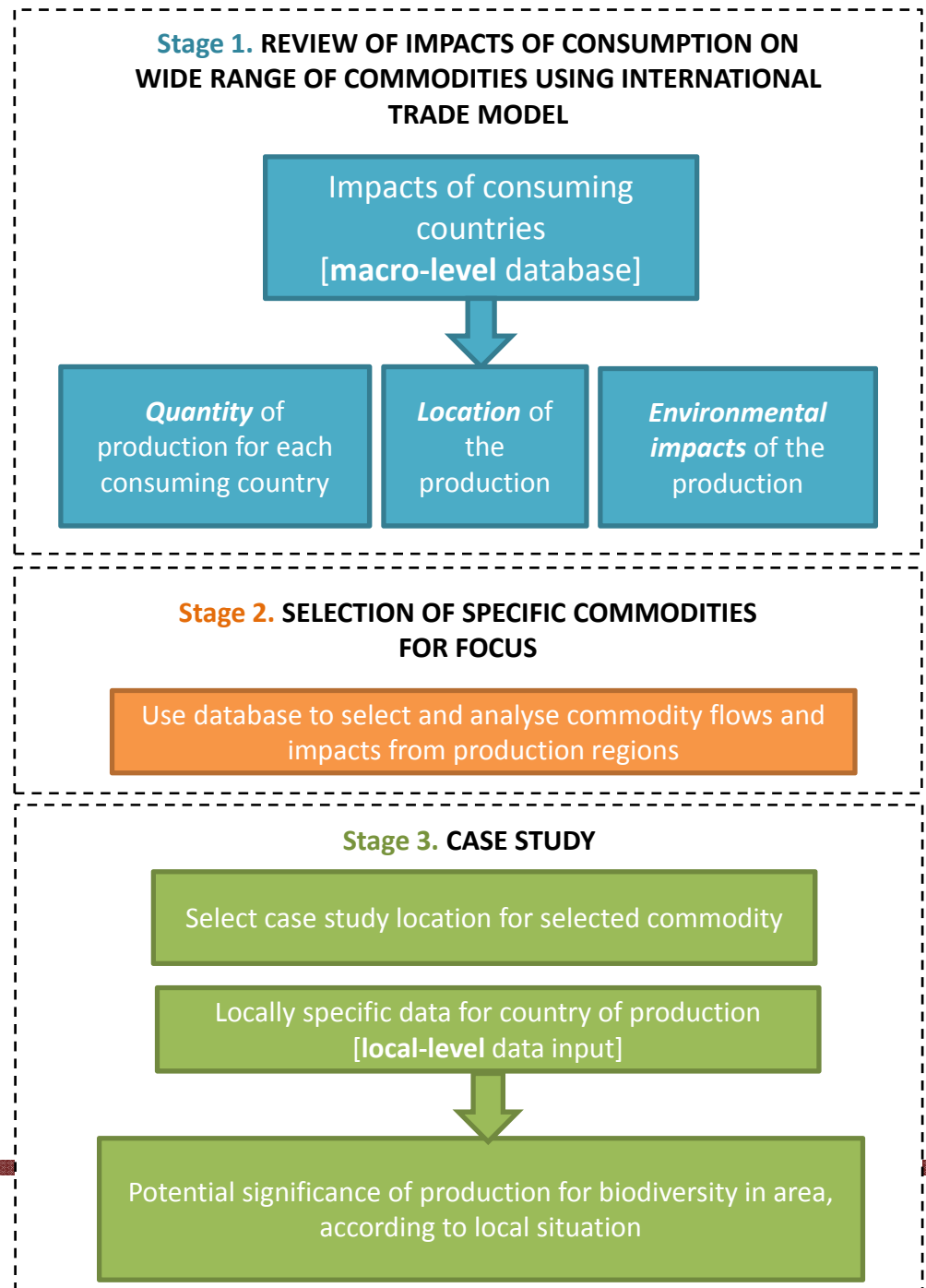
Study	Products covered	Method Applied	Biodiversity Indicator
Trends in EU virtual land flows: EU agricultural land use through international trade, Van Sleen (2009)	Wheat case study	Material flow analysis with a multi-criteria assessment of impacts	Genetic diversity, Species diversity, Overall, environmental utility
Dutch Trade and Biodiversity, Kamphuis et al. (2011)	Soya, palm oil and tropical timber products	Trade flow knowledge	Relative species richness, Relative species richness of original species
Some specific products, some broader	Soya, lumber palm oil, cotton, shrimps and wine	Trade flow exporters. Identification of ecoregion country of production, threats to E	and area d by import
footprint of UK biofuel consumption, JNCC (2009)	Biofuels	UK biofuels consumption trade data countries and crops, estimate land and ecosystems under pressure	atched to region
The global land use impact of the United Kingdom's biomass consumption, JNCC (2011) Part I.	Biomass	Material flow data (e.g. domestic material consumption) combined with biomass import data, land yields and water	Matched land area requirements of imports to Biogeographical realms, biomes and specific countries
UK National Ecosystem Assessment Technical Report. Chapter 21, UNEP-WCMC (2011)	Biomass	Import data converted to land area requirements using crop yields and matched to the Biogeographical Realms by country of origin (crop water requirements are also included to estimate embedded water).	Matched land area requirements of imports to Biogeographical realms, biomes and specific countries

Species richness indicators and ecoregions

Variety of methods, material flows, import and export quantities

Approach

- Assessment framework developed
- Specific method/ approach developed for each stage



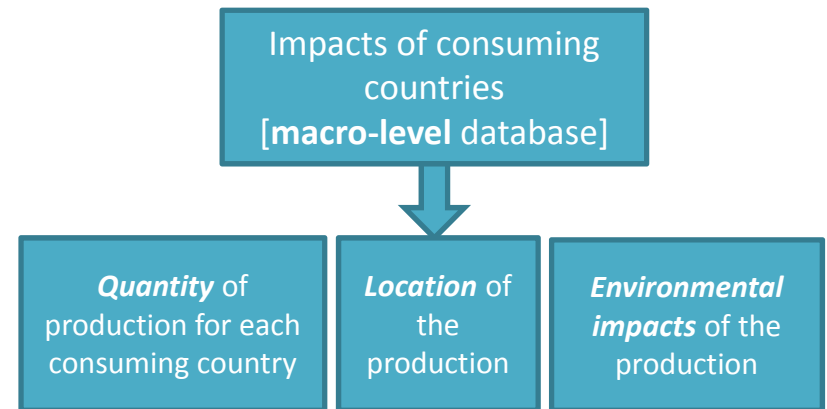
Methods Applied

Stage 1

Create a database of consumption-based impacts for a range of commodities

- Consumption-based indicators (e.g. land/carbon footprint) exist, but with the following issues:
 - No data on local significance; need to link to local impacts
 - Usually at aggregated product-group level (e.g. footprint of dairy products)
 - Origin of production is not kept in database; difficult to trace
 - Reliance on financial data to track flows

