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Pimkie Environmental Profit & Loss account

Scope: supply chain, use and end of life

Strictly Private and Confidential

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Agenda

Context & purposes

Goal and scope of the study

The **goal of the study** is to measure the environmental impacts of the Pimkie supply chains, and to identify hot spots, assessing the relative contribution to global results of the different life cycle stages, types of textile, supplier locations and brands.

To do so, we use the existing framework of **organizational life cycle assessment (organizational LCA)**, as standardized in ISO 14072:2014, complementing the result interpretation phase by an EP&L valuation.

How it works

Organizational LCA follows the same approach as (standard) product LCA, with the successive steps of:

- methodology definition (scope of companies/products, identification of supply chains, environmental impact indicators),
- data collection,
- life cycle inventory,
- and life cycle impact assessment (LCIA).

The **functional unit** of the study is "Delivering Pimkie products during 1 year", for instance 2018.

The **data collection** phase aims at gathering the following information from the Pimkie brand:

- Quantity of textile products sold (number of articles), typical composition (textile types) and weight per article.
- Quantity of packaging required (for intermediary transport as well as final stage).
- Location (country) of main producers and logistics (e.g. road, sea freight, train, plane) associated to product supply chains.

All information regarding production processes and transport emission factors are supplied by PwC based on LCA databases.

Methodology

The French brand Pimkie

Pimkie metrics

- The global turnover of Pimkie for FY2018 was equal to **€587 millions** (source: Pimkie).
- **41 607 000 products** produced by Pimkie's suppliers, representing a mass of **12 116 tons**.
- Pimkie's clothes are sold in **29 countries** (**France represents 53% of revenues,** while France-Germany-Italy-Spain represent 88.5%) through a network of 700 stores.

Perimeter of the study

Timeframe considered: 1 year – 2018.

Activities considered: 7 tiers considered, from raw material production to end of life of products.

Countries considered: all fabrication countries, all selling countries and major countries producing cotton and wool.

Products considered: see opposite.

Resources considered: 27 textile components considered, 4 means of transportation from assembly plants to shops as well as use of electricity & water by consumers to regularly clean clothes, and 3 end of life scenarios.

12,000 excel rows sent by Pimkie has been treated and all products ordered by Pimkie have been taken into account.

Number of clothes produced for Pimkie

9,759,000	*T-shirts*	23.46%
4,537,000	*Sweaters*	10.91%
4,453,000	*Blouses*	10.70%
4,293,000	*Trousers*	10.31%
3,589,000	*Pair of jeans*	8.63%
3,089,000	*Dresses*	7.43%
1,919,000	*Jackets*	4.61%
1,523,000	*Skirts*	3.66%
1,457,000	*Coats*	3.50%
1,015,000	*Footwear*	2.44%
1,007,000	*Bags*	2.42%
925,000	*Swimsuit*	2.22%
910,000	*Belts*	2.19%
706,000	Accessories	1.70%
668,000	*Warm scarfs*	1.61%
443,000	*Socks*	1.06%
381,000	*Jewellery*	0.92%
366,000	*Hats*	0.88%
201,000	*Gloves*	0.48%
184,000	*Scarfs*	0.44%
182,000	*Pair of glasses*	0.44%
41,607,000		

Source: Pimkie, PwC analysis

We applied a 7-step methodology to calculate EP&L results from the data you transmitted us

1 Scope & boundary

Which impacts

Which parts of the business

Which parts of the value chain

2 Map the value chain

Understand all activities and processes

From natural resource to finished product, use and disposal

3 Impact assessment

Determine the impacts associated with each part of the value chain

Identify how impacts arise and what data is required to measure them

4 Collect data

Source data from within the business: spent data as well as location of supplier plants (tiers 1 and 2)

Analyse date to obtain weight and composition of articles sold

5 Fill any data gaps

Where actual data is not available use LCA models already available with PwC France

6 Value changes

Value the changes in welfare to society and the economy as a result of business activities

7 Calculate EP&L results

By combining data from Pimkie (see next page), LCA models, EP&L coefficients, generate, analyse and interpret EP&L results

Analyse drivers of impacts

The Organizational LCA impact data of Pimkie supply chain is monetized using PwC UK's valuation coefficients

The environmental outcome data from the organizational lifecycle assessment (OLCA) for one year of production from Pimkie brand is valued across:
GHGs, air pollution, waste, land use, water pollution and water consumption.

Environmental

- GHG emissions
- Air pollution
- Land use
- Waste
- Water consumption
- Water pollution

Valued results are then generated in euros by sub-environmental indicator. These results are used as intensity multipliers for Pimkie brands to calculate their total product impact, according to the number of products they produce over a specified period of time.

Methodology to obtain valuation coefficient is explained in appendix.

Organizational LCA data for one year of Pimkie production
i.e. environmental outcomes per unit of value chain stage

×

Valuation coefficient data
i.e. social cost per unit of environmental outcome

=

Monetized environmental impact
i.e. value to society/social cost of environmental outcome

Valuation methods

Impact drivers and impact on people

	GHGs	*Air pollution*	*Water consumption*	*Water pollution*	*Solid waste*	*Land use*
DRIVERS	o **GHGs** *CO_2* *CH_4* *N_2O* *HFCs* *PFCs* *SF_6*	o **Air pollutants** *SO_2* *PM2.5* *PM10* *NH_3* *NOx* *VOCs*	o **Water consumed**	o **Discharge to water** Inorganic Organic Nutrients	o **Solid waste disposal (hazardous & non hazardous)** *Incineration* *Landfill* *Recycling*	o **Land use** *Occupation of converted land* *New conversions of natural ecosystems*
PEOPLE	• Human health • Built environment • Economic disruption • Agriculture and timber • Desertification • Other ecosystem services	• Human health impact • Visibility impacts • Impact on agriculture of air pollutants.	• Malnutrition • Water borne diseases • Depletion of groundwater resources • Subsidy cost of water • Economic opportunity cost • Various, based on specific valuation • methodology	• Human health • Recreation • Property values • Fishstocks • Other ecosystem services	• Human Health • Disamenity • Agriculture • Emission to air • GHGs • Land use • Other ecosystem services	• Economic impacts • Health impacts • Cultural impacts

<u>See more about Valuation methods:</u> Appendix from PwC UK

Perimeter of the study (1/3)

Activities considered

Tier 4 — *Raw materials production*

Synthetic-based

- Extraction
- Chemical production
- Processing
- Transportation

Plant-based, animal-based

- Crop farming (plants)
- Direct operations
- Offsite feed production (wool)
- Fertilisers
- Processing
- Transportation

Tier 3 — *Yarns spinning*

- Processing

Tier 2 — *Fabrics production*

- Weaving
- Dyeing
- Printing
- Waste treatment
- Chemical production

Tier 1 — *Products assembly*

- Assembly

Tier 0 — *Direct operations*

- Products transportation
- Stores

USE — *Products usage**

- Washing
- Drying

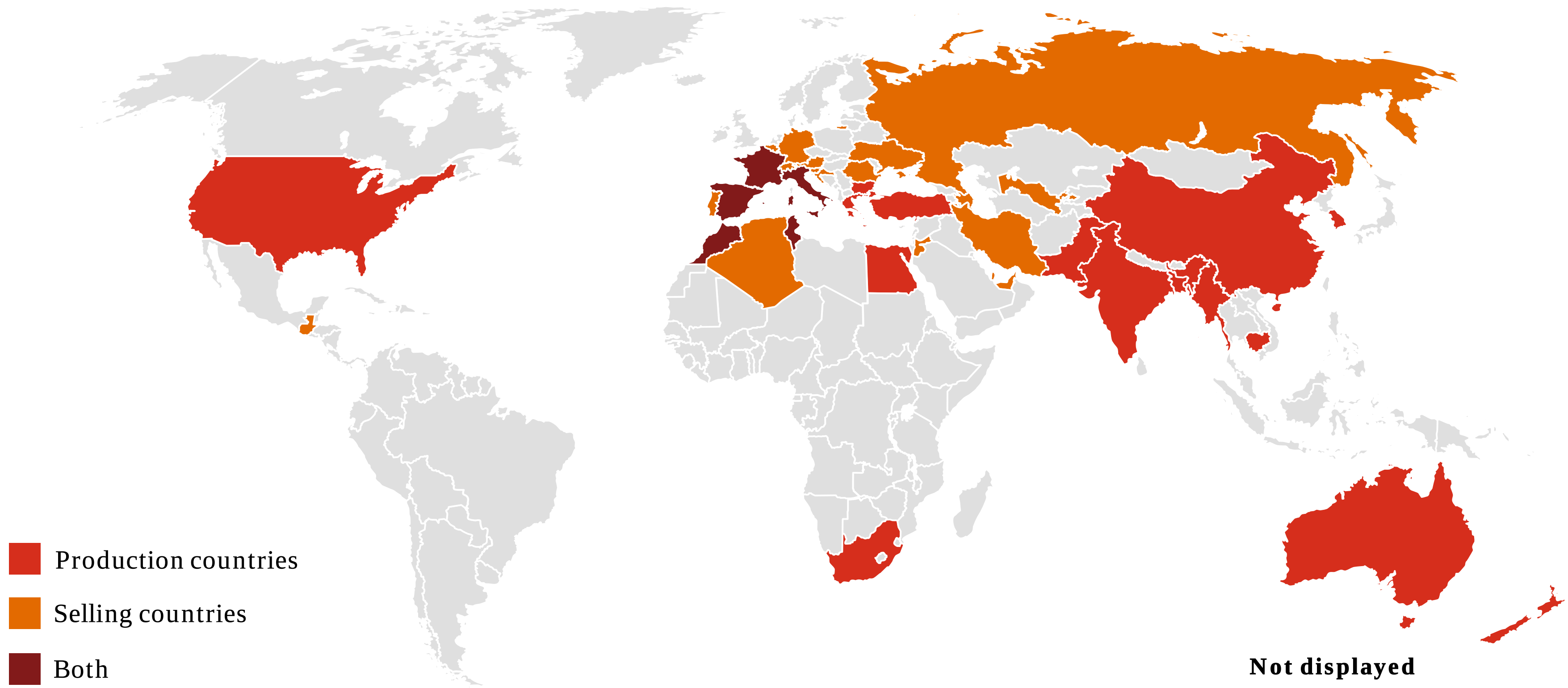
EoL — *Products end of life*

- Re-use**
- Recycling**
- Landfilling
- Incineration

*: ironing and dry cleaning not included
**: re-use and recycling outside of the perimeter (new life cycle)

Perimeter of the study (2/3)

Countries considered



Not displayed

Luxembourg
Bahrain
Malta
Kosovo
Mauritius
Andorra

France includes Overseas France

Perimeter of the study (3/3)

Resources considered

Raw materials production (Tier 4)	Yarns spinning (Tier 3)	Fabrics production (Tier 2)	Products assembly (Tier 1)	Direct operations (Tier 0)	Products usage (USE)	Products end of life (EoL)
Cotton*	Polyester	**Synthetics**	Electricity*	Electricity*	Electricity*	Synthetics
Polyamide	Viscose	**Vegetal fibres**	Water	Energy	Water	– Landfilling
Wool*	Elastane	**Animal fibres**		– Cargo ship		– Incineration
Acrylic	Modacrylic			– Cargo aircraft		Vegetal fibres
Acetate	Lyocell			– Truck*		– Landfilling
Modal	Linen			– Train*		– Incineration
Feather	Down					Animal fibres
Polyurethane	Polypropylene					– Landfilling
Elastodiene	Elastomultiester					– Incineration
Mohair	Metallic fibre					
Synthetic	Textile					
Jute	Iron					
Copper	Plastic					
	Paper					

*: assessment of environmental impacts is country-dependent

Hypotheses

Rounded figures are presented but exact numbers are used for calculation

Tier 0 – direct operations

Categories of products and multi-elements (1/2)

The percentage of elements are based on the information on Orsay products as information for Pimkie was not available for products with multi-elements.

Category	Element	%
Accessories	Main fabric	85
Accessories	Filling Shell Lining Reverse	15
Swimsuit	Main fabric	80
Swimsuit	Lining	20
Belt	Main fabric	50
Belt	Lining	50
Footwear	Shoe-upper	15
Footwear	Lining & internal sole	70
Footwear	External sole	15

Category	Element	%
Footwear	Main fabric	50
Footwear	Lining & internal sole	35
Footwear	External sole	15
Footwear	Handle	15
Footwear	Lining & internal sole	70
Footwear	External sole	15
Blouses	Main fabric	90
Blouses	Yoke Filling Lining	10
Hats	Main fabric	80
Hats	Filling	20
Scarfs	Main fabric	90
Scarfs	Reverse	10

Category	Element	%
Gloves	Main fabric	50
Gloves	Back	25
Gloves	Lining	25
Gloves	Lining	25
Gloves	Right side	50
Gloves	Reverse	25
Gloves	Main fabric	75
Gloves	Lining	25
Skirts	Main fabric	85
Skirts	Filling Lining Yoke Dos	15

Source: Pimkie, PwC analysis

Tier 0 – direct operations

Categories of products and multi-elements (2/2)

The percentage of elements are based on the information on Orsay products as information for Pimkie was not available for products with multi-elements.

Category	Element	%
Coats	Main fabric	75
Coats	Lining	20
Coats	Fur	5
Coats	Main fabric	65
Coats	Lining	20
Coats	Lining sleeve Filling	10
Coats	Fur	5
Coats	Main fabric	70
Coats	Lining	20
Coats	Filling	10
Coats	Main fabric	55
Coats	Lining	20
Coats	Fur	5
Coats	Filling 2	10
Coats	Filling	10

Category	Element	%
Coats	Main fabric	80
Coats	Lining	20
Sweaters	Main fabric	80
Sweaters	Collar Yoke	20
Sweaters	Main fabric	85
Sweaters	Yoke Lining	15
Bags	Main fabric	90
Bags	Lining Edge cotes Filling	10
Dresses	Main fabric	75
Dresses	Lining Back Yoke	25

Category	Element	%
T-Shirt	Main fabric	90
T-Shirt	Sleeves Back Yoke	10
T-Shirt	Main fabric	80
T-Shirt	Filling	10
T-Shirt	Lining	10
Jackets	Main fabric	85
Jackets	Lining	15

Source: Pimkie, PwC analysis

Tier 0 – direct operations

Direct operations: transportation modes – cargo shipping from China to Europe is the predominant transport mode

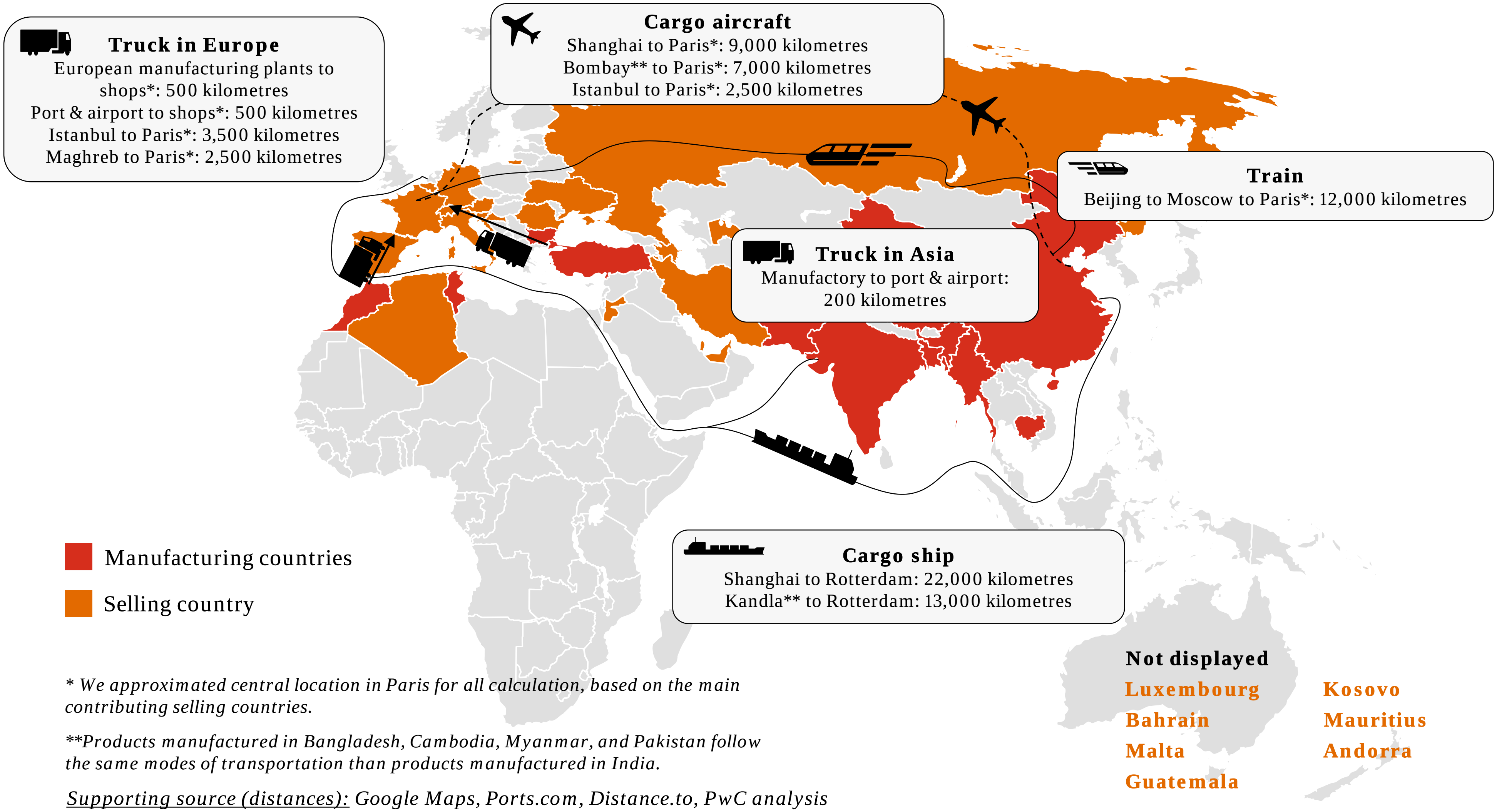
Transportation mode of Pimkie products between manufacturing sites (tier 1) and stores (tier 0) by manufacturing countries

Mass (kg)	Product (kg)	Cargo ship	Cargo aircraft	Train	Truck
China	**6,131,000**	4,807,000	1,311,000	9,000	4,000
Bangladesh	**1,500,000**	1,164,000	336,000	-	-
Cambodia	**1,310,000**	1,085,000	225,000	-	-
Tunisia	**897,000**	-	-	-	897,000
India	**876,000**	561,000	315,000	-	-
Turkey	**780,000**	-	15,000	-	765,000
Morocco	**388,000**	-	-	-	388,000
Myanmar	**196,000**	181,000	15,000	-	-
Pakistan	**24,000**	22,000	2,000	-	-
Italy	**6,000**	-	-	-	6,000
France	**5,000**	-	-	-	5,000
Bulgaria	**3,000**	-	-	-	3,000
Total	**12,116,000**	64.6%	18.3%	0.1%	17.1%

Source: Pimkie, PwC analysis
Breakdown of mass of products per transportation mode based on breakdown per number of products

Tier 0 – direct operations

Direct operations: transport to shops (road, sea, rail, air freight)



** We approximated central location in Paris for all calculation, based on the main contributing selling countries.*

***Products manufactured in Bangladesh, Cambodia, Myanmar, and Pakistan follow the same modes of transportation than products manufactured in India.*

<u>Supporting source (distances):</u> Google Maps, Ports.com, Distance.to, PwC analysis

Tier 0 – direct operations

Direct operations: shops and road transport

Electricity consumption of shops

Pimkie provided information for 265 shops in France.

Extrapolation to the entire network of 700 shops is based on the number of shops.

Electricity consumption (265 shops) = Ec (265) = 14,796 MWh

Electricity consumption (700 shops) = Ec (265)/ 265 * 700

= **39,084 MWh**

Data source: *Pimkie*

Electricity consumption repartition

Electricity consumption is spread over all countries where Pimkie is implemented following sales. Thus, the repartition applied to the 39,084 MWh consumed is the following:

Country	France	Germany	Italy	Spain	Morocco	Tunisia	Russia	Europe	World
%	53.3%	12.4%	11.9%	10.8%	0.6%	0.1%	0.1%	9.7%	1.1%

Fuel consumption of trucks

Fuel consumption of trucks:

$$Consumption\ (L) = km \times 38/100 \times (2/3 + 1/3 \times actual\ load\ /\ payload + empty\ return\ rate \times 2/3)$$

Actual load : 24 tons

Payload : 24 tons

Empty return rate: 50%

Supporting data: *AFNOR's fascicule for NF 01 – 010, PwC default datasets*

Products manufactured in Bangladesh, Cambodia, Myanmar and Pakistan

Results assume the same modes of transportation for products manufactured in Bangladesh, Cambodia, Myanmar and Pakistan than India.

Loss rate

No loss rate was considered for Tier 0.

Tier 1 – products assembly

Product assembly is mostly performed in China

Manufacturing countries of Pimkie products

	Mass of products (kg)	%	Cumul %
China	6,131,000	50.6%	50.6%
Bangladesh	1,500,000	12.4%	63.0%
Cambodia	1,310,000	10.8%	73.8%
Tunisia	897,000	7.4%	81.2%
India	876,000	7.2%	88.4%
Turkey	780,000	6.4%	94.9%
Morocco	388,000	3.2%	98.1%
Myanmar	196,000	1.6%	99.7%
Pakistan	24,000	0.2%	99.9%
Italy	6,000	<0.01%	99.9%
France	5,000	<0.01%	99.9%
Bulgaria	3,000	<0.01%	100.0%
Total	**12,116,000**		

Source: Pimkie, PwC analysis

Tier 1 – products assembly

Product assembly – additional assumptions

Electricity and water consumption

Tier 1 (product assembly) is usually considered as having less environmental impacts than other stages of the supply chain.

- Tier 1 electricity consumption represents 14% of Tier 2 electricity consumption.
- Tier 1 water consumption represents 20% of Tier 2 water consumption.
- Breakdown of consumptions per country based on the country breakdown per mass of products (see previous slide).

Supporting source: Quantis & Climate Works Foundation (2018). *Measuring Fashion: Insights from the Environmental Impact of the Global Apparel and Footwear Industries study*. p. 4

Products manufactured in Bangladesh

Results assume that electricity and water used to manufacture products in Bangladesh have the same impact than electricity and water used in Thailand.

Electricity assimilation is based on similarity between energetic mix of Bangladesh with Thailand (Coal, oil, gas, nuclear).

Source: IEA

Loss rate

Results assume a loss rate of 18.4% during the fabrication processes of Tier 1 (min = 10%, max = 22%).

Supporting source: Ademe (2016). *Principes généraux pour l'affichage environnemental des produits de grande consommation*. p. 28

Tier 2 & 3 – fabrics production & yarn spinning

Fabrics production and yarn spinning are mostly performed in China

Spinning-Weaving-Dying countries of Pimkie clothes by type of fibre

Spinning-Weaving-Dying countries	Synthetic (kg)	%	Animal fibres (kg)	%	Plant fibres (kg)	%
China	**5,212,000**	**78.7%**	**94,000**	**79.1%**	**2,381,000**	**44.3%**
Turkey	701,000	10.6%	17,000	14.6%	790,000	14.7%
Bangladesh	411,000	6.2%	-	0.0%	886,000	16.5%
Morocco	130,000	2.0%	1,000	1.2%	744,000	13.9%
Pakistan	5,000	0.1%	-	0.0%	222,000	4.1%
Spain	4,000	0.1%	-	0.0%	190,000	3.5%
Cambodia	116,000	1.8%	6,000	5.1%	51,000	1.0%
India	4,000	0.1%	-	0.0%	67,000	1.3%
Egypt	25,000	0.4%	-	0.0%	-	0.0%
Tunisia	1,000	<0.1%	-	0.0%	14,000	0.3%
France	1,000	<0.1%	-	0.0%	9,000	0.2%
South Korea	1,000	<0.1%	-	0.0%	9,000	0.2%
Myanmar	7,000	0.1%	-	0.0%	1,000	<0.1%
Italy	2,000	<0.1%	-	0.0%	5,000	0.1%
Hong Kong	6,000	0.1%	-	0.0%	-	0.0%
Bulgaria	-	0.0%	-	0.0%	3,000	0.1%
	6,626,000		**118,000**		**5,372,000**	

Source: Pimkie, PwC analysis

Tier 2 & 3 – fabrics production & yarn spinning

Fabrics production and yarn spinning– additional assumptions

Computation of Tier 2 & 3 impacts

Results assume the following computation of Tier 2 & 3 impacts :

For Synthetics and Plant fibres

Spinning-Weaving-Dying countries	Accounting for	Computed as
South Korea & Hong Kong	0.1% - 0.2%	**China**
Bangladesh, Cambodia, Myanmar & Pakistan	8% - 22%	**India**
Bulgaria, Egypt, Spain, France, Italy, Morocco, Tunisia	2.5% - 18%	**Turkey**

For Animal fibres

All countries (India, Cambodia and China) are computed as China (where 79% of animal fibres are woven).

Yarn spinning consumption of electricity

Results assume an electricity consumption of 5.4 MJ for each kilogram of synthetic fibre and 10 MJ for each kilogram of vegetal or animal fibre spun.

Supporting source: generic data from PwC previous project, 2013

Loss rate

Results assume a loss rate of 6.25% during the fabrication processes of Tier 2.

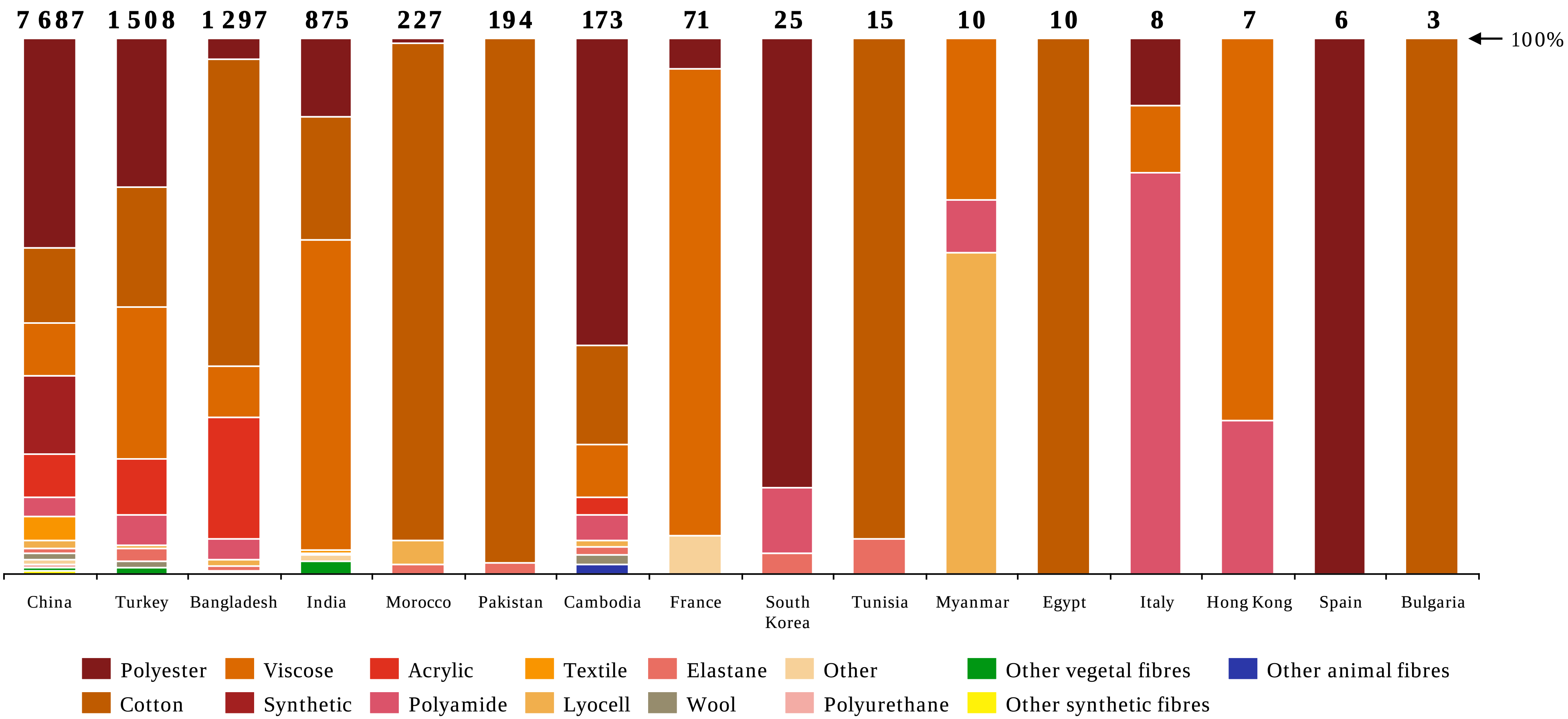
Results assume a loss rate of 2.33% for synthetic fibres and 8% for vegetal and animal fibres during the spinning processes of Tier 3.

Supporting source: Ademe (2018). *Base Impacts Data Documentation. Sector: Textile*. p. 12-30

Tier 4 – raw materials production

Quantities of raw materials (1/3)

Pimkie products are mostly woven in China (mass in ton)



Source: Pimkie, PwC analysis

*: synthetic, textile, iron, copper, plastic, other

Tier 4 – raw materials production

Quantities of raw materials (2/3)

Mass (Ton)	China	Turkey	Bangladesh	India	Morocco	Pakistan	Cambodia	France	South Korea	Tunisia	Myanmar	Egypt	Italy	Hong Kong	Spain	Bulgaria
Polyester	3,011	419	52	127	2	-	99	4	21	-	-	<1	1	-	6	-
Cotton	1,065	335	742	201	211	190	32	-	-	14	-	10	-	-	-	3
Viscose	762	428	123	507	-	-	17	62	-	-	3	-	1	5	-	-
Synthetic	1,124	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acrylic	614	159	293	<1	-	-	6	<1	-	-	-	-	-	-	-	-
Polyamide	286	88	54	1	-	-	8	<1	3	-	1	-	6	2	<1	-
Textile	344	-	-	5	-	-	-	-	-	-	-	-	-	-	-	-
Lyocell	106	9	15	-	10	-	2	-	-	-	6	-	-	-	-	-
Elastane	81	34	9	2	4	4	3	<1	1	1	-	<1	<1	<1	<1	-
Wool	87	17	-	1	-	-	3	-	-	-	-	-	-	-	-	-
Other	58	<1	-	9	-	-	-	5	-	-	-	-	<1	-	-	-
Polyurethane	55	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Modal	7	17	6	15	-	-	-	-	-	-	-	-	-	-	-	-
Linen	37	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Metallic Fibre	14	1	3	<1	-	-	-	<1	<1	-	-	-	<1	-	<1	-
Modacrylic	13	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Mohair	5	1	-	-	-	-	3	-	-	-	-	-	-	-	-	-
Plastic	9	-	-	<1	-	-	-	-	-	-	-	-	-	-	-	-
Jute	<1	-	-	7	-	-	-	-	-	-	-	-	-	-	-	-
Iron	4	-	-	<1	-	-	-	-	-	-	-	-	-	-	-	-
Polypropylene	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Feather	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Elastomultiester	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Copper	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acetate	<1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Down	<1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Elastodiene	<1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Source: Pimkie, PwC analysis

Tier 4 – raw materials production

Quantities of raw materials (3/3)

Mass (ton)	Total	%	Cumul %
Polyester	3,742	30.9%	30.9%
Cotton	2,803	23.1%	54.0%
Viscose	1,908	15.7%	69.8%
Synthetic	1,124	9.3%	79.0%
Acrylic	1,072	8.8%	87.9%
Polyamide	449	3.7%	91.6%
Textile	349	2.9%	94.5%
Lyocell	148	1.2%	95.7%
Elastane	139	1.1%	96.8%
Wool	108	0.9%	97.7%
Other	72	0.6%	98.3%
Polyurethane	55	0.5%	98.8%
Modal	45	0.4%	99.2%
Linen	37	0.3%	99.5%
Metallic Fibre	18	0.1%	99.6%
Modacrylic	13	0.1%	99.7%
Mohair	9	0.1%	99.8%
Plastic	9	0.1%	99.9%
Jute	7	0.1%	100%
Iron	4	<0.01%	100%
Polypropylene	2	<0.01%	100%
Feather	1	<0.01%	100%
Elastomultiester	1	<0.01%	100%
Copper	1	<0.01%	100%
Acetate	<1	<0.01%	100%
Duvet	<1	<0.01%	100%
Elastodiene	<1	<0.01%	100%
Total	**12,116**		

Two key textiles representing almost 55% of raw materials

Source: Pimkie, PwC analysis

Tier 4 – raw materials production

Raw material production - assumptions

Raw material assimilation

Results assume that the following raw materials have similar production process in term of impacts:

Pimkie components	%	Considered as
Modacrylic	100%	**Acrylic**
Lyocell & Modal	100%	**Viscose**
Down	100%	**Feather**
Metallic fibre	98% 2%	**Polyethylene** **Aluminium**
Synthetic	50% 50%	**Polyurethane** **Polyvinylchloride**
Elastodiene & Elastomultiester	100%	**Elastane**
Textile	100%	**Cotton**
Jute	50% 50%	**Hemp** **Linen**
Plastic	50% 50%	**Polyethylene** **Polyvinylchloride**
Other	98% 2%	**Paper** **Copper**
Polyamide	100%	**Nylon 6 (PA6)**

Raw material sources – excluding cotton & wool

Results assume that raw materials – excluding cotton & wool – sources used to manufacture Pimkie products come from China.

Supporting data: *63.5% of fabrics used by Pimkie are manufactured in China*

Supporting source:
- International Fiber Journal (2008). *China's Chemical Fiber Producers*. p.6
- Trademap.org

This source highlights that China is the polyester producer world leader by representing 66% of the world production with 20 000 t. Moreover, on trademap.org, it is stated that China imported only 350 t in 2018.

Polyester is the first fibre used by Pimkie (31%).

Cardboard use &weight

Results assume that Pimkie use 1,000,000 cardboards 60 x 40 x 35 packaging.

Source: *Pimkie*

Results assume that cardboard 60 x 40 x 35 packaging weights 700 grams.