1. REVIEW OF IMPACTS OF CONSUMPTION ON WIDE RANGE OF COMMODITIES USING INTERNATIONAL TRADE MODEL



Stage 1

Creating the consumption-based database

Apply common footprint method based on input-output analysis, but develop and adapt database to specific project needs (local-level production, physical data, product level detail...)

Techniques Applied:

- Multi-regional input-output (MRIO) model developed using GTAP8 data, following method described in Peters, G.P., Andrew, R., & Lennox, J. (2011)
- FAO physical data linked to MRIO model using methods described in Ewing et al. (2012) and building on the EUREAPA approach (www.eureapa.net)

Stage 1 Data Inputs

To track direct and indirect flows through global economy:

- GTAP8 database of financial trade flow data, between 129 countries/world regions and 57 sectors

To identify quantity and location of production in physical units:

- FAO database on production, imports and exports of up to 200 agricultural (fisheries/forest) commodities
- British Geological Survey and UN Comtrade for minerals production

To identify environmental impacts:

- FAOStat for land areas
- Water Footprint Network
- FertiStat
- Biodiversity databases (IUCN, WWF)

Stage 1 Data Outputs

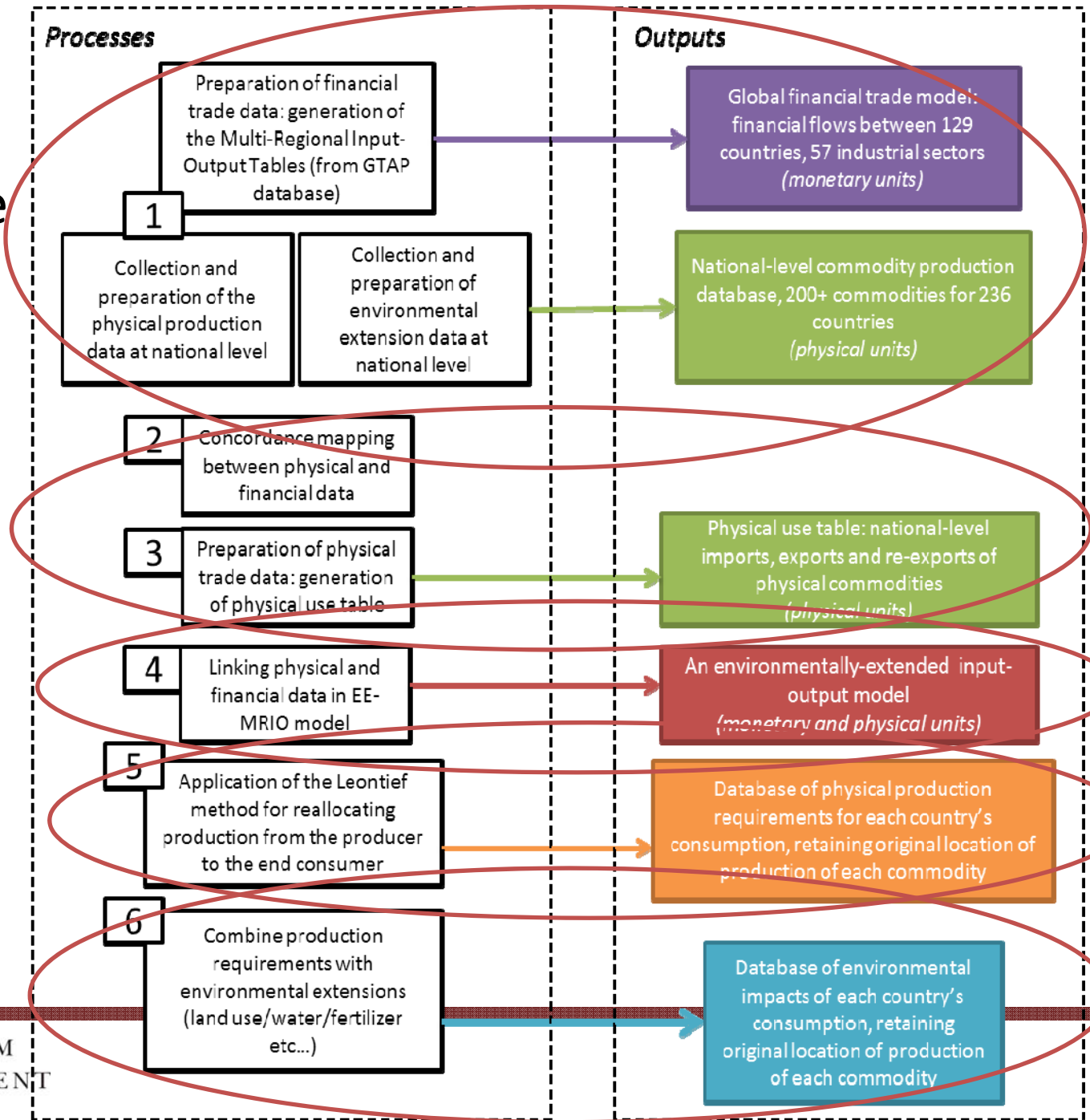
- For Defra all data were organised according to the requirement to satisfy UK demand for all goods and services
- Once the database was complete we can view:
 - How many tonnes of commodity are required in each country to satisfy UK demand* for 57 goods/services
 - Estimated land (ha) and water (m³) is required to produce these tonnes
 - Then additional environmental information about that country

* Run for UK for Defra, but 129 countries in the model

Stage 1

How we generated those outputs

- Multi-regional input-output tables
- Physical use tables
- Environmental extensions
 - Land use
 - Water use and scarcity
 - Fertiliser use
 - Biodiversity status indicators