Supporting source: *Internet benchmark*

Tier 4 – raw materials production

Raw material production – cotton assumptions

Raw material sources – cotton

Results assume the following sources of cotton depending on the weaving countries:

	Sources of cotton used								
Pimkie's weaving countries	**Chinese cotton**	**Egyptian cotton**	**Greek cotton**	**Indian cotton**	**Italian cotton**	**US cotton**	**Pakistani cotton**	**Turkish cotton**	**Pimkie quantity (ton)**
China	85%			5%		10%			1,065
Bangladesh	5%			60%		10%	20%	5%	742
Turkey						30%	20%	50%	335
Morocco								100%	211
India				90%		10%			201
Pakistan				15%			85%		190
Cambodia				100%					32
Tunisia			100%						14
Egypt		70%	20%			10%			10
Bulgaria			70%					30%	3

Supporting source: Trade Map – ITC (https://www.trademap.org)

Tier 4 – raw materials production

Raw material production – wool assumptions

Raw material sources – wool

Results assume the following sources of wool depending on the weaving countries:

Sources of wool used

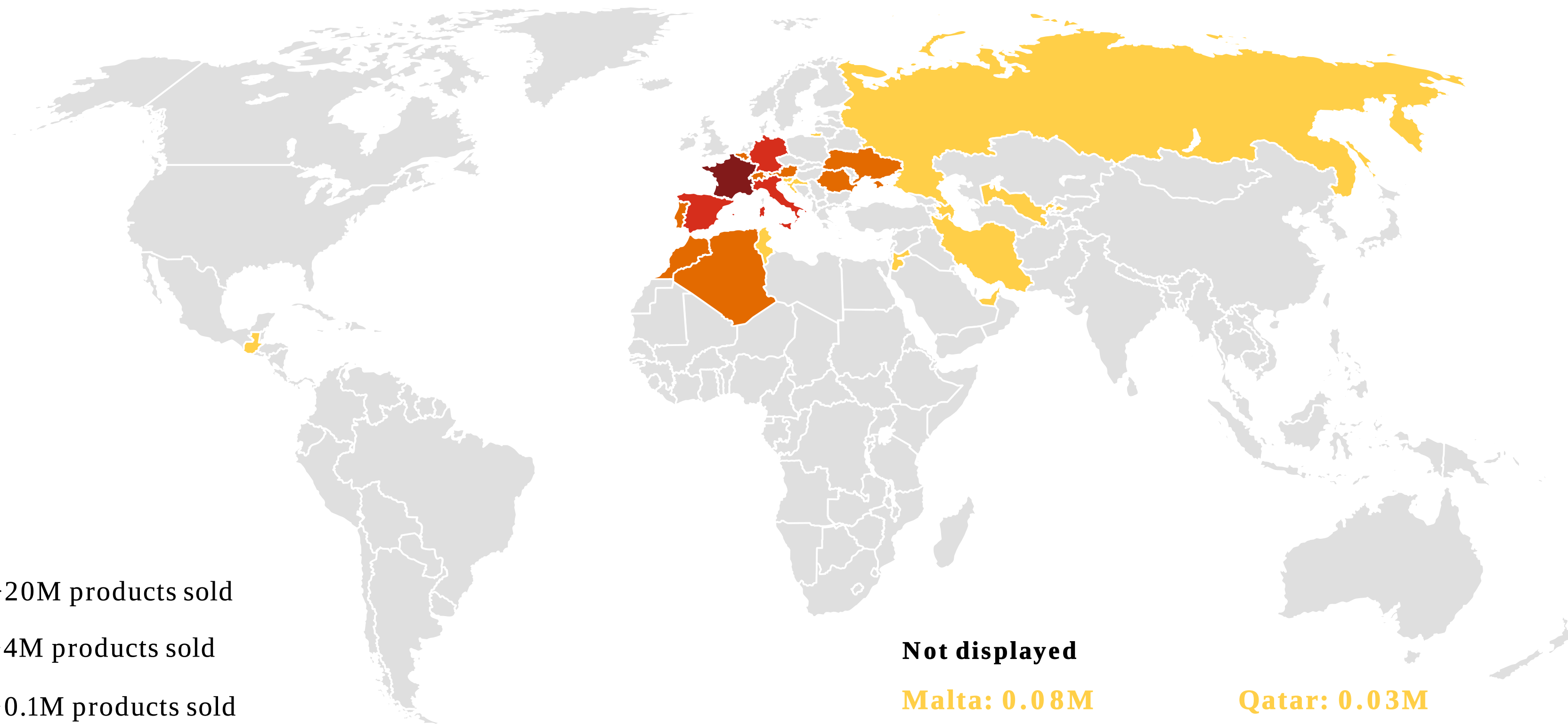
Pimkie's weaving countries	South African wool	Australian wool	New Zealander wool	Pimkie quantity (ton)
China	15%	70%	15%	87
Turkey		50%	50%	17
Cambodia		100%		3
France		100%		1

Supporting source: Trade Map – ITC (https://www.trademap.org)

Use phase

Product usage is assumed to take place where clothes are sold

Pimkie sales by country



- >20M products sold
- >4M products sold
- >0.1M products sold
- <0.1M products sold

Not displayed

Malta: 0.08M
Luxembourg: 0.05M
Bahrain: 0.04M
Mauritius: 0.03M
Qatar: 0.03M
Andorra: 0.03M
Kosovo: 0.01M

Source: Pimkie, PwC analysis

France includes Overseas France

Use phase

Product usage integrates data on retention time, washing and drying habits

Lifespan and washing practices of clothes

Results assume the following washing hypotheses based on a European study:

Clothes	Weight	Lifespan	Washings per month	Washing program	Number of washings (whole lifespan)
Accessories	258 grams	5 years	0.17	Gentle 40°	10
Bags	573 grams	7 years	0.08	Gentle 40°	7
Belts	90 grams	5 years	-	-	-
Blouses	143 grams	4.8 years	3	Regular 40°	173
Coats	1170 grams	7 years	0.17	Gentle 40°	14
Dresses	264 grams	7.1 years	0.50	Gentle 40°	43
Footwear	778 grams	3 years	-	-	-
Pair of glasses	37 grams	1 years	-	-	-
Gloves	63 grams	5 years	0.17	Gentle 40°	10
Hats	96 grams	7 years	0.17	Gentle 40°	14
Jackets	579 grams	6.8 years	0.25	Gentle 40°	20
Pair of jeans	416 grams	3.5 years	1	Regular 40°	42
Jewellery	37 grams	2 years	-	-	-
Scarfs	229 grams	5 years	0.17	Gentle 40°	10
Warm scarfs	367 grams	5 years	0.17	Gentle 40°	10
Skirts	208 grams	6.9 years	1	Regular 40°	83
Socks	62 grams	3 years	6	Regular 40°	216
Sweaters	403 grams	6 years	1	Regular 40°	72
Swimsuit	109 grams	3.1 years	2	Regular 40°	74
T-shirts	133 grams	4.6 years	4	Regular 40°	221
Trousers	258 grams	4.7 years	1	Regular 40°	56

Supporting source: MDPI (2018). *Does Use Matter? Comparison of Environmental Impacts of Clothing Based on Giber Type.*

Use phase

Product usage – additional assumptions

Use of drying machines

Results assume that 35% of clothes washed with a Regular program are dried with a drying machine. Moreover, 0% of clothes washed with a Gentle program are dried with a drying machine.

Water and Electricity consumption of washing machines

Results assume the following consumption of water and electricity depending on the washing program:

	Regular 40°	Gentle 40°
MJ/kg washed	0.51	0.255
L/kg washed	11.11	11.11

Supporting source: Cycleco (2019). *Product Environmental Footprint Category Rules (PEFCR). T-shirts*. p. 89.

Electricity consumption of drying machines

Results assume that drying machines consume 1.206 MJ/kg of clothes dried.

Supporting source: Cycleco (2019). *Product Environmental Footprint Category Rules (PEFCR). T-shirts*. p. 89.

Global water and energy consumption

The average weight (weighted average for each category) of clothes categories is used for the calculation of global consumption per category.

Based on the breakdown of sales (clothes categories versus countries), we modelled the energy consumption.

Unsold products

Results assume that 3.5% of Pimkie products are not sold, and then given to associations. Thus, the impact of their usage is not integrated in the scope of our calculations.

Data source: *Pimkie*

Electricity and water consumption repartition

Electricity and water consumption is spread over all countries where Pimkie is implemented following sales (see opposite).

Country	France	Germany	Italy	Spain	Morocco	Tunisia	Russia	Europe	World
%	53.3%	12.4%	11.9%	10.8%	0.6%	0.1%	0.1%	9.7%	1.1%

End of Life

Product end of life

Post-consumer textile wastes treatment

Results assume the following scenario for post-consumer textile wastes, based on the French context:

Re-use / Recycling	Landfilling	Incineration
36%	**29%**	**35%**

Supporting sources: ECO-TLC (2017). *Rapport d'Activité*. p. 6
ADEME (2016). *Déchets. Chiffres-clés*. p. 89.

Assimilation of different types of fibres

Our model for monetarization of waste treatment includes the following assumptions:

- All organic materials are considered as emitting methane in landfills. In incineration, their combustion generate biomass CO2 not accounted for in GhG emissions.
- Synthetic fibres and metals are considered as inert materials in landfills not emitting GhG emissions. Incineration of plastics generate CO2 emissions.

Material	Re-use Recycling (Ton)	Landfilling (Ton)	Incineration (Ton)
Polyester	1,347	1,085	1,310
Cotton	1,009	813	981
Viscose	687	553	668
Synthetic	405	326	393
Acrylic	386	311	375
Polyamide	162	130	157
Textile	126	101	122
Lyocell	53	43	52
Elastane	50	40	49
Wool	39	31	38
Other	26	21	25
Polyurethane	20	16	19
Modal	16	13	16
Linen	13	11	13
Metallic fibre	6	6	6
Modacrylic	5	4	4
Plastic	3	3	3
Mohair	3	3	3
Jute	3	2	2
Iron	2	2	-
Polypropylene	1	<1	1
Elastomultiester	1	<1	<1
Copper	<1	1	-
Feather	1	<1	<1
Acetate	<1	<1	<1
Down	<1	<1	<1
Elastodiene	<1	<1	<1
	4,364	**3,515**	**4,237**

Source: *Pimkie, PwC analysis*

Limits

Fabrics transportation, second life and end of life

Fabrics transportation from weaving manufactories (Tier 2) to assembly manufactories (Tier 1) has not been considered

Considering that externalities of transportation from Tier 2 to Tier 1 is not significant as compared to other process steps in the studied system, and based on our experience with other similar projects, it has not been considered in the perimeter of study.

Key facts to justify this exclusion:

- ➔ only 21% clothes are assembled in a different country than where fabrics has been woven (source: Pimkie);
- ➔ distance to travel from weaving manufactories to assembly manufactories is lower than from assembly manufactories to Pimkie stores;
- ➔ we assume that no cargo plane are used to transport fabrics.

Second life of Pimkie clothes (re-use) has not been considered

Commonly in LCAs, products externalities considered are only those included in the initial life cycle of the product. Indeed, product second life duration is usually poorly known; that is to say, reliable hypotheses can hardly be formulated.

Focusing on the first life of the clothes is even more relevant for an Organization Life Cycle Assessment, where results focus on activities under the supervision of the organization, on which measures can be implemented, tracked, assessed and attributed to the organization.

End of Life management follows authorized treatment

We assume that EoL management of the clothes and packaging follows authorized treatments and that there is no illegal dumping in the environment.

The potential impact of radioactive waste is not well quantified and has not been taken into account.

Other limits

Several raw materials production countries have not been considered

Due to a lack of reliable data to assess impact of raw materials production in some countries, we modelled these data with countries where high-quality data were available.

Uzbekistan cotton exports have not been considered

Cotton imports from main exporting countries (USA, China, India, Pakistan, Turkey, Greece, Egypt, Italy) have been considered for all Pimkie weaving countries. Since that Uzbekistan represents only 3% of Chinese imports and less than 1% of other weaving countries imports, its cotton exports have not been considered.

Contribution to plastic continent has not been considered

The potential impact of washing textiles (in particular synthetic) in terms of microfibre production and possible migration to oceans and contribution to plastic continent in the oceans is not well quantified yet and has not been taken into account.

Energy aspects are integrated in the monetarization through related water consumption, air and water emissions

Resource depletion is not integrated in the scope of the monetarization.

The potential long-term sanitary impacts of radioactive waste storage is not well quantified and would be levelled off by actualization of costs and has hence not been taken into account.

Results

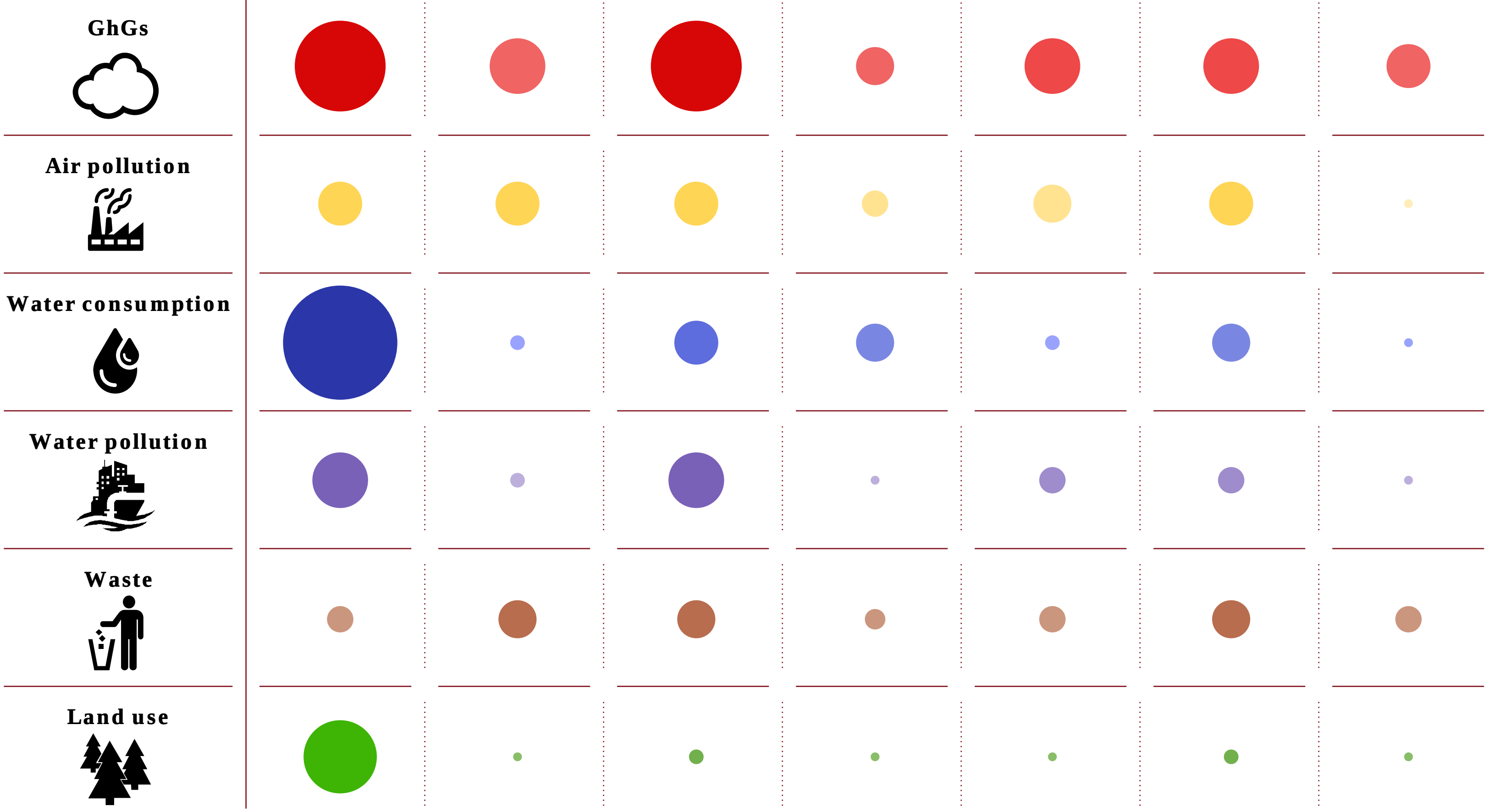
Pimkie externalities: LCA results without valuation

Externalities	Tier 4 *Raw materials production*	Tier 3 *Yarn Spinning*	Tier 2 *Fabrics production*	Tier 1 *Products assembly*	Tier 0 *Direct operations*	USE	EoL	Total
GhGs (ton CO_2 eq.)	92,500	36,700	101,000	6,400	30,800	40,800	13,500	**321,600**
Hazardous and non-hazardous wastes (ton)	5,400	7,900	8,300	1,300	6,400	25,300	7,100	**61,800**
Land use (ha)	16,600	<50	<50	<50	<50	<50	<50	**16,600**
Water consumption (1,000 m^3)	18,500	<50	2,600	600	200	8,900	1,000	**31,800**

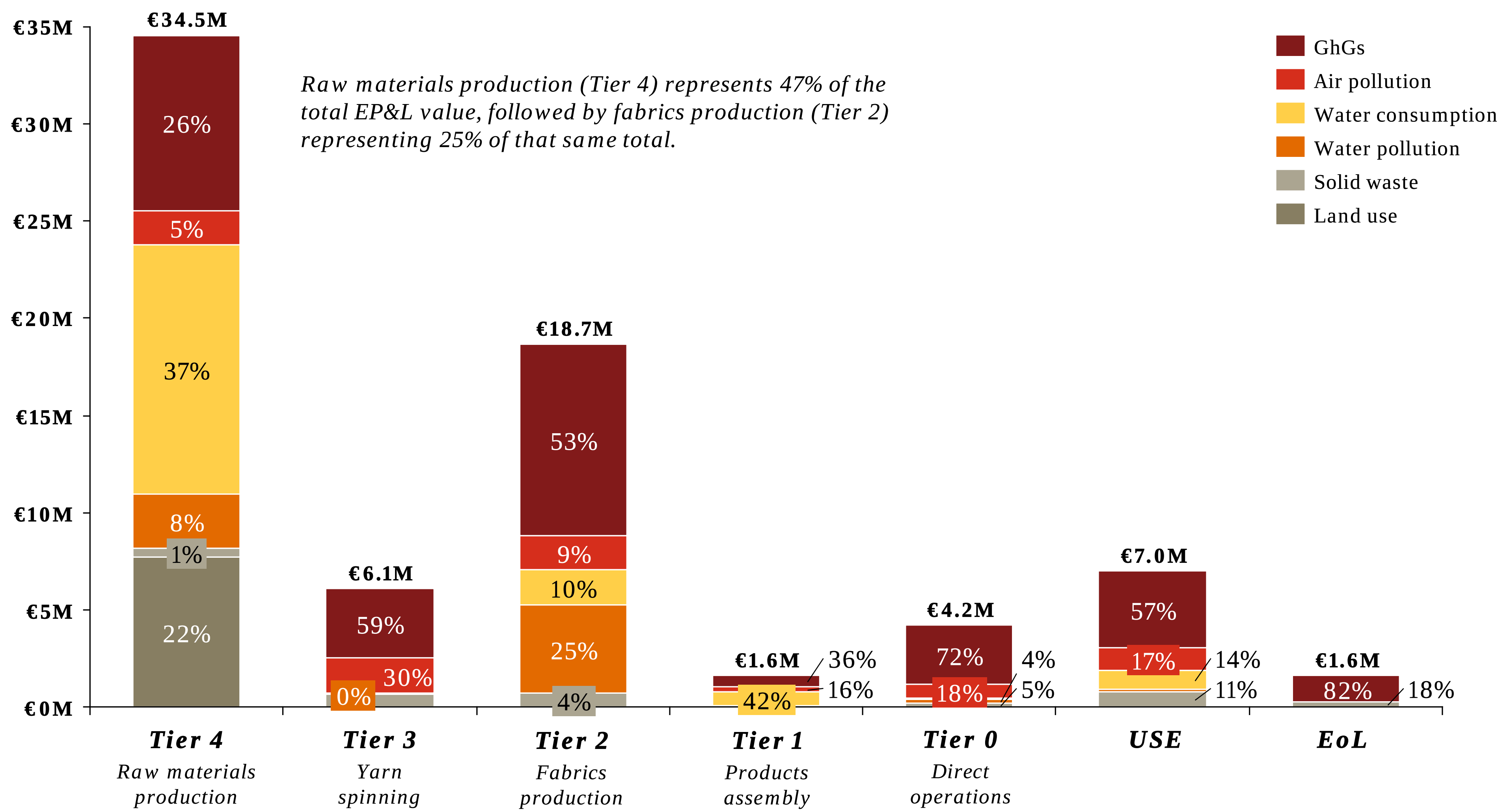
Water and air pollution are not presented in this table due to a too high number of contributing entries.

Externalities linked to Pimkie supply chains and use phase represented €73.6M in 2018

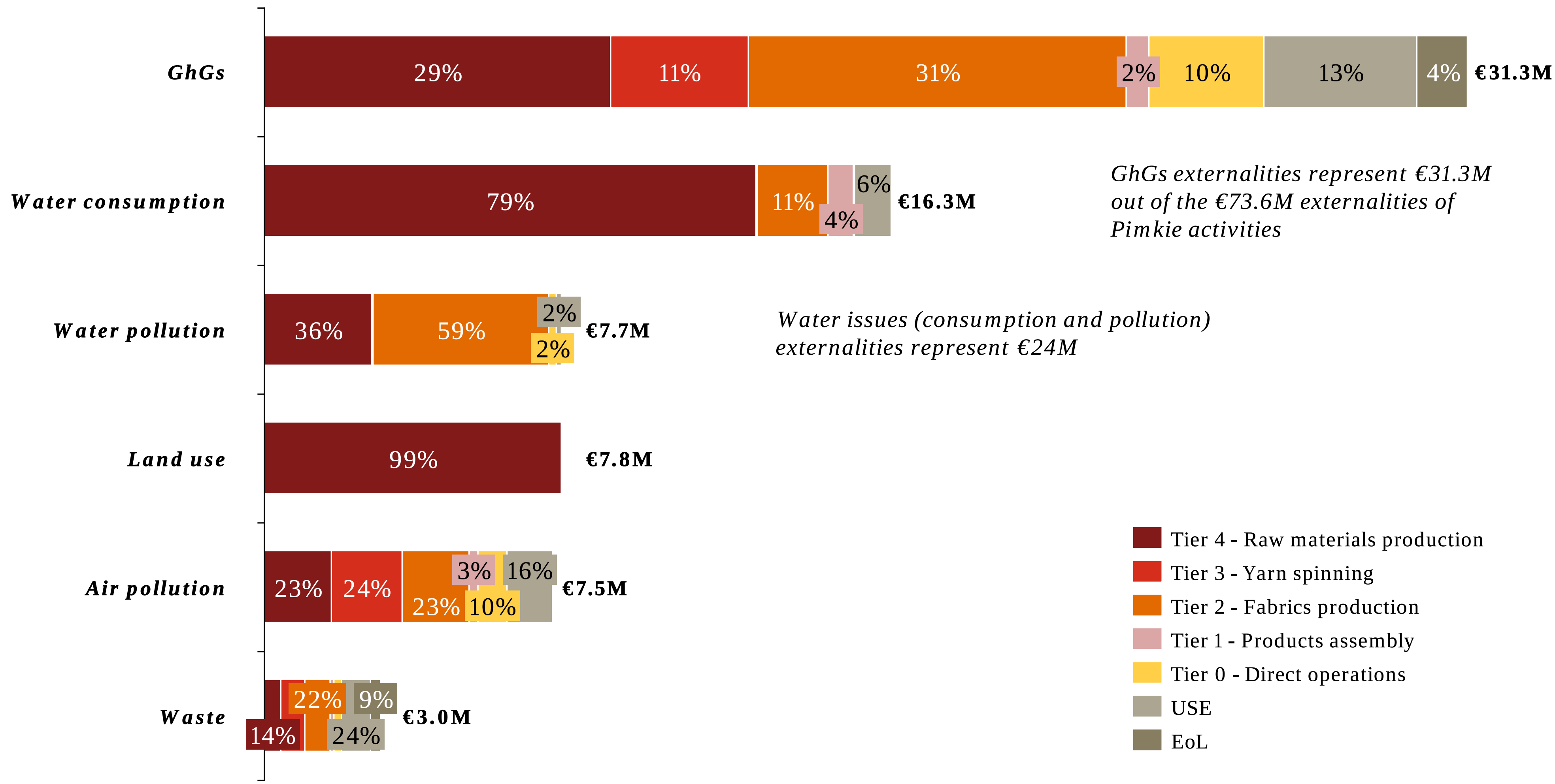
	Tier 4 Raw materials production	Tier 3 Yarn spinning	Tier 2 Fabrics production	Tier 1 Products assembly	Tier 0 Direct operations	USE	EoL	Total
GhGs								42.5% **€31.3M**
Air pollution								10.2% **€7.5M**
Water consumption								22.1% **€16.3M**
Water pollution								10.5% **€7.7M**
Waste								4.1% **€3.0M**
Land use								10.6% **€7.8M**



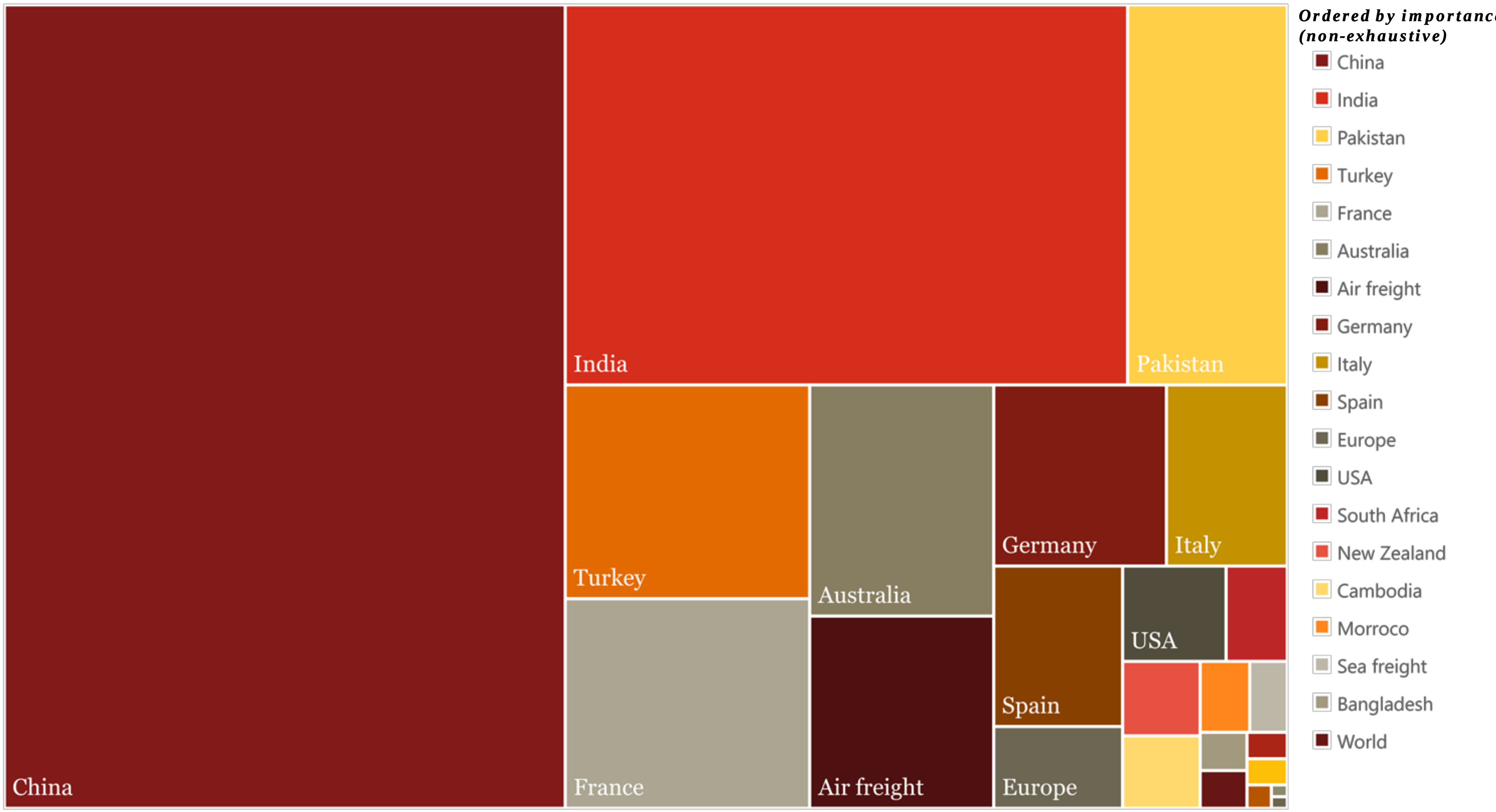
Tier 4 and Tier 2 combined represent 72% of Pimkie externalities



GhGs emissions represent 42.5% of Pimkie supply chains and use phase externalities



China hosts 44% of Pimkie externalities, at a larger scale, Asia represents 71% of the Pimkie externalities