Stage 1 Diagram of resulting model

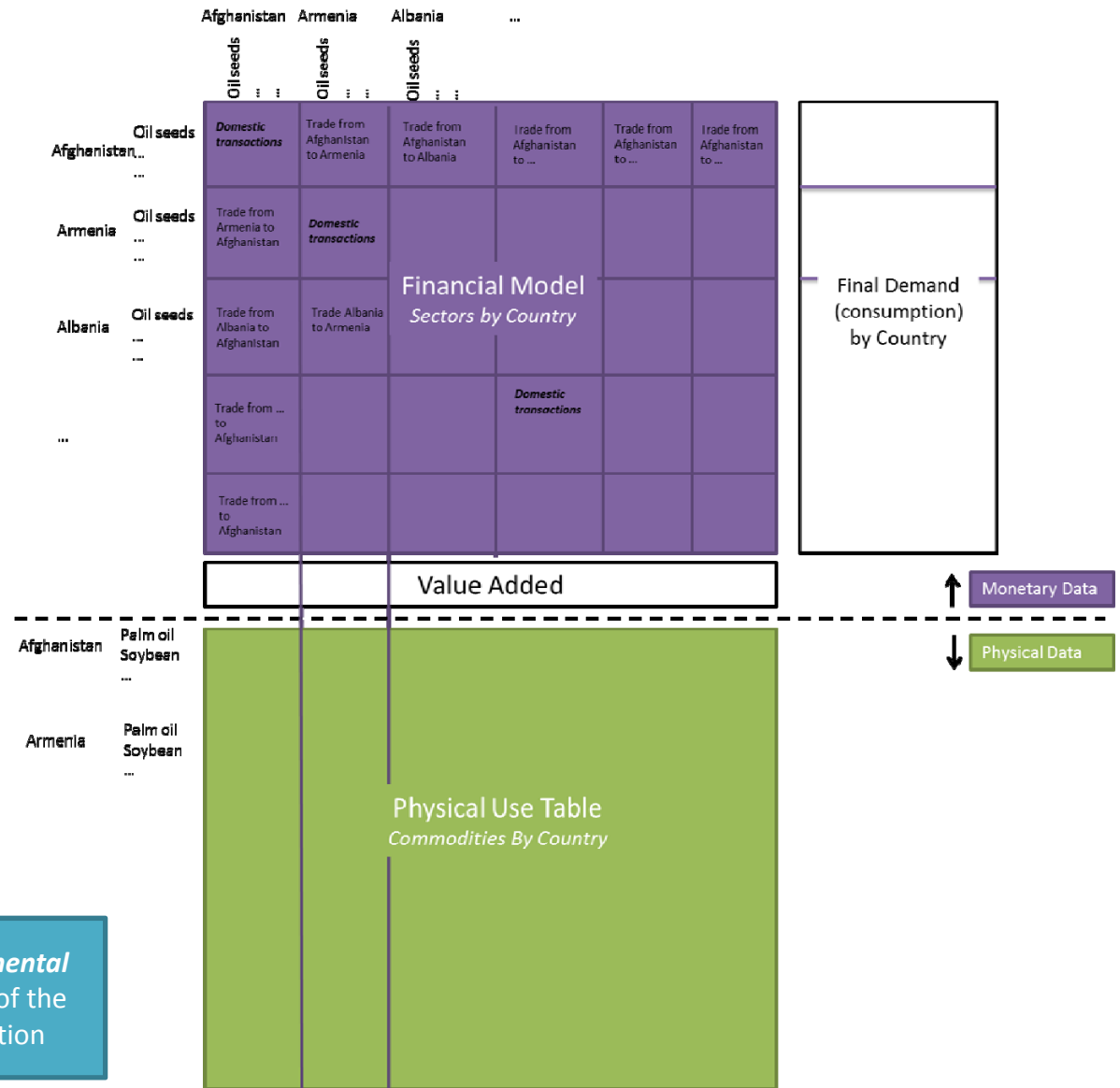
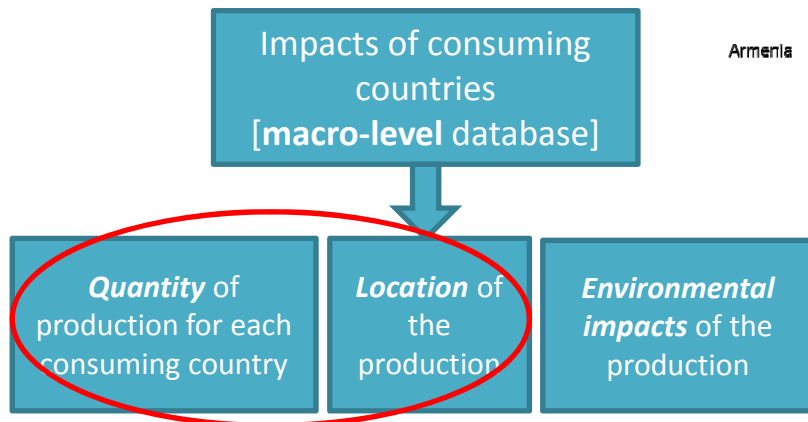
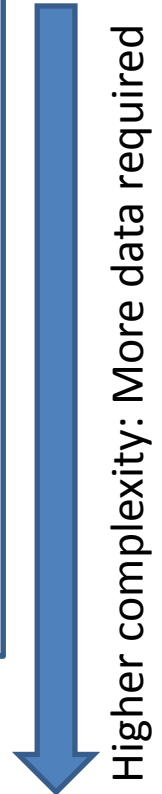


Diagram Adapted from: Brad R. Ewing, Troy R. Hawkins, Thomas O. Wiedmann, Alessandro Galli, A. Ertug Ercin, Jan Weinzettel, Kjartan Steen-Olsen, Integrating ecological and water footprint accounting in a multi-regional input-output framework, Ecological Indicators, Volume 23, December 2012, <http://www.sciencedirect.com/science/article/pii/S1470160X12000714>