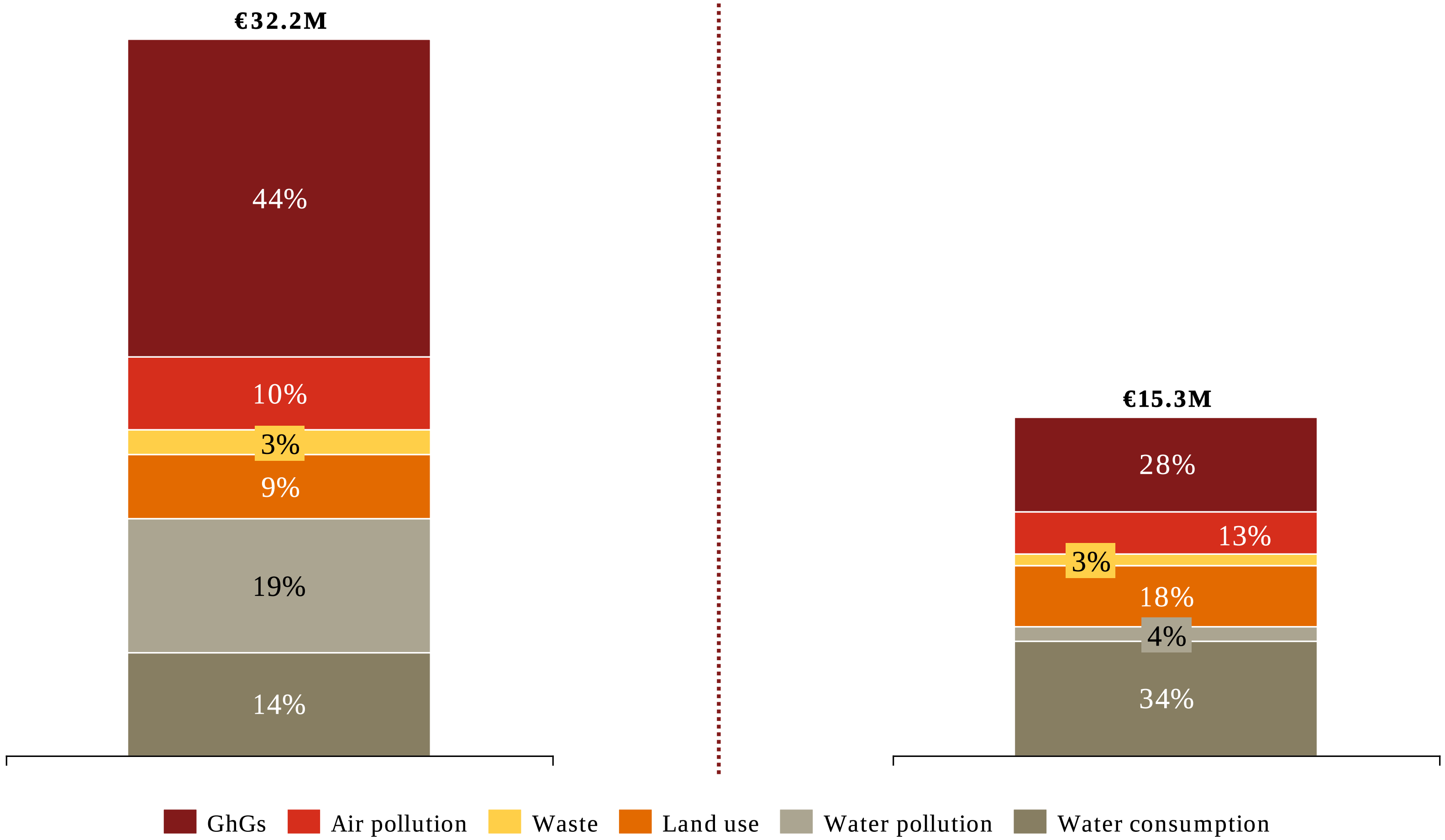


Focus: China & India

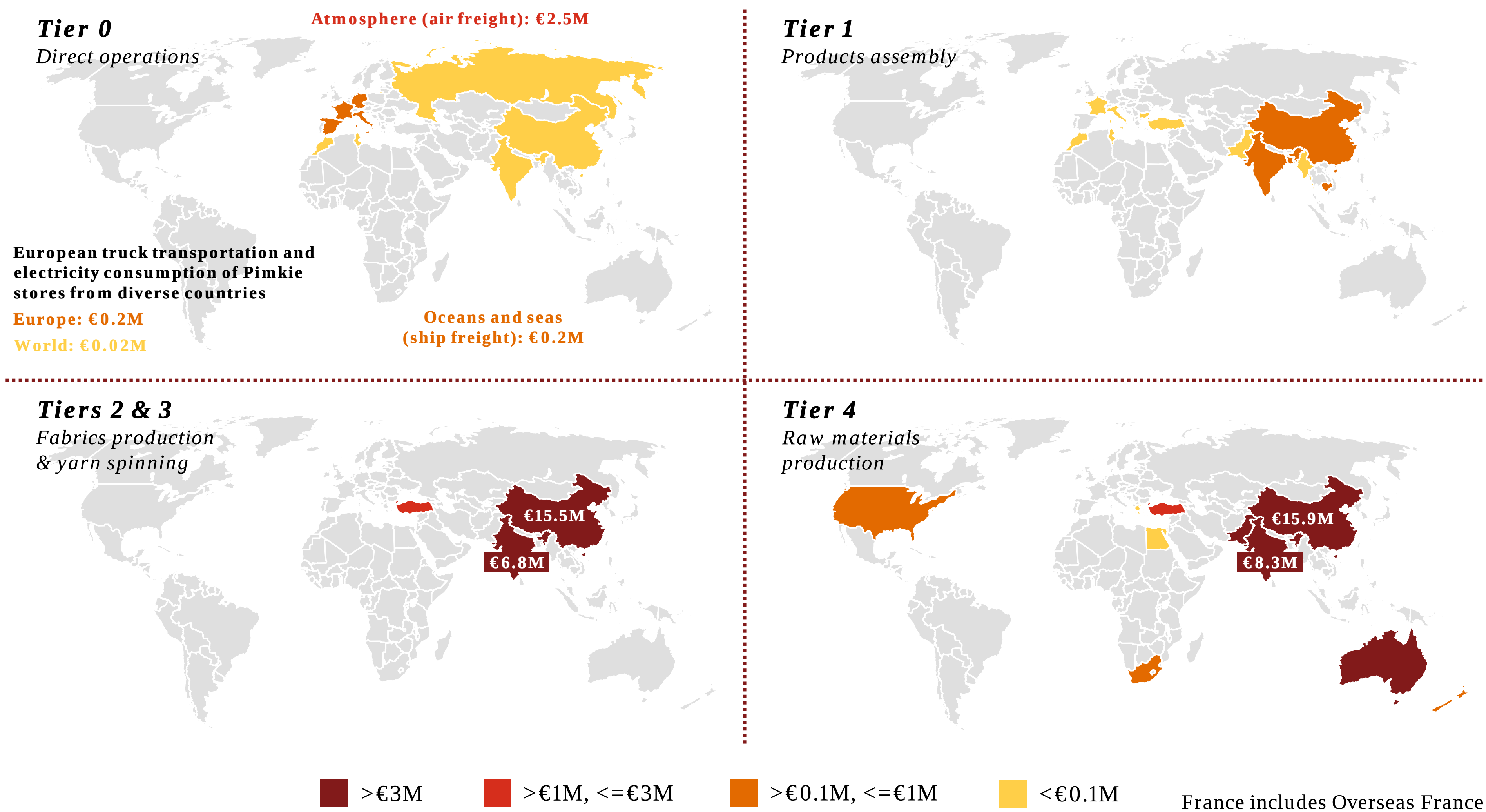
All tiers considered

China

India



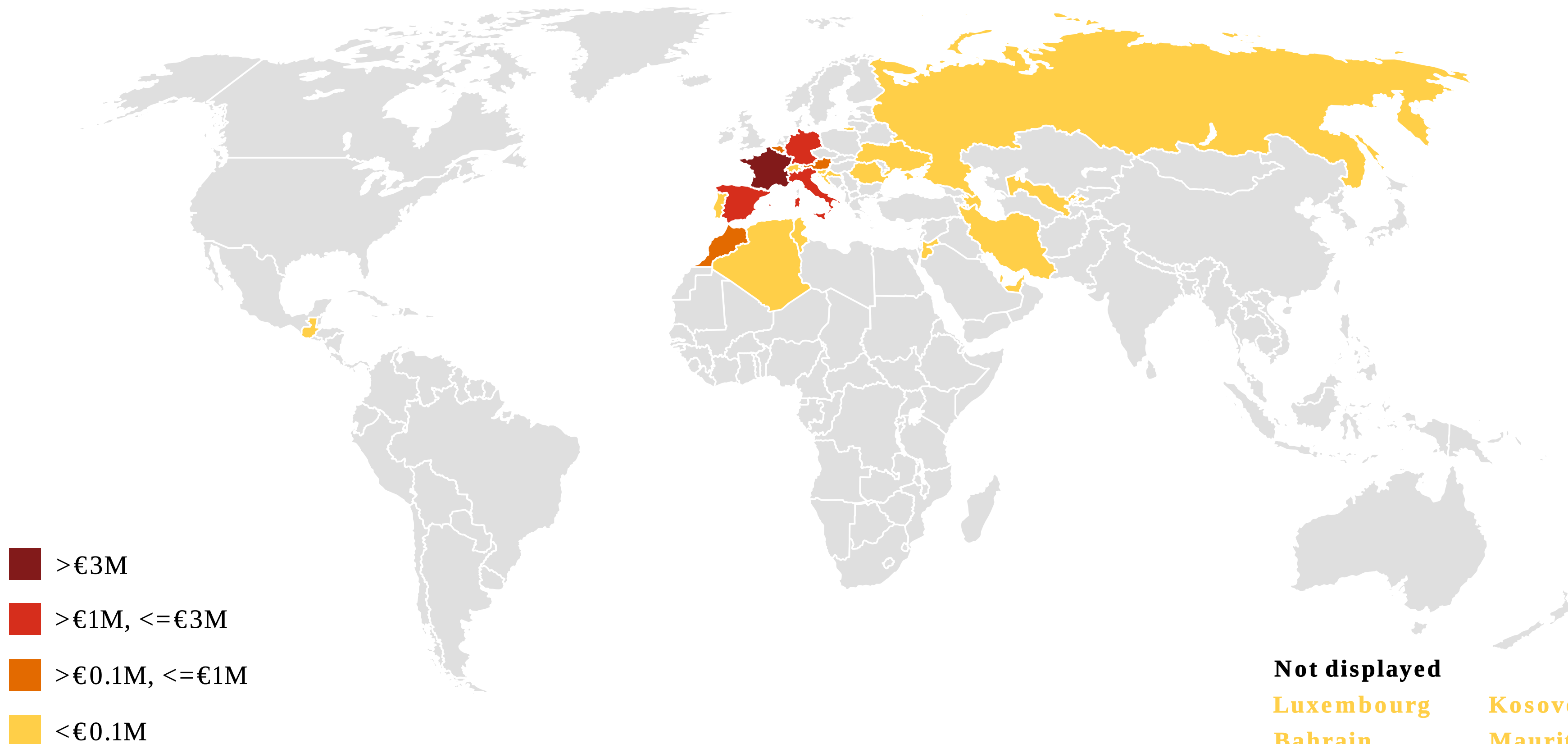
Pimkie externalities related to Tier 1 to Tier 4 are mainly generated in Asia



France includes Overseas France

Pimkie externalities related to usage and end of life phases are mainly generated in Europe

USE & EoL

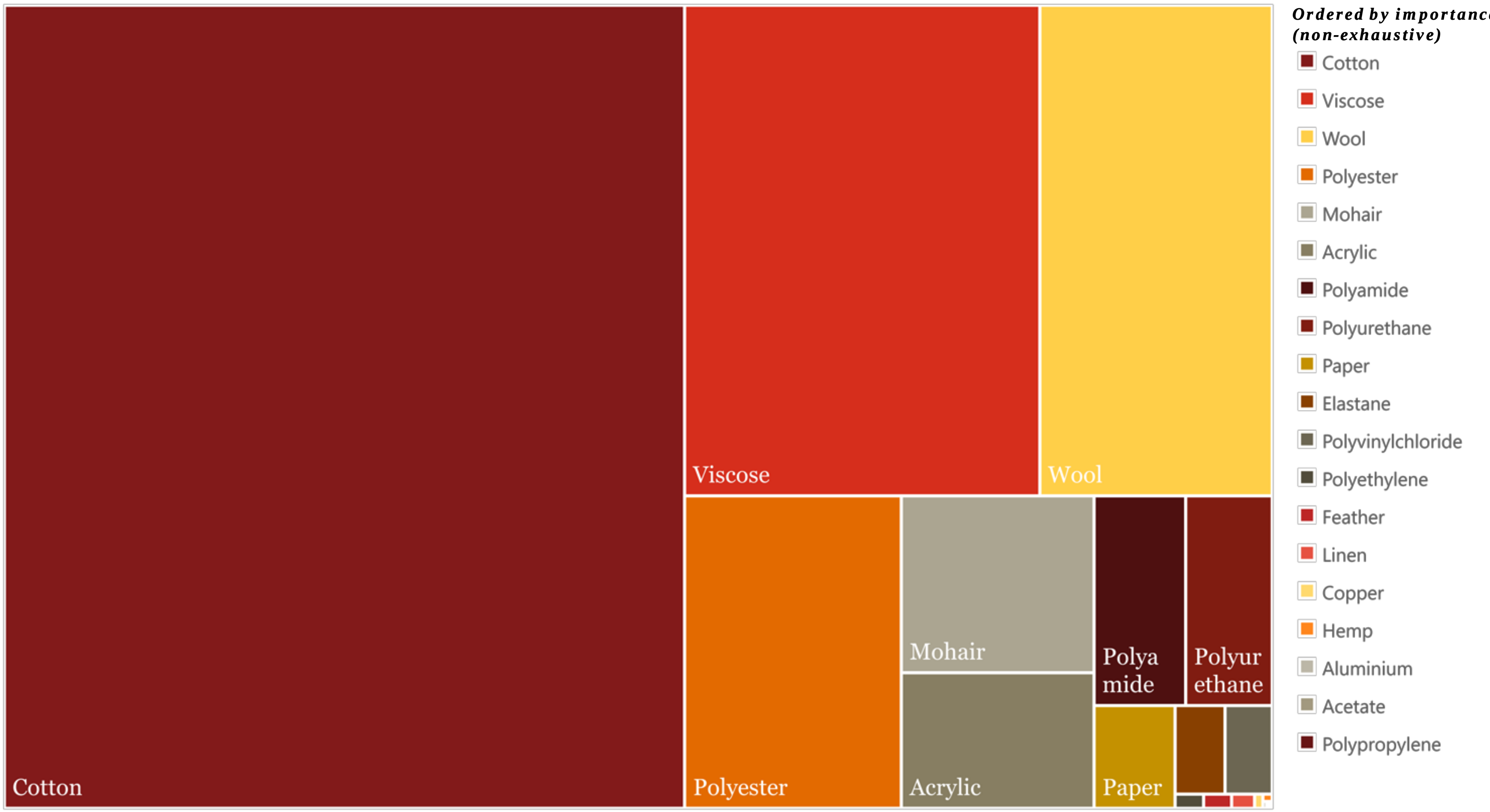


Not displayed

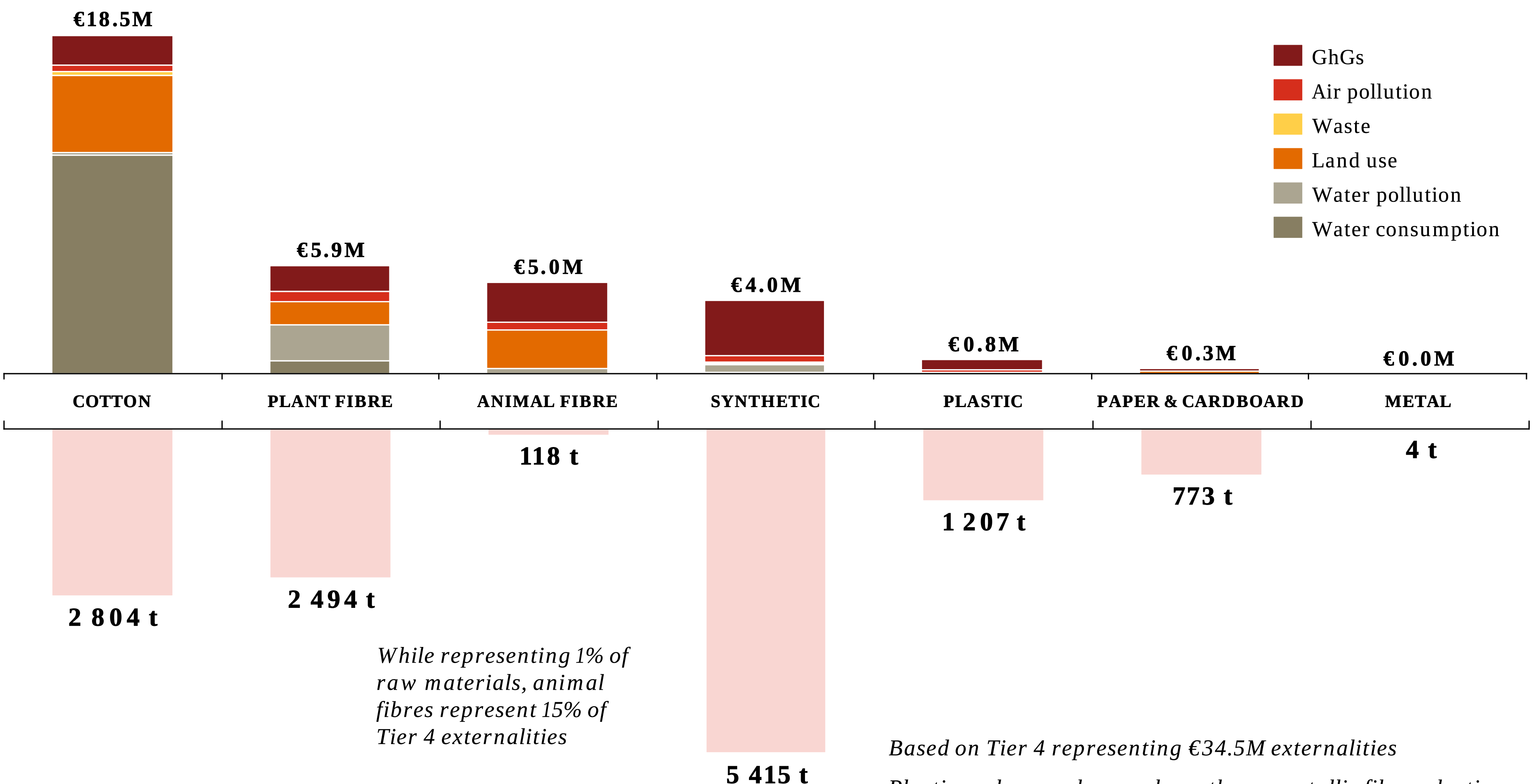
Luxembourg
Bahrain
Andorra
Kosovo
Mauritius
Malta

France includes Overseas France

Top 3 raw materials with the largest impact represent 82% of raw materials production (Tier 4) externalities



Cotton represents 54% of externalities related to raw materials production

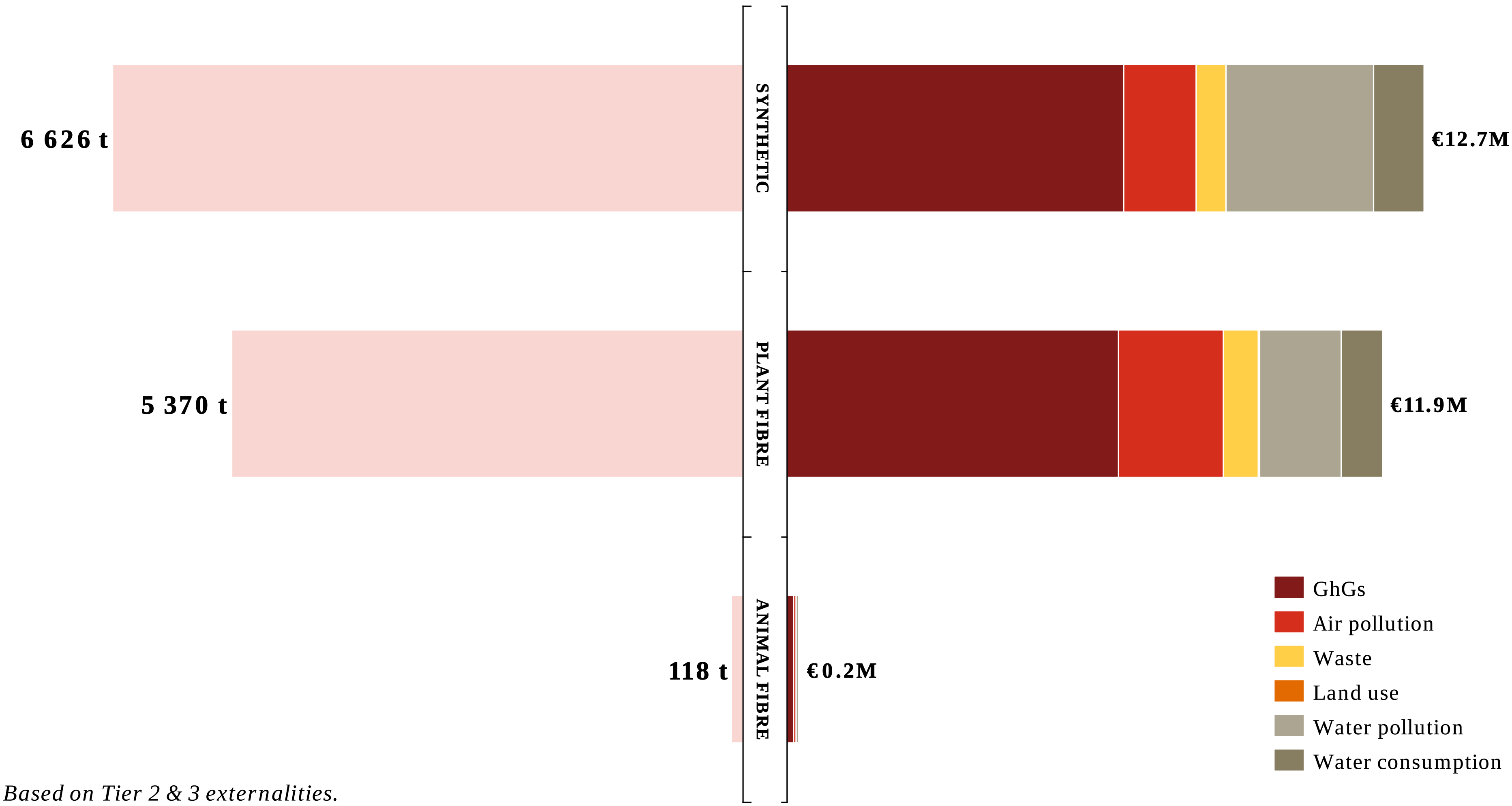


While representing 1% of raw materials, animal fibres represent 15% of Tier 4 externalities

Based on Tier 4 representing €34.5M externalities

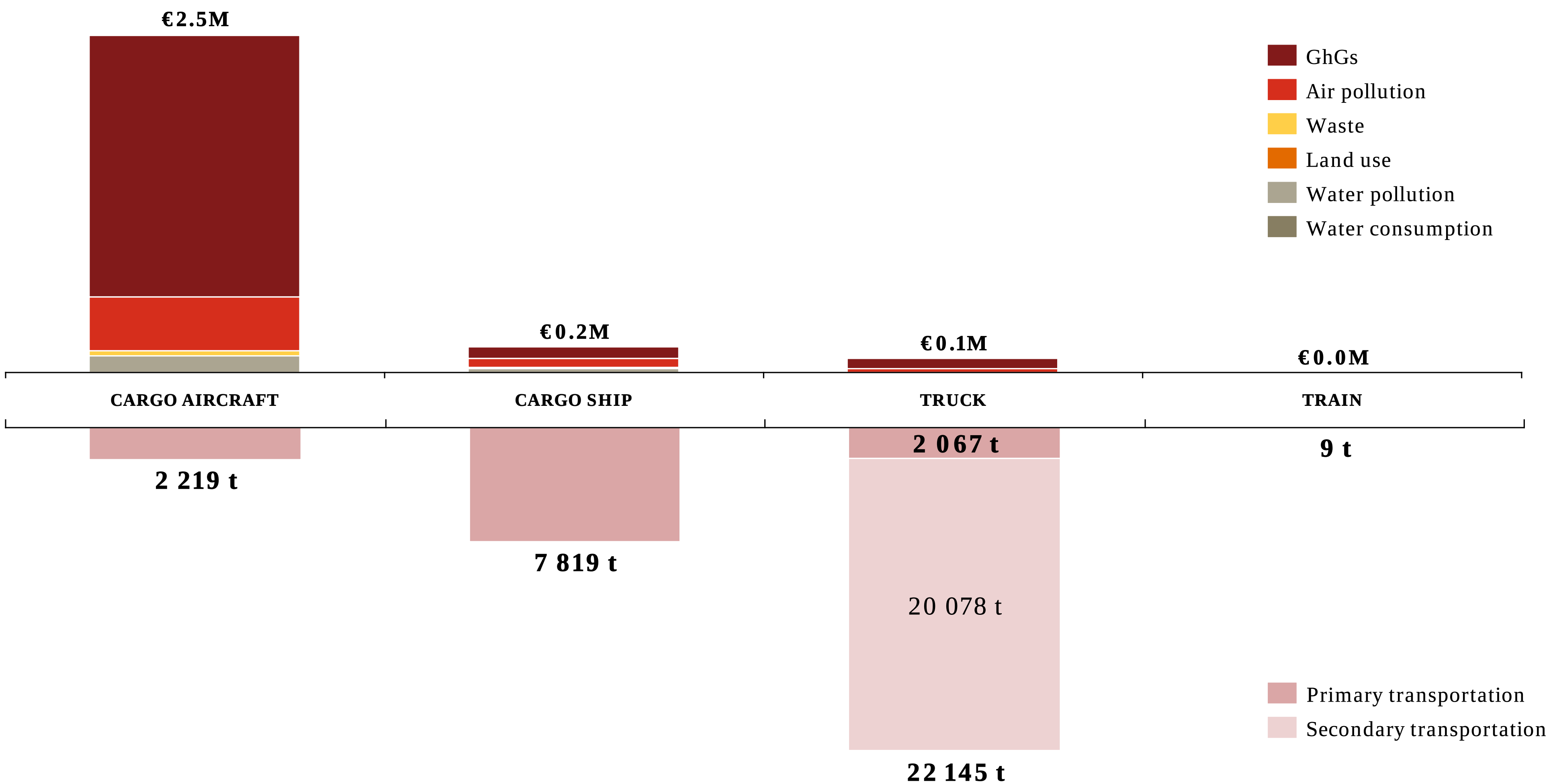
Plastic: polypropylene, polyurethane, metallic fibre, plastic, and 'synthétique' categories

Fabrics production externalities are similar whatever the type of fibre woven



Based on Tier 2 & 3 externalities.

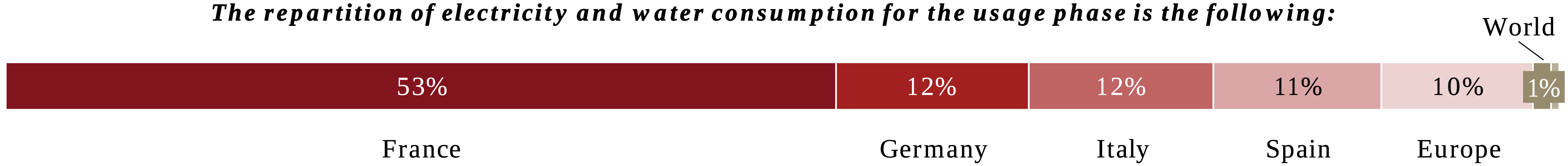
Air freight generate 89% of transportation externalities while representing 18% of tonnages transported



Based on Tier 0 externalities

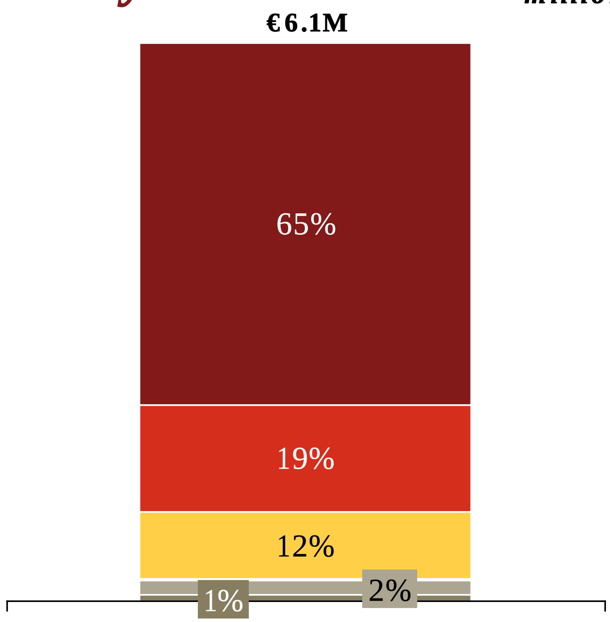
Electricity consumed in usage phase generates non-negligible externalities

The repartition of electricity and water consumption for the usage phase is the following:



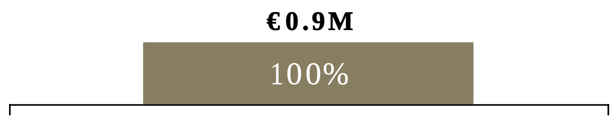
Electricity

Consumption: 658 millions of MJ



Water

Consumption: 8.6 billions of L



Appendices

Sustainability & Climate Change

Fashion3 environmental valuation
Monetising supply chain impacts

*Strictly Private
and Confidential*

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and Confidential***

May 2019

pwc

Summary of key assumptions and limitations

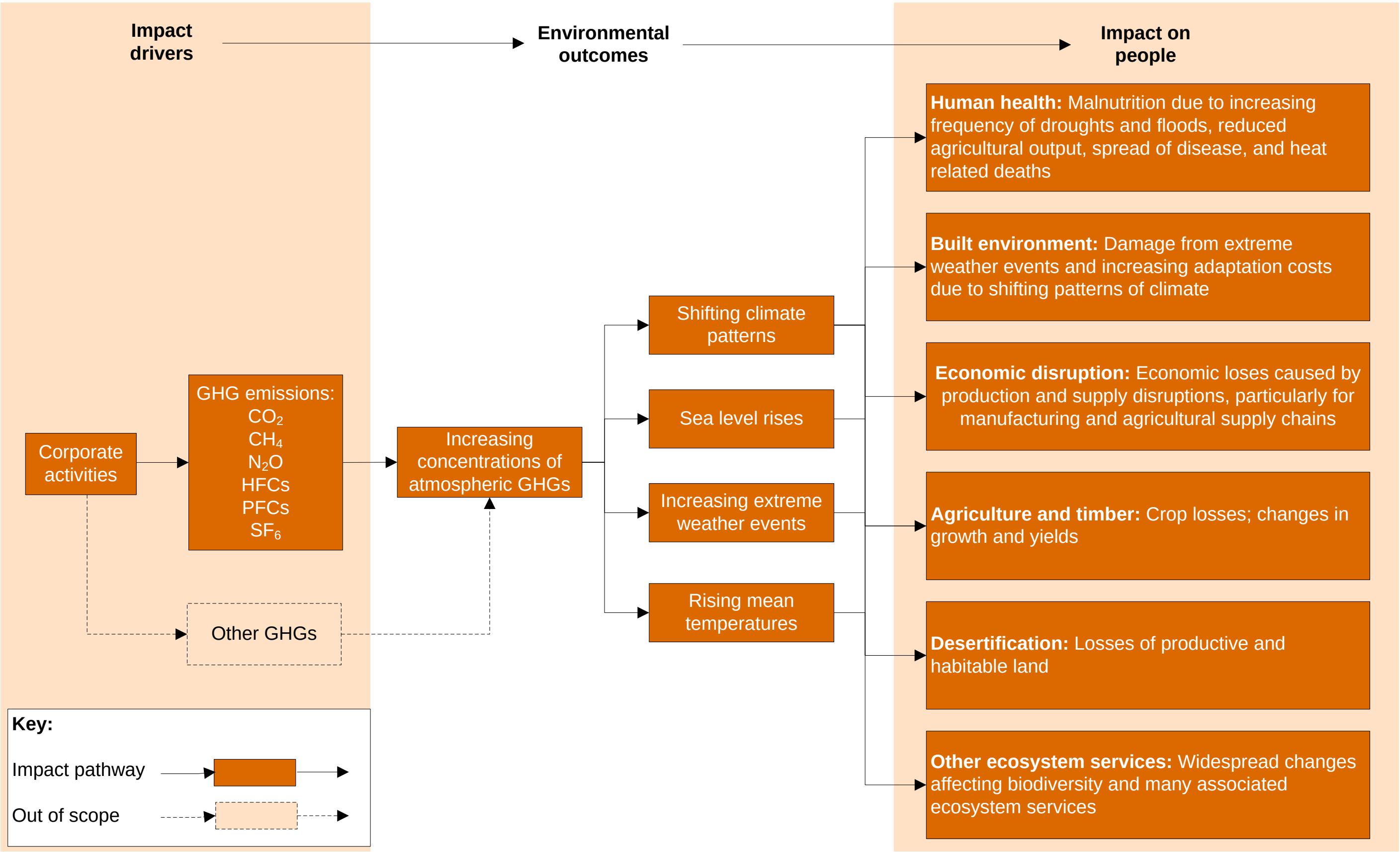
The table below summarises the key assumptions applied in PwC UK's application of valuation coefficients to the LCA intensities provided by PwC France.

Category	Assumption/Limitation
All	Material intensities have been modelled off at least one key sourcing location for Fashion3, the impact of sourcing a specific material from various locations can vary significantly and so should be considered when interpreting results/hot spotting.
All	Pollutants listed as air pollutants acephate, chloropyrifos, tribufos, cyanazine, aldicarb, methyl parathion, trifluralin, other pesticides, diazinon, propetamphos, cypermethrin are valued as water pollutants.
All	Where the impact country is Europe this has been mapped to Rest of Europe coefficients.
All	Where the impact country is World this has been mapped to Rest of World coefficients.
Electricity	Land use type for electricity intensities has been assumed to be 'Manufacturing and Services'.
Electricity adjustment	In some cases the LCA base country is not equal to the impact country, where this is the case the electricity impact has been adjusted to reflect differences in grid efficiencies between the base and impact countries.
End of life	Waste coefficients (per kg of waste) have been provided for incineration and landfill for the locations specified. individual indicator quantities are not able to be valued as the waste coefficients take these into account.
Exchange rate	A rolling 5 year average exchange rate for USD --> EUR has been calculated and applied to convert coefficients from USD to EUR.
GHGs	The IPCC recommends applying a social cost of carbon (SCC) growth rate of 3% per year as well as currency inflation, this growth rate has been applied to the GHG coefficient to express this in 2018 terms.
Inflation	A global average inflation rate has been used to inflate valuation coefficients from their base years to the impact year (2018).
Land use and water consumption valuation	Rest of World water consumption and land use coefficients are not available (due to the underlying methodologies it is not possible or accurate to calculate an average coefficient for the world.) Therefore intensities for these indicators and locations are currently zero, this does not represent the actual intensity.
Material	Land use for materials has been aligned to the most relevant land use type for a given material/sub-process step.
Transport	Transport in the Indian Ocean has been mapped to South East Asia coefficients.
Transport	Transport from China to Europe has been mapped to Rest of the World coefficients.
Valuation coefficients	All valuation coefficients are expressed in 2018€.
Water pollution	Water pollution coefficients are not available for the following water pollutants: Tribufos, Other pesticides, Perfluorooctanoic acid (PFOA), Bromodichloromethane, Octylphenol, Octylphenol diethoxylates, OP2EO, Bromoform, Chlorodibromomethane, Short Chain Chlorinated Paraffins (SCCP) with C10 –C13, di-n-butyl phthalate, Dimethyl phthalate, Dimethyl phthalate, 4-Chloro-3-methylphenol, 2,3,4,6-Tetrachlorophenol, Nonylphenolethoxylates (NPEOs), Manganese, COD, BOD5, Chlorides and Sulfates.

Overview of valuation methods: GHGs

GHGs
Impact pathway

Our GHG valuation methodology uses a meta-analysis of Social Cost of Carbon (SCC) estimates to value the impacts of GHGs on people. The impact pathway below illustrates the relationship between an organisation emitting GHGs to the environment, the environmental outcome and the subsequent impact on people. The SCC considers the following impacts: human health, built environment, economic disruption, agriculture and timber, desertification and other ecosystem services.



GHGs

Summary of the meta-analysis approach

1. Collate relevant peer reviewed studies

- There are 300+ estimates of the Social Cost of Carbon available in the literature

Most studies | Some studies | No studies

	Market	Non-market	Socially Contingent
Projection	Coastal Projection Loss of Dryland Energy (heating/cooling)	Heat stress Loss of wetland	Regional Costs Investment
Bounded Risks	Agriculture Water Variability (drought, floods, storms)	Ecosystem Collapse Biodiversity Loss of Life Secondary Social Effects	Comparative advantage and market structures
System Change	Significant loss of land and resources Non-marginal losses	Higher order social effects Regional Collapse Irreversible Losses	Regional collapse

2. Select sample

	Sample selection criteria
Quality of study	Peer reviewed only.
Age of study	Ten most recent peer reviewed studies.
Discount rate	Pure Rate of Time Preference = 0%.
Treatment of outliers	Excluded if > three standard deviations from mean.
Equity weighting	No selection criteria applied.
Damage valuation approach	No selection criteria applied.

3. Calculate central estimate

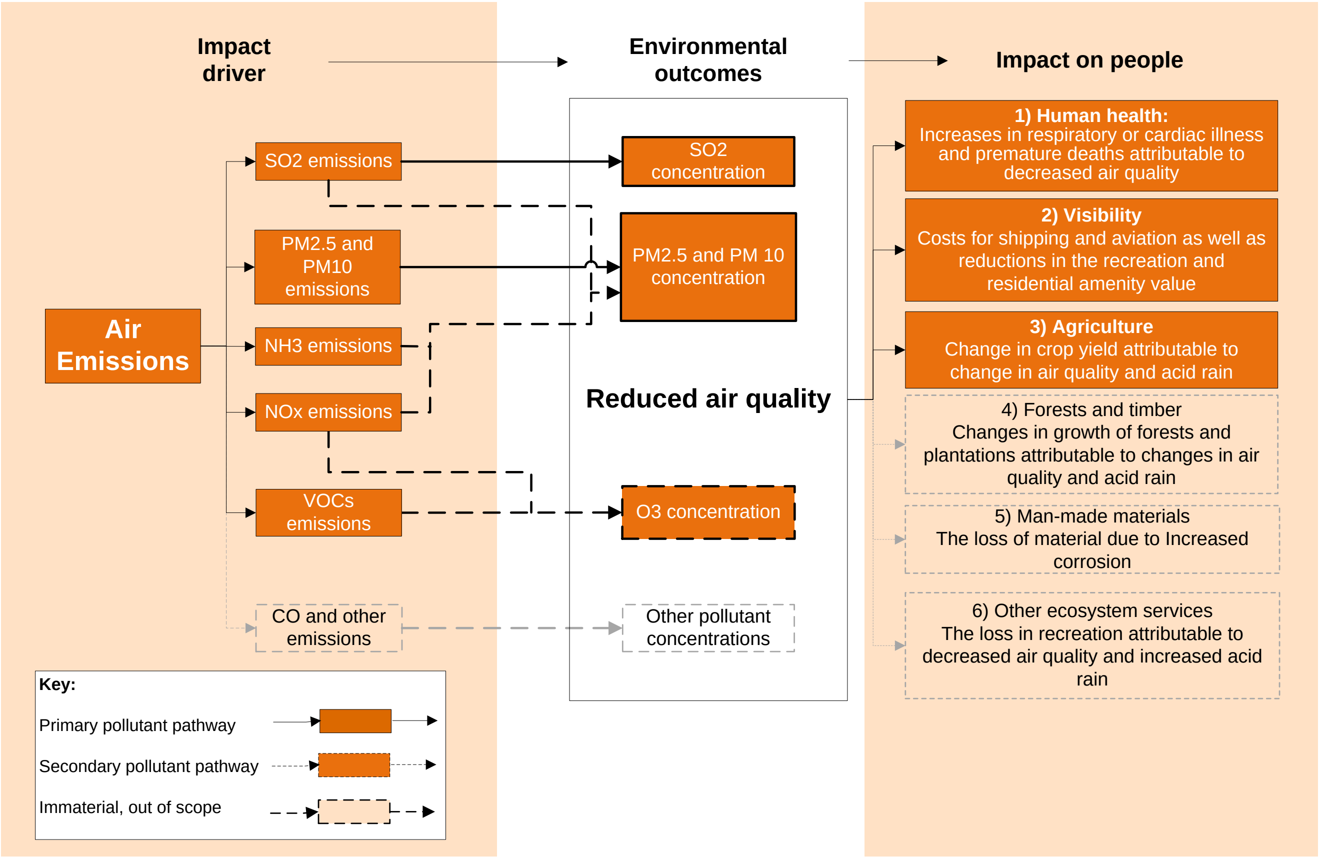
	Calculation from sample
Multiple estimates	Multiple estimates weighting applied.
Monetary inflation	World PPP adjusted GDP deflators.
Growth rate of SCC over time	3%.
Unit conversion	Converted from \$/tC to \$/tCO2e.
Distribution of data	No fitted distribution.
Deriving central estimate	Arithmetic mean and median reported. Mean recommended to better account for the risk of catastrophic climate scenarios.