Stage 1

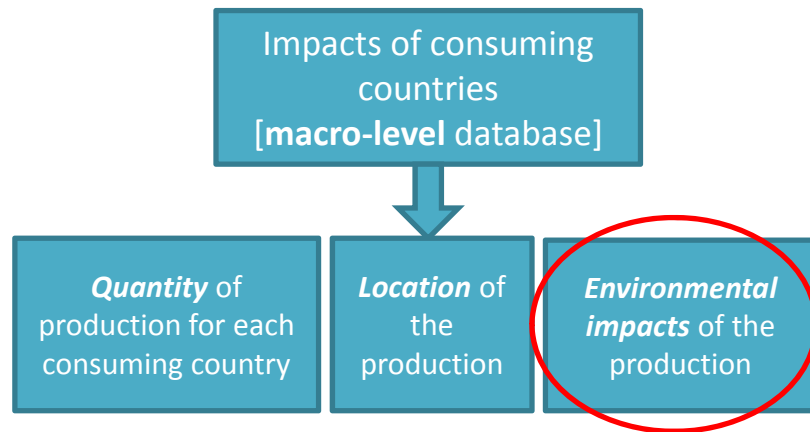
Methods for Linking the Monetary and Physical Data

- Method 1: Allocate physical production of each product and country within FAO to an equivalent producing sector and region within GTAP
 - Relies solely on financial MRIO data to model trade in commodities between sectors
- Method 2: Allocate physical production to importing regions in GTAP using FAO trade data
 - Full 'MRIO-physical use' approach (Ewing et al. 2012); requires harmonisation of datasets and method for dealing with re-exports in the physical data
- Method 3: Create full physical input-output table
 - Retains product detail to greatest extent, but resource intensive and data often unavailable



Implementation Issues

- Dealing with region irregularities in FAO
- Data irregularities (e.g. unspecified trade) in FAO
- Import/export matching errors in FAO
- Re-exports - algorithms developed
- Concordances between FAO and GTAP
- Other physical datasets – Minerals and Fisheries



Stage 1

Environmental extensions added

Land area

- FAOStat contains yield data for each crop at national level that is multiplied by units of production.

Water use and scarcity

- Obtained from Water Footprint Network
- Green, blue and grey water use for each crop at national level that is multiplied by units of production
- Water scarcity available for major river basins; we transformed this into estimates of 'extreme' water scarcity at national level for comparison against blue water use outputs.

Environmental extension details continued...

Fertiliser application

- FAO Fertistat contains N,P, and K application data from some crops (and crop groups) and countries.
- Can be multiplied by area of production to obtain figures for consumption.
- Data is sparse and relatively old.

Biodiversity data

- IUCN Red List, Important Bird Area and WWF Global 200 regions are all associated with threats.
- KBAs and AZEs contain no threat data.
- Can be output at national level for comparison with other extensions.

Stage 2

Selection of Specific Commodities for Focus

2. SELECTION OF SPECIFIC COMMODITIES FOR FOCUS

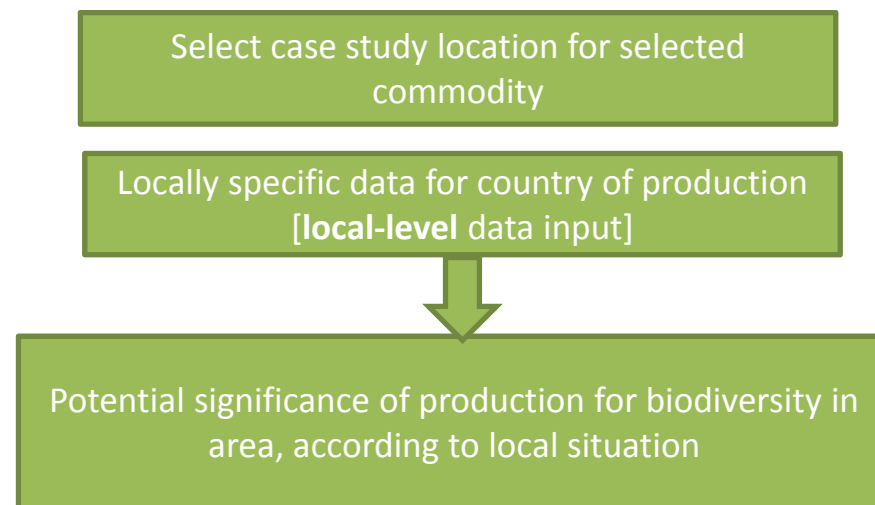
Use database to select and analyse commodity flows and impacts from production regions

- Steering group selected priority commodities for analysis and presentation in report:
 - bananas, bauxite, coffee, cocoa, cotton, hardwood (non-coniferous industrial roundwood), oil palm fruit (palm oil), rice, shrimp, soyabean, sugarcane and wheat

Stage 3

Selection of Commodity Location for In-Depth Case Study of Production System

3. CASE STUDY



- **Brazil** was selected as location for focus for soyabean case study and assessment of potential biodiversity impacts

Initial Results

- Model runs have been done for UK in detail and in summary for all of Europe (27 countries individually and aggregated) so far
- Limited time for detailed analysis
- Case studies completed for Soyabean in Brazil, Palm Oil in Indonesia and Malaysia. Some initial sugarcane case studies completed as well.

Database Summary Outputs Examples

Country where production occurs for UK demand

General country-level data

Model output Impacts (all due to UK demand)

Impacts linked to other environmental data

Impacts for UK Demand	Country name	Armenia	Afghanistan	Algeria	American Samoa	Andorra
FAO FAOSTAT	Total land area (ha)	2,848,000	65,220			47,000
FAO FAOSTAT	Total agricultural land area (ha)	1,751,900	37,000			19,400
FAO FAOSTAT	Total arable land area (ha)	452,100	7,794			2,300
FAO FAOSTAT	Total Soybeans production quantity (tonnes)	0	0	400	0	0
FAO FAOSTAT	Total area harvested for Soybeans production (ha)	0	0	200	0	0
MRIO Model output	Soybeans production quantity (tonnes)	0	0	3	0	0
MRIO Model output	Area harvested for Soybeans production (ha)	0	0			
MRIO Model output	Green water use for Soybeans production (m ³)	0	0	8,160	0	0
MRIO Model output	Blue water use for Soybeans production (m ³)	0	0	0	0	0
MRIO Model output	Grey water use for Soybeans production (m ³)	0	0	0	0	0
Water Footprint Network	Number of basins in country that face extreme water scarcity	0	1	0	1	0
Water Footprint Network	Mean number of months of severe scarcity for basins that face extreme scarcity		4		6	
Water Footprint Network	Total area of basins in country facing extreme water scarcity (km ²)		1233148.5		45249.3	
Water Footprint Network	Proportion of total water basin area in country facing extreme water scarcity		1		1	
FAO FertiStat	Rate of N Application (kg/ha)					
FAO FertiStat	Rate of P Application (kg/ha)					
FAO FertiStat	Rate of K Application (kg/ha)					
MRIO Model output/FAO FertiStat	Consumption of N (tonnes)					
MRIO Model output/FAO FertiStat	Consumption of P (tonnes)					
MRIO Model output/FAO FertiStat	Consumption of K (tonnes)					
IUCN Red List of Threatened Species	Total number of species (CR; EN)	9	10	5	2	3
BirdLife International Important Bird Areas (IBAs)	A1	3	1	0	4	0
BirdLife International Important Bird Areas (IBAs)	A2	0	0	0	0	0
BirdLife International Important Bird Areas (IBAs)	A3	0	0	0	0	0
IBAT Alliance	Key Biodiversity Areas	17	17	15	31	0
IBAT Alliance	Areas of Zero Extinction	1	1	0	0	0
WWF Ecoregions/Global 200	Number of threatened ecoregions (terrestrial)		1	2	2	1
WWF Ecoregions/Global 200	Mean status of threatened terrestrial ecoregions		1.5	1.36	1.36	1.5
WWF Ecoregions/Global 200	Number of threatened ecoregions (riverine and marine)			2	1	

What are production and land area requirements of different commodities for UK consumption?

	Production			Land Area		
	Production that takes place to satisfy UK demand for all goods and services (tonnes)*	Total world production; FAO, 2007 (tonnes)	Percentage of total world production required to satisfy UK demand	Land area required to satisfy UK demand for all goods and services (ha)*	Total land area harvested; FAO, 2007 (ha)	Percentage of world harvested land area required to satisfy UK demand
Bananas	871,778	89,191,386	0.98%	41,562	4,683,550	0.89%
Cotton	1,490,580	73,551,789	2.03%	732,444	33,410,494	2.19%
Wheat	15,641,990	612,611,392	2.55%	3,073,557	216,705,177	1.42%
Soyabean	3,410,798	219,676,859	1.55%	1,269,774	90,127,528	1.41%
Sugarcane	14,651,373	1,620,593,131	0.90%	251,938	22,809,305	1.10%
Rice	3,310,057	657,149,812	0.50%	694,355	155,137,979	0.45%
Oil palm fruit	1,701,053	193,126,508	0.88%	95,727	13,953,854	0.69%
Cocoa	134,382	3,883,052	3.46%	299,774	8,637,643	3.47%
Coffee	116,597	8,140,198	1.43%	159,659	10,626,475	1.50%

	Units	Total production that takes place to satisfy UK demand for all goods and services*	Total world production	Percentage of total world production required to satisfy UK demand
Industrial Roundwood (Non-coniferous)	m3	10,356,966	632,132,047	1.64%
Bauxite	tonnes	5,093,063	213,148,398	2.39%

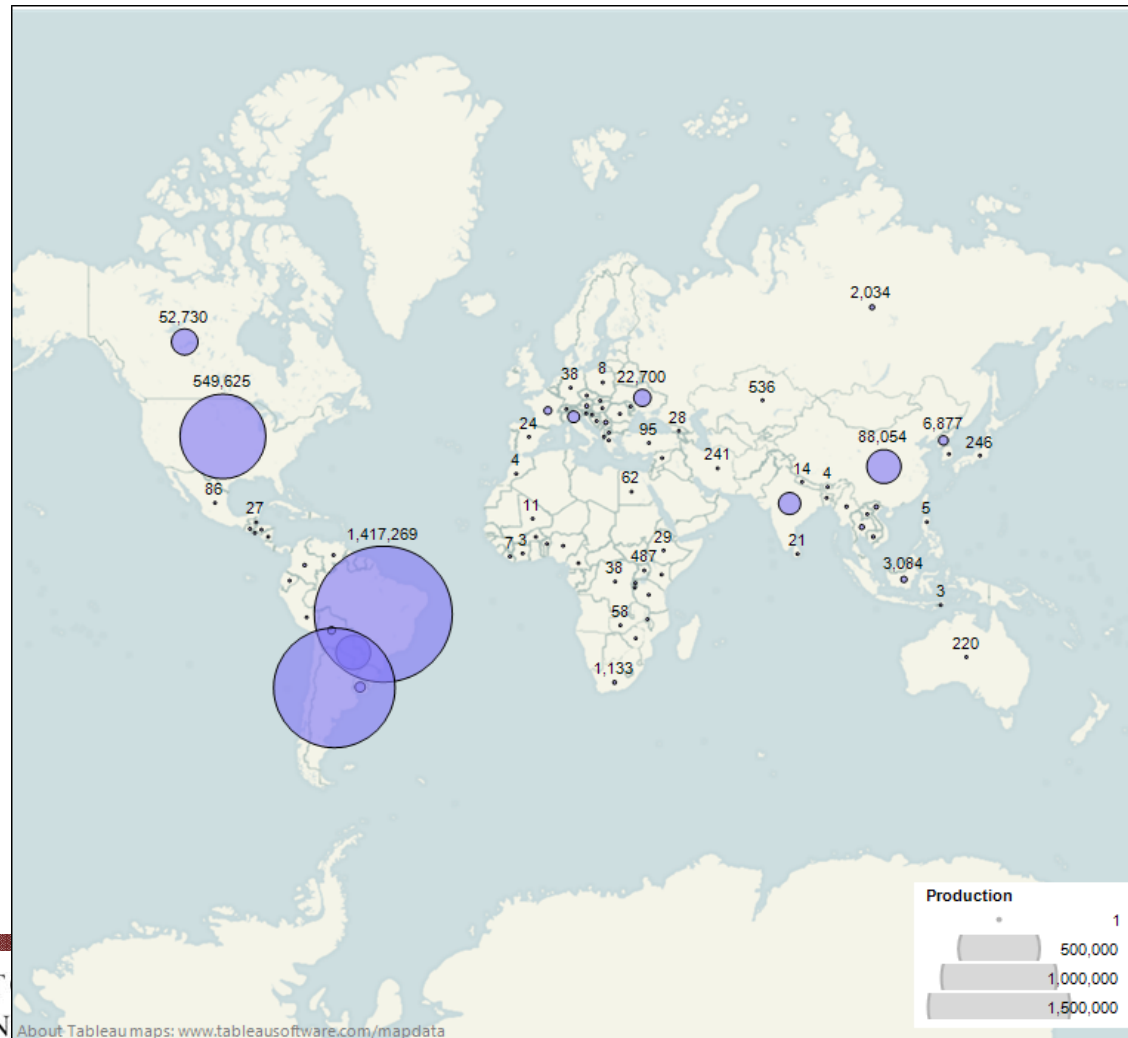
* = data calculated by our model

Stage 1 and 2 Standard trade data compared to modelled results of consumption-based impacts