Overview of valuation methods:
Air pollution

Air pollution

Impact pathway

Our air pollution valuation methodology covers the following air pollutants: NOx, SOx, PM2.5, PM10, NH3 and VOCs. The impact pathway below illustrates the relationship between an organisation emitting these pollutants to the environment, the environmental outcome and the subsequent impact on people. Within our valuation methodology we consider the human health impact, visibility impacts and the impact on agriculture of air pollutants.



Materiality based on United States:

≈94%

≈3.5%

≈1.5%

Air pollution

Summary of calculation approach (for human health impacts)

1. Characterise area

- Location specific modelling of demography and weather (precipitation rate, wind direct & wind speed)
- US department of Energy weather database with 2,100 stations worldwide

50km

2. Estimate change in concentration

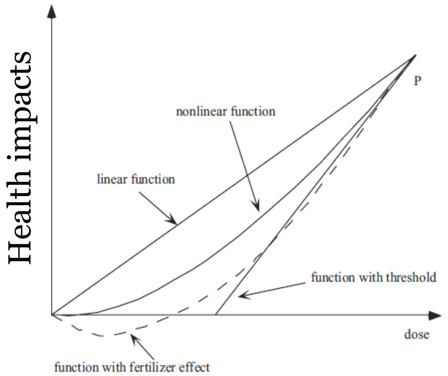
•Dispersion modelling E.g. Change in PM2.5 concentrations

•ATMOS 4.0 is a simplified peer reviewed version of the US NOAA model

0.0001	0.0001	0.0002	0.0003	0.0005	0.0007	0.0006	0.0004	0.0003	0.0002
0.0002	0.0002	0.0004	0.0006	0.0006	0.0009	0.0014	0.0010	0.0004	0.0003
0.0002	0.0003	0.0005	0.0008	0.0010	0.0013	0.0017	0.0011	0.0005	0.0003
0.0001	0.0002	0.0003	0.0005	0.0009	0.0013	0.0013	0.0011	0.0006	0.0003
0.0001	0.0001	0.0003	0.0004	0.0004	0.0006	0.0011	0.0013	0.0009	0.0005
0.0001	0.0002	0.0004	0.0004	0.0003	0.0010	0.0020	0.0017	0.0010	0.0005
0.0001	0.0002	0.0003	0.0003	0.0010	0.0029	0.0031	0.0019	0.0010	0.0005
0.0001	0.0001	0.0004	0.0005	0.0015	0.0036	0.0034	0.0016	0.0008	0.0004
0.0001	0.0001	0.0004	0.0006	0.0009	0.0025	0.0030	0.0014	0.0005	0.0002
0.0001	0.0001	0.0003	0.0005	0.0005	0.0013	0.0018	0.0010	0.0005	0.0002

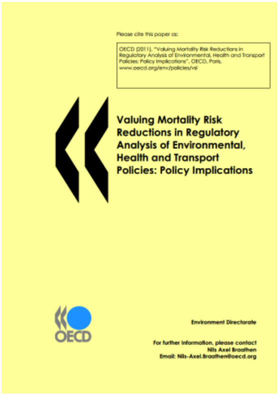
3. Calculate number of health outcomes

- Mortality
- Morbidity (respiratory and cardiac disease)



4. Value health outcomes

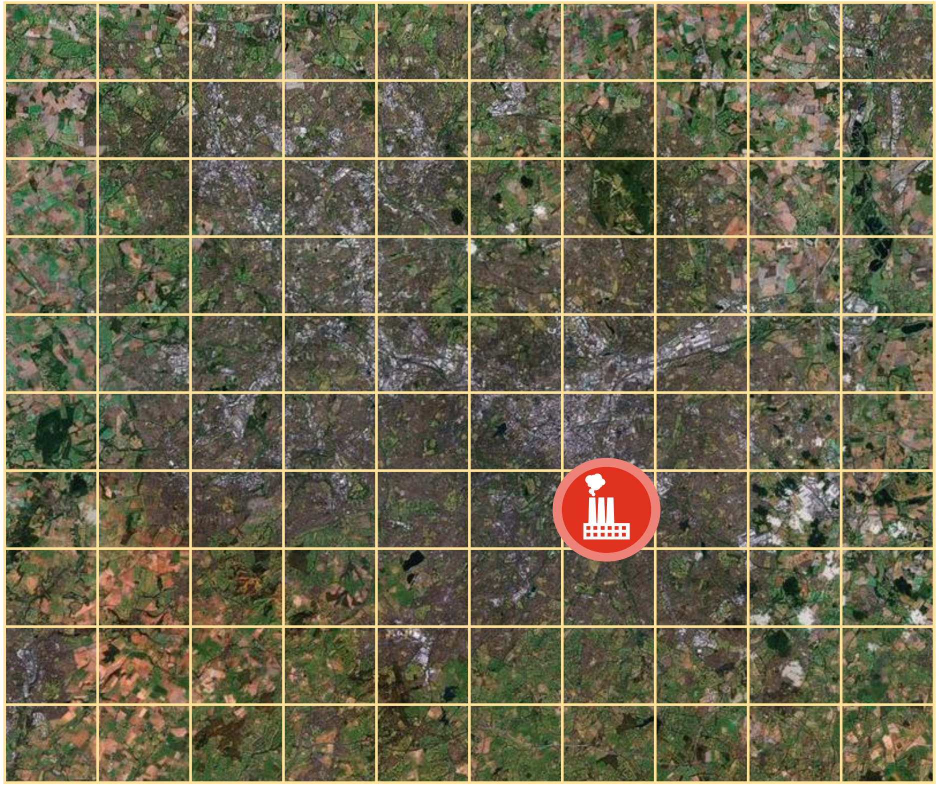
- OECD recommended methods for valuing life and health
  E.g. OECD VSL is €2,640,000
- Adjusted for differences in incomes and preferences using income elasticity of 0.6



1. Human Health: primary air pollutants

We start with a 50x50km grid square which can be overlaid anywhere on the earth's surface and populated with local data

1. The Location of pollution source can be resolved to a town level.
2. This is accompanied by a wide array of local information including population distribution & density, city type and baseline mortality and morbidity figures.



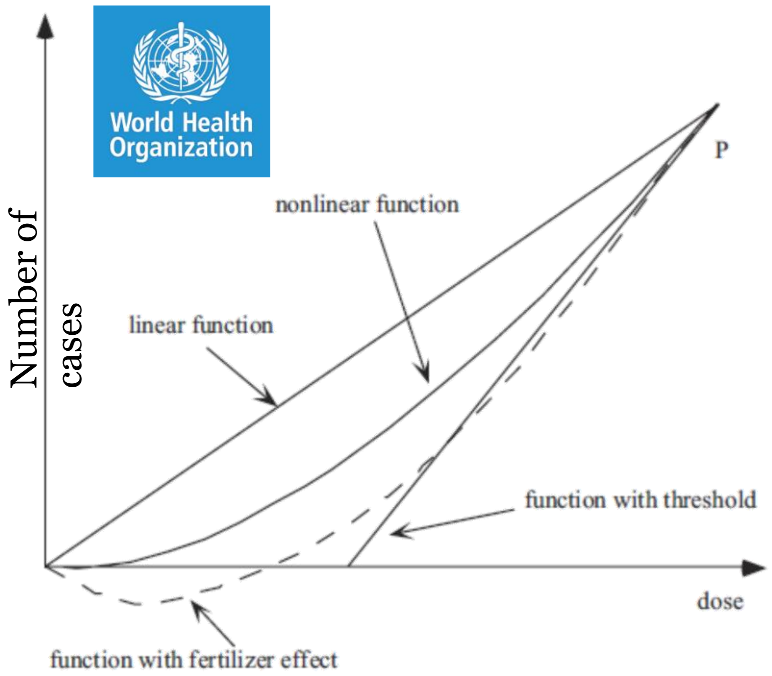
3. This overlaid with measured wind, precipitation and temperature data.
4. The trajectory of a unit emission of each pollutant (NOX, SOX, PM10, PM25) is then modelled using a Lagrangian multi-specie, multiphase atmospheric model, to determine a spatial impact matrix.

0.0001	0.0001	0.0002	0.0003	0.0005	0.0007	0.0006	0.0004	0.0003	0.0002
0.0002	0.0002	0.0004	0.0006	0.0006	0.0009	0.0014	0.0010	0.0004	0.0003
0.0002	0.0003	0.0005	0.0008	0.0010	0.0013	0.0017	0.0011	0.0005	0.0003
0.0001	0.0002	0.0003	0.0005	0.0009	0.0013	0.0013	0.0011	0.0006	0.0003
0.0001	0.0001	0.0003	0.0004	0.0004	0.0006	0.0011	0.0013	0.0009	0.0005
0.0001	0.0002	0.0004	0.0004	0.0003	0.0010	0.0020	0.0017	0.0010	0.0005
0.0001	0.0002	0.0003	0.0003	0.0010	0.0029	0.0031	0.0019	0.0010	0.0005
0.0001	0.0001	0.0004	0.0005	0.0015	0.0036	0.0034	0.0016	0.0008	0.0004
0.0001	0.0001	0.0004	0.0006	0.0009	0.0025	0.0030	0.0014	0.0005	0.0002
0.0001	0.0001	0.0003	0.0005	0.0005	0.0013	0.0018	0.0010	0.0005	0.0002

1. *Human Health: primary air pollutants*

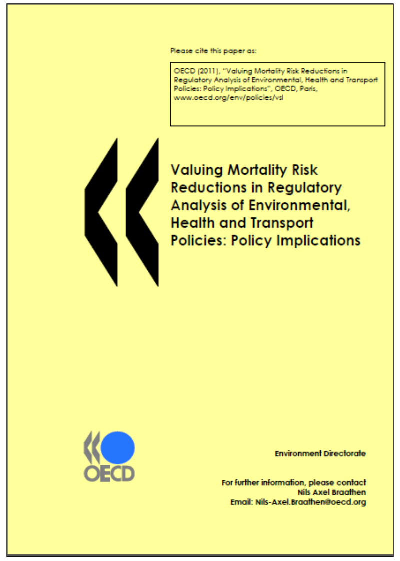
We use established dose-response relationships to estimate the resulting change in health conditions. The effect of these health conditions is then estimated using established valuation evidence.

5. With the number of individuals likely to be affected by the pollution now determined, it's possible to use established dose-response functions, such as those provided by the World Health Organisation to calculate the number of acute cases affecting individuals and the severity and extent of implications for their health.



6. Once the number and severity of health cases have been established, it's then possible to use credible sources to determine the number of cases and value per case, determining the social cost per unit of emission.

7. Multiplying this "valuation coefficient" by the actual quantity of pollution emitted provides the final value of the operations welfare impact on society, due to their emission to the local environment.



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Valuing Mortality Risk Reductions in Regulatory Analysis of Environmental, Health and Transport Policies: Policy Implications

OECD

Environment Directorate

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2. Human Health: secondary air pollutants

Quantification and valuation of secondary air pollutants

Emissions of NO_x, VOCs and NH_3 can form low level Ozone (O_3). The inhalation of O_3 can cause harm to human health.

The formation of O_3 results from a complex non-linear reaction and modelling it requires detailed location-specific information. In the absence of this information, the EP&L methodology uses a multivariate transfer function constructed based on Muller and Mendelsohn's (2007) results for US counties.

The transfer function is used to estimate a location specific estimate of the health impacts of secondary air pollution as a function of ambient ozone concentration, local income, and local population density.

$$\boldsymbol{ln(societal\ cost)_i = \alpha + \beta_1\, ln(population\ density) + \beta_2\, ln(median\ income) + \beta_3 ln(ozone\ concentration)}$$

The total societal cost derived from this equation is scaled to reflect the difference in the WTP values used by PwC and M&M.

Societal costs of secondary pollutants using value transfer from M&M

→

Ratio:

M&M US WTP estimates to PwC US WTP estimates

→

Total societal costs of secondary pollutants consistent with the WTP values used for primary pollutants

3. Visibility

Impacts on visibility

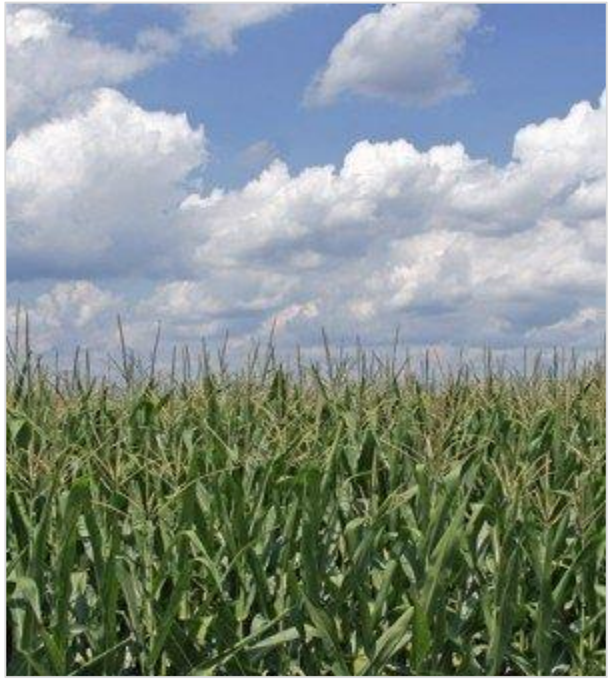
- The impacts include reduction in amenity value for residents of major cities, as well as reduced quality of views (e.g., mountain vistas).
- The EP&L quantifies and values societal impacts in one step using a multivariate transfer function constructed based on Muller and Mendelsohn's (2007) visibility results for US counties.
- The transfer function allows a location specific estimate of air pollution impacts on visibility as a function of ambient ozone concentration, temperature, rainfall, local population density and income.

$$\begin{aligned}\ln(\text{societal cost})_i &= \alpha + \beta_1 \ln(\textit{population density}) + \beta_2 \ln(\textit{median income}) + \beta_3 \ln(\textit{annual rainfall}) \\ &+ \beta_4 \ln(\textit{average annual maximum temperature}) \\ &+ \beta_5 \ln(\textit{ambient ozone concentration})\end{aligned}$$

4. Agricultural productivity

Impacts on agricultural productivity

- Not all air pollutants are harmful to crop productivity, however, low level ozone inhibits plant growth, therefore VOC, NOx and NH3 emissions which contribute to ozone can result in reduced agricultural productivity.
- The lost economic value of crops is used as a proxy for the societal impact of air pollution via agriculture, calculated as the change in production caused by a one tonne increase in the pollutant, multiplied by the average market price for the crop.
- The EP&L applies these societal costs to different locations adjusting the values based on Gross National Income (at PPP).