FAO Product Description	Domestic Supply to UK (production + imports – exports) standard trade (tonnes)	Total production that takes place globally to satisfy UK demand for all goods and services, consumption approach (tonnes)	Commodity analysed in the MRIO model
Bananas	939,489	871,778	Bananas
Cocoa Beans	278,798	134,382	Cocoa beans
Coffee	160,819	116,597	Coffee, green
Sugar (Raw Equivalent)	2,076,272	14,651,373	Sugarcane (not incl. beet)
Soyabean Oil	366,379	3,410,798	Soyabean
Soyabeans	809,992		
Soyabean Cake	2,536,574		
Palm Oil	594,733	1,701,053	Oil palm fruit
Rice (Paddy Equivalent)	569,435	3,310,057	Rice, paddy
Cotton Lint	1,966	1,490,580	Seed cotton
Cottonseed Cake	124		
Cottonseed Oil	2,306		
Cottonseed	76		
Wheat	13,851,884	15,641,990	Wheat
Industrial Roundwood (non-coniferous)	197,568 (cubic meters)	10,356,966 (cubic meters)	Industrial Roundwood (non-coniferous)
Bauxite	44,465	5,093,063	Aluminium ores & concentrates

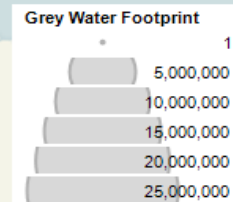


In which countries is the soyabean production for UK consumption of goods and services located?



What are the environmental impacts of the soyabean production for UK consumption?

Country name	Soyabean land area harvested to satisfy UK demand for all goods and services (ha), 2007	Rate of Nitrogen application, FertiStat (kg/ha)	Consumption of Nitrogen for soyabean for UK demand (tonnes)
USA	195,831	30	5,875
Brazil	503,767	8	4,030
China	60,574	60	3,634
Argentina	369,341	2	739
Canada	22,916	25	573
Paraguay	35,719	10	357
Viet Nam	1,056	45	48
Uruguay	3,555	10	36
Hungary	401	52	21
Thailand	1,293	12	16



Stage 3: Case Study Results

- Full case study provided in final report, some highlights:
 - 75% of soyabean grown in cerrado region of Brazil
 - Cerrado is large savannah-forest in northern Brazil and biodiversity hotspot (Conservation International)
 - Agriculture is main threat
 - Two-thirds of the cerrado has already been converted to agriculture (Galford, 2010)
 - Increasingly mechanised and concentrated production, larger plantations in North
 - Deforestation has slowed recently; concern that it may increase again
 - Other threats: soil erosion, chemical pollution, crop modification
 - Other issues: national policies, social and economic benefits

Limitations and Assumptions

- Data quality
 - Time lag
 - Aggregations
- Modelling assumptions
 - Sectoral imports assumptions
 - Physical trade assumptions
- Data availability
 - Limited trade data for some commodities (fish/minerals)
 - Limited data for some environmental extensions
- Interpretation
 - Very disaggregated, not aggregated into single footprint measure. Gives more detail but harder to assess.

Discussions, Limitations and Recommendations

- Framework helps to identify some possible local impacts of goods finally consumed in the UK
- Assesses a variety of different commodities in a consistent, comparable and repeatable manner
- Supply chain analysis demonstrates importance of considering all goods and services (e.g. soyabean embedded in wearing apparel example)
- Retention of country of production allows local-level assessment, important when local situation varies (e.g. water)

Next Steps

- Further analysis of results – just database developed so far
- They would like to discuss an indicator...
- We have made a start on an application of structural path analysis method for EU analysis, early stages
- Use and testing of alternative datasets
- Downscale physical table to regions within Brazil using local-level production, trade and environmental data

Thank you!

References

- Ewing, B.R., Hawkins, T.R., Wiedmann, T.O., Galli, A., Ertug Ercin, A., Weinzettel, J. & Steen-Olsen, K. (2012) Integrating ecological and water footprint accounting in a multi-regional input-output framework. *Ecological Indicators*, 23, 1-8.
- Peters, G.P., Andrew, R., & Lennox, J. (2011) Constructing an environmentally-extended multi-regional input-output table using the GTAP database. *Economic Systems Research*, 23, 131-152.

The model database and scripts

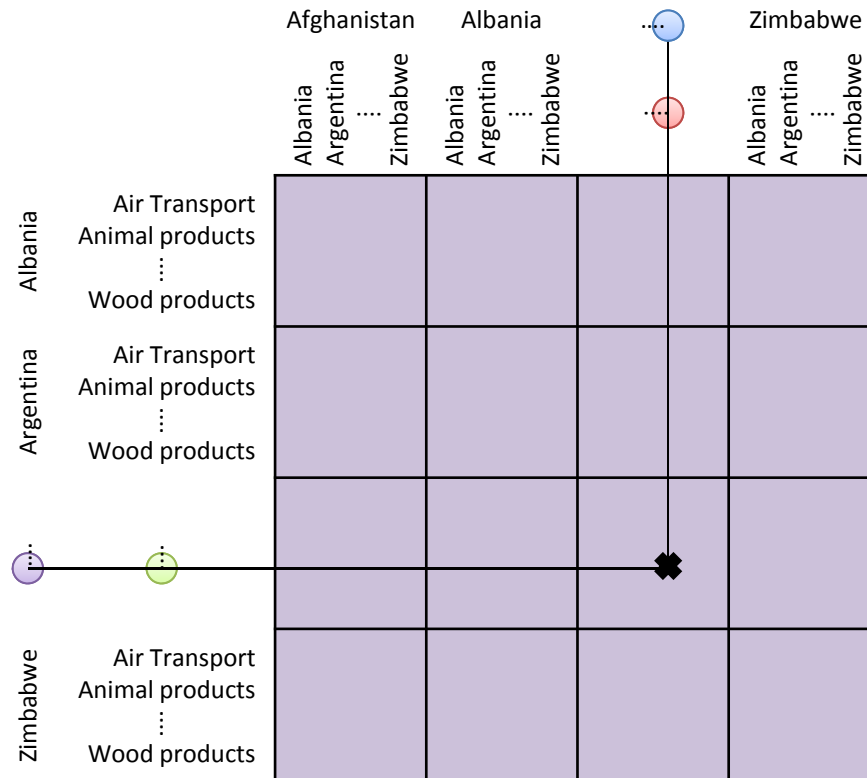
Inputs are:

- Production and trade tables (with calculated re-exports) - physical
- Financial input-output tables - financial
- Environmental extensions tables

Outputs are:

- Raw impact data for specified product and demand region of choice
- Processed data with by country, by sector (in country of final shipping) and by sector (country of product origin) orderings
- Processed impact data with hard- and soft-linked biodiversity threats and risks

		Afghanistan			Albania			...	Zimbabwe				
		Albania	Argentina	...	Zimbabwe	Albania	Argentina	...	Zimbabwe	Albania	Argentina	...	Zimbabwe
Albania	Air Transport												
	Animal products												
	...												
	Wood products												
Argentina	Air Transport												
	Animal products												
	...												
	Wood products												
...	...												
Zimbabwe	Air Transport												
	Animal products												
	...												
	Wood products												



Impact in **Country** due to demand from **Region** for products from **Sector** in **Region**

129 GTAP regions

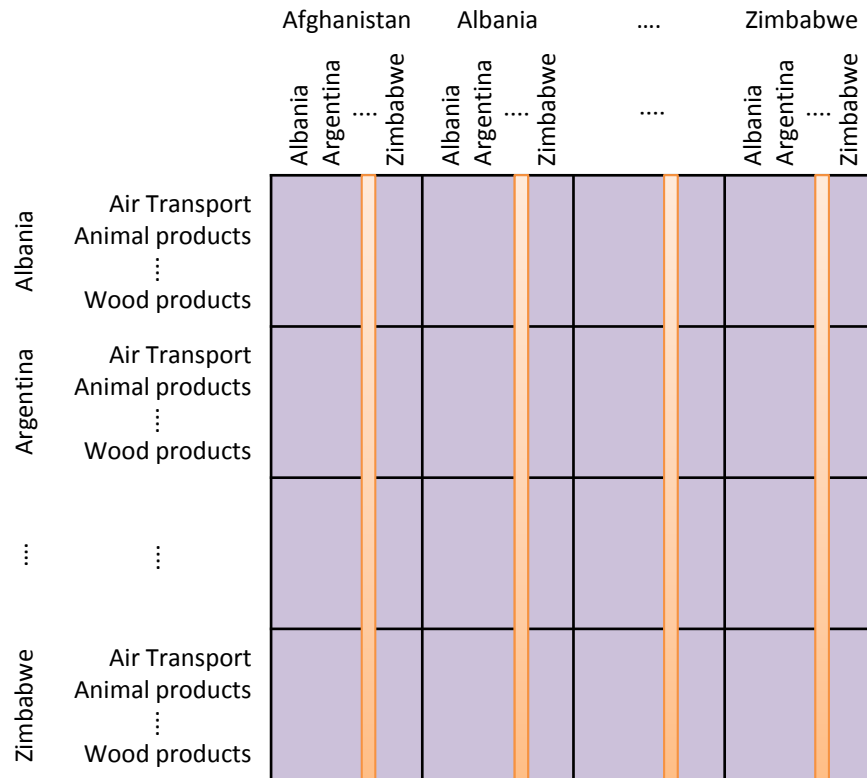
The diagram illustrates a data matrix for the GTAP model. It features a grid of cells representing the interaction between 129 GTAP regions (rows) and 236 FAO countries (columns). The regions are grouped into 57 GTAP sectors, which are further divided into three categories: Air Transport, Animal products, and Wood products. The countries are grouped into three categories: Afghanistan, Albania, and Zimbabwe. The matrix is color-coded: the top row is blue, the first column is red, and the bottom row is green. The cells are purple.

	Afghanistan	Albania	...	Zimbabwe
Albania				
Argentina				
...				
Zimbabwe				
Air Transport				
Animal products				
...				
Wood products				

236 FAO countries

57 GTAP sectors

→ 223854732 cells



Impacts associated with UK demand

		Afghanistan	Albania	Zimbabwe
Albania	Air Transport				
	Animal products				
	...				
	Wood products				
Argentina	Air Transport				
	Animal products				
	...				
	Wood products				
...	...				
Zimbabwe	Air Transport				
	Animal products				
	...				
	Wood products				



Production/impact in **Country** due to UK demand for products from **Sector** in **Region**

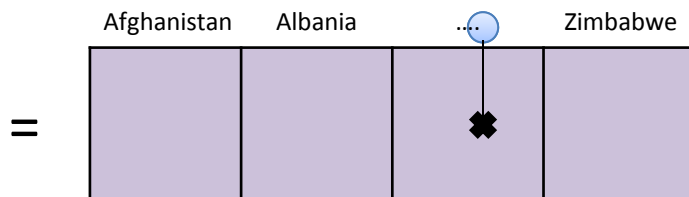
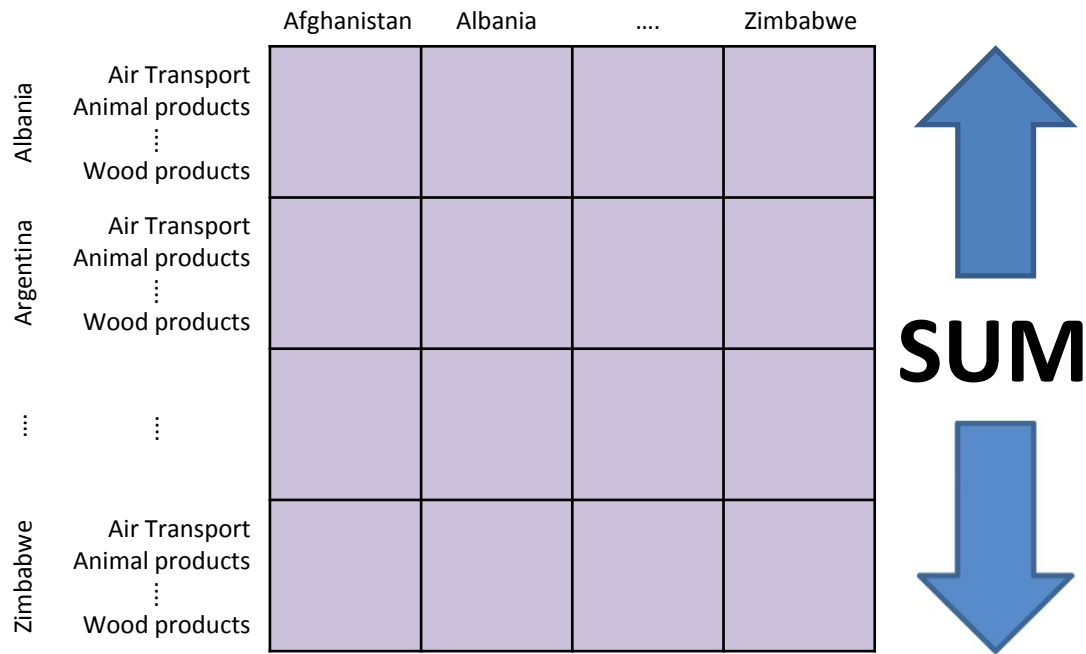
129 GTAP regions



236 FAO countries

57 GTAP sectors

→ 1735308 cells



Production/impact in **Country** due to UK demand

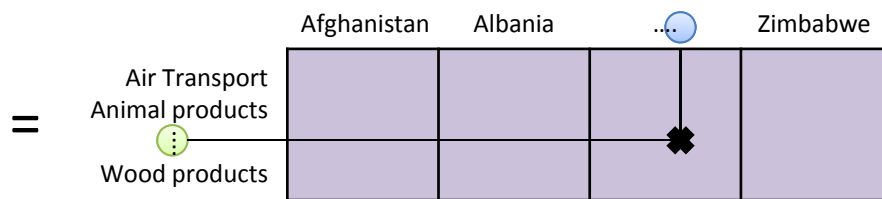
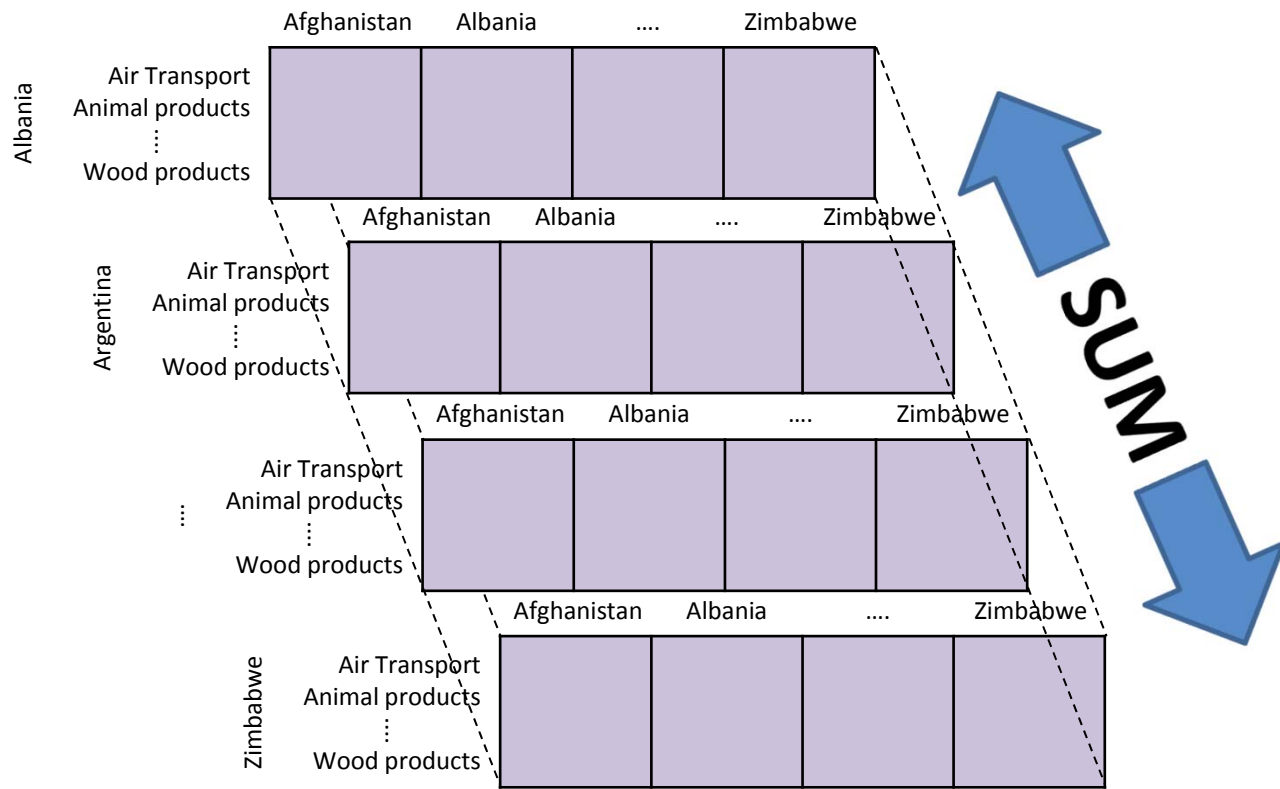
		Afghanistan	Albania	Zimbabwe
Albania	Air Transport				
	Animal products				
	Wood products				
Argentina	Air Transport				
	Animal products				
	Wood products				
...	...				
Zimbabwe	Air Transport				
	Animal products				
	Wood products				

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Albania	Air Transport	
	Animal products	
	Wood products	
Argentina	Air Transport	
	Animal products	
	Wood products	
...	...	
Zimbabwe	Air Transport	
	Animal products	
	Wood products	



Production/impact globally due to
UK demand for Sector in Region



Production/impact in **Country** due to UK demand for **Sector**