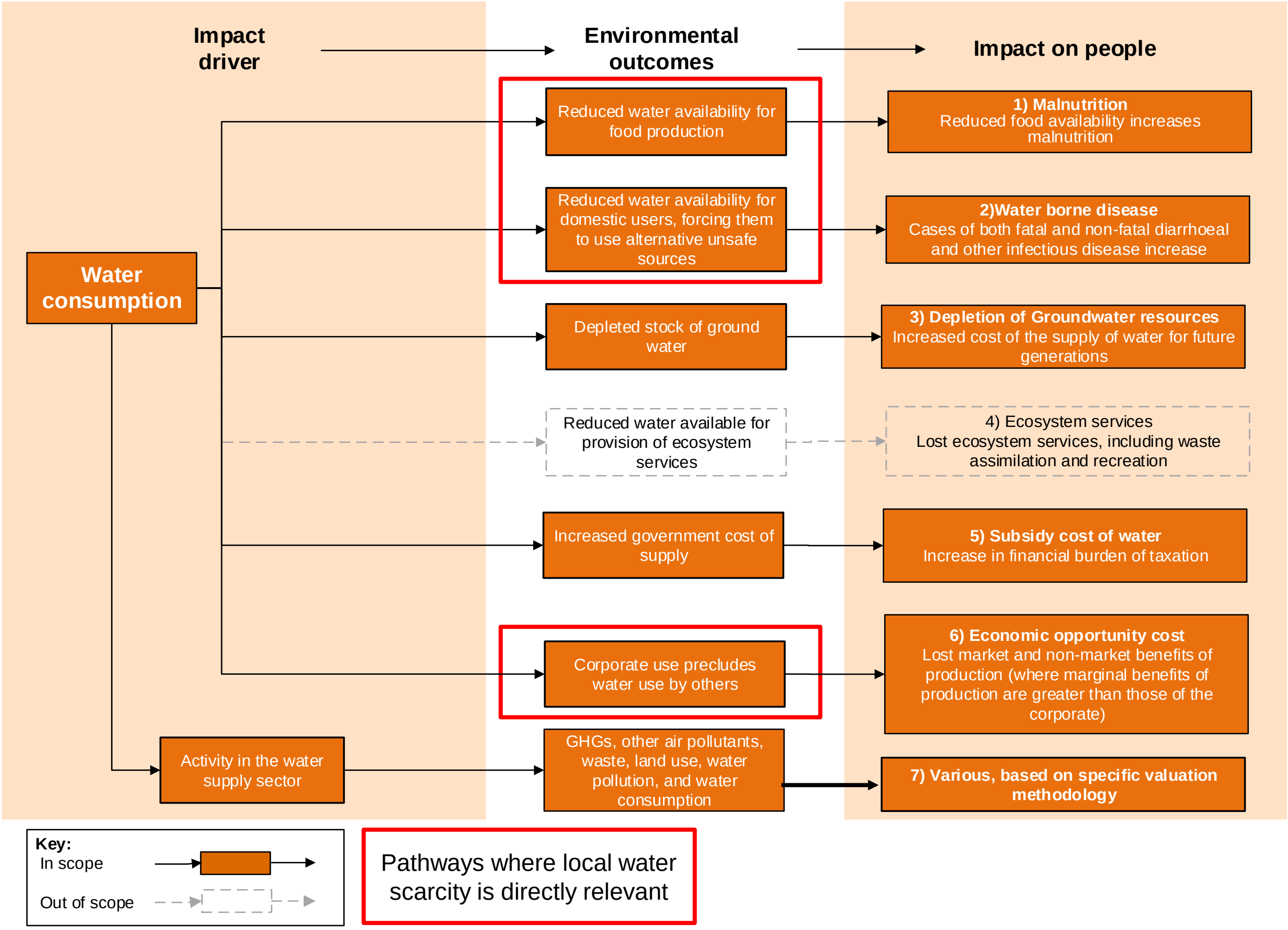


Overview of valuation methods:
Water consumption

Water consumption

Impact pathway

Our water consumption valuation methodology considers water consumed by an organisation. The impact pathway below illustrates the relationship between an organisation consuming water, the environmental outcome and the subsequent impact on people.



Water consumption

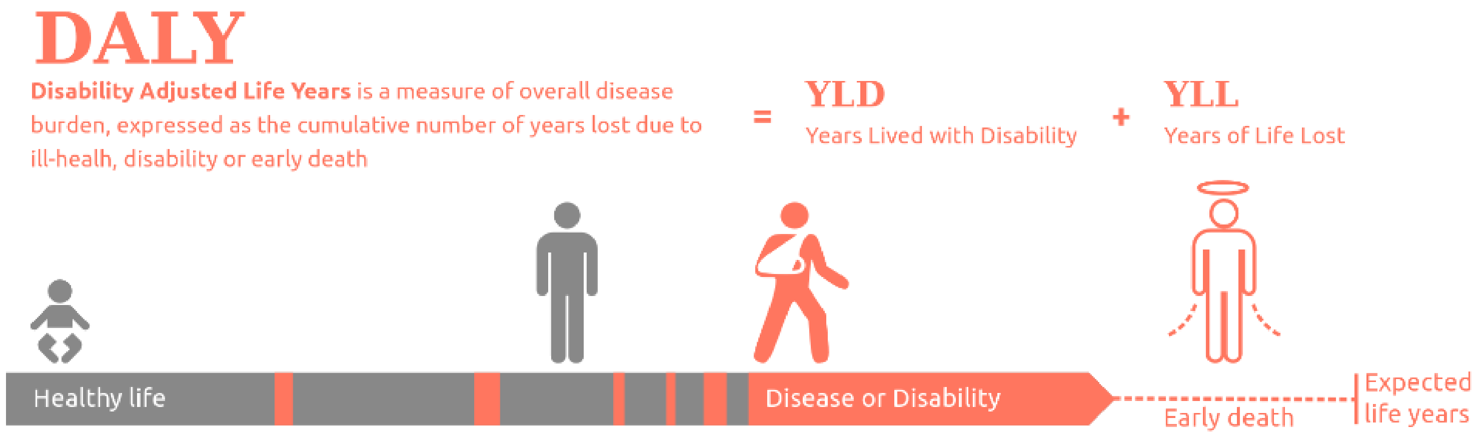
Valuation modules

Introduction to DALYs

1. Malnutrition
2. Water Borne Diseases
3. Depletion of Groundwater resources
4. Subsidy Cost of Water
5. Economic Opportunity Cost

Introduction to Disability Adjusted Life Years (DALY)

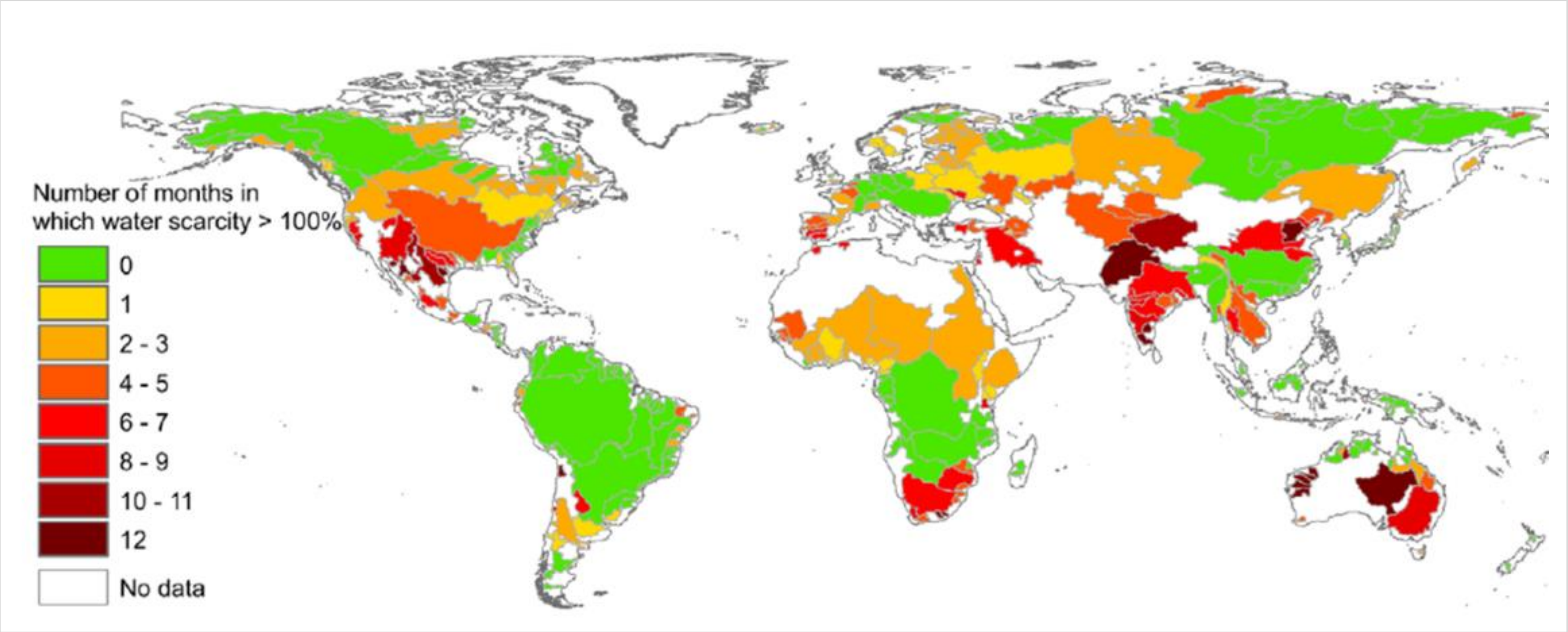
- DALYs measure the **overall burden of disease**, combining years of life lost due to premature death (**YLL**) and 'healthy' years lost due to ill health of disability (**YLD**).
- Number of healthy years lost are calculated by multiplying the length of time the disease occurs and a disability weighting based on the severity of the disease (Prüss-Üstün et al. 2003, WHO).



1. Malnutrition

Overview

- Industrial water use can reduce the water available for agriculture, which can drive malnutrition in some countries.
- The standard metric of **DALYs** is used to estimate the welfare impacts per m^3 of water consumption.
- The **Water Stress Index** (WSI) is used to indicate the local pressure on water resources and provides a measure of competition between users.
- The WSI is calculated on a scale of 0.01 to 1, indicating the average proportion of water consumption by one user that deprives another user (in a given water shed, Alcamo et al., 2003)



Source: Water Footprint Network, 2012

1. Malnutrition

Valuation of societal costs (1/2)

Step 1: Calculate the Water Deprivation Factor (WDF)

- WDF estimates the amount of water the agricultural sector is deprived of as a result of water consumption by others.

$$WDF_i = WSI_i \times WU_{\%},agriculture,i$$

Step 2: Calculate the Effect Factor (EF)

- The EF is the annual number of malnourishment cases caused by deprivation of 1 m³ of freshwater. It is a function of the water required to avoid malnutrition (WR) and the Human Development Factor related to vulnerability to malnutrition (HDF).

$$EF_i = WR_{malnutrition}^{-1} \times HDF_{malnutrition,i}$$

Step 3: Calculate the Damage Factor (DF)

- The DF estimates the amount of harm per case of malnutrition and is derived from a regression of the Malnutrition rate (MN) and the DALY malnutrition rate, at a country level.

$$DFmalnutrition = DALYs \ / \ capita.year$$

Step 4: Calculate the Human Health Factor (HHF)

- **HHF** describes the DALYs per unit of water consumed using outputs from steps 1-3

$$HHFi(DALYsm^3consumed) = WDF_i \times EF_i \times DF_{malnutrition}$$

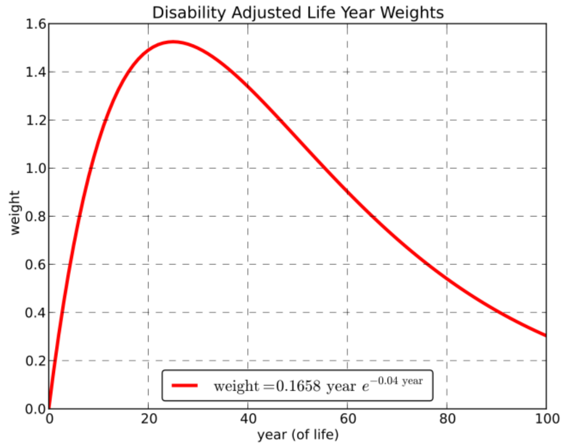
1. Malnutrition
Valuation of societal costs (2/2)

Step 5: Estimate the monetary value to a DALY

- The Value of Statistical Life (VSL) is used to derive the value of the DALY (Lvovsky et al. 2000 & Pearce et al. 2004)

  Value of DALY= VSL / Number of DALYs lost

- DALYs are weighted as the value of a year of disability free life differs for all ages. **A higher value** is placed on avoiding disabilities between early teens to mid fifties (Prüss-Üstün *et al.*, 2003).
- A 3% discount rate is applied to future years as people are willing to pay more to avoid disability today than to avoid it in the future.
- The number of DALYs is calculated by multiplying the proportion of life lost (PLL) by the life expectancy:



Age of premature death	Life expectancy	Proportion of life lost (PPL_{wd})	DALYs lost (PLL_{wd} x life expectancy)	VSL	Value of DALY
47	78	23.4%	18.3	$3.4m	$185,990

- The value of a DALY for OECD nations is transferred to other countries, where an income is included differences between income per capita are adjusted for PPP.

Step 6: Estimate the societal cost

- The societal cost can be estimated by multiplying the number of DALYs /m³ of water consumption with the welfare value per DALY.

2. *Water Borne Diseases*

Valuation of societal costs (1/2)

Poor water infrastructure + Reduction in clean water due to corporate water use → Consumption of dirty water → Diarrhoeal diseases / Other water-borne infectious diseases

The environmental outcome of corporate water consumption is reduced water availability to domestic users.

This is calculated by: **Corporate water consumption x WSI**

Step 1: Construct an econometric model for water-borne disease

- Analysis by Motoshita et al. (2010) shows that water-borne disease decreases as household connection to water increases. PwC includes WSI and econometric results to predict how water-borne disease would reduce if corporate water use was reallocated to domestic users.

Identify relevant water-borne diseases

- Diarrhoeal diseases
- Other non-diarrhoeal infectious diseases e.g.:
  - Intestinal nematode infections
  - Protein-energy malnutrition
  - Lymphatic filariasis

Set out Hypothesis to be tested & key variables

- Null hypothesis: increase in clean water availability would reduce water-borne disease.
- Example variables:
  - DALYs associated with diarrhoeal/non diarrhoeal water-borne diseases.
  - Domestic water withdrawal/capita/year

Construct econometric models

- Cross country datasets used for analysis
- Chosen specification for diarrhoeal and non diarrhoeal models.

$$\ln Dalys = \alpha + \beta 1 \ln dww + \beta 2 \ln undernour + \beta 3 \ln healthexp + \beta 4 \ln wsi + \beta 5 \ln govteff$$

- Quantile regression is used as it provides different relationships for different country groups.

2. *Water Borne Diseases*

Valuation of societal costs (2/2)

Step 2: Predict how water-borne disease would change if corporate water use decreased**.**

- Regression analysis has shown that for locations where the prevalence of disease is below **0.0016 DALYs/capita/yr** for diarrhoea and **0.0009 DALYs/capita/yr** for non- diarrhoea, the level of domestic water use **does not** influence the **prevalence of disease**.
- Where disease levels are **below** these levels there is considered to be **no impact** of corporate water use on the prevalence of water borne disease. Where disease levels are **above** these values the DALYs per capita per year for each group of diseases are predicted from the econometric model.
- The total corporate and industrial water use for a locality is multiplied by the WSI to give the portion that deprives other users of water. This is reallocated to domestic users to predict how much lower DALYs per capita per year could be if this water was available to domestic users.

$$\mathbf{DALY/m^3}_{\textbf{corporate consumption}} = \textbf{Reduction in DALYs/capita/year x population}_{\textbf{region}}$$

Step 3: Assign the value of a DALY

- Locally-specific DALY values are assigned to DALY/m^3 estimates using age weighted adjustment and parameter estimates from the OECD.

Step 4: Calculate the societal impacts of disease

- The overall societal cost per m^3 can be estimated from the damage factor of corporate water use in DALYs lost to disease per m^3 of water withdrawal and the location specific value of a DALY.

3. Depletion of Groundwater resources

Valuation of societal costs

- The rate of groundwater depletion and the expected time to depletion are used to estimate the future annual shortfall in water supply for a given water basin/region.
- The environmental outcome of corporate groundwater consumption is the reduced stock and ultimate depletion of groundwater reserves.
- Location specific estimates can be developed to **estimate the societal costs** based on the predicted socio-economic impacts in the given context. An **increased cost of supply** is used as a lower bound proxy for potential societal impacts.

Step 1: Estimate the cost of future water supply

- Desalinisation and transportation costs are used as a **proxy** and are income adjusted according to the location of interest.

Step 2: Estimate the cost per unit of water withdrawn in current year

- The **future** cost of groundwater depletion is averaged over the total water withdrawal.
- The discounted of future water supply associated with the current year depletion is divided by the total water withdrawal within that location.

4. *Subsidy Cost of Water*

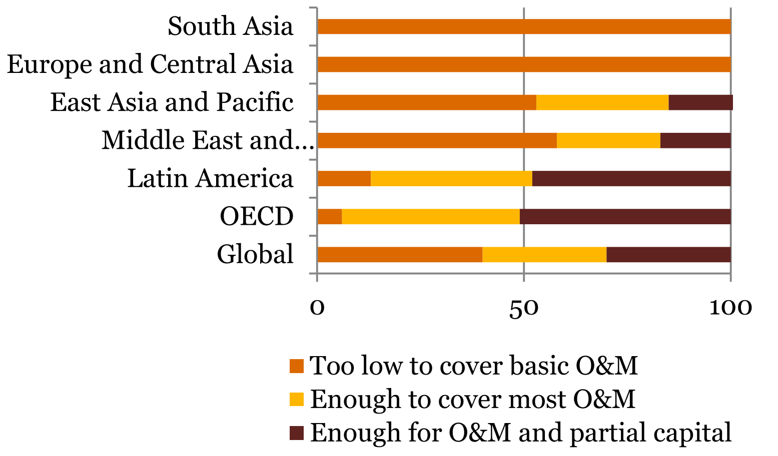
Valuation of societal costs

- Subsidy costs of water estimated the financial burden imposed on tax payers as a result of subsidies on corporate water use.
- The World Bank's (2005) review of average water tariffs in 132 major cities found that 40% were not sufficient to cover basic operation and maintenance costs (O&M).
- Within the OECD only 50% covered O&M and "some" capital costs.
- As there is only partial cost recovery, corporate water use puts a financial burden on tax payers supporting subsidies.
- To calculate the subsidy costs, for a given price schedule:

Subsidy Costs = Revenue from water supply – financial costs of delivery

- This gives the total shortfall in finances, which can then be attributed to water use per m^3 (withdrawal not consumption).

Cost recovery in water pricing
(% of utilities who's average tariffs are…)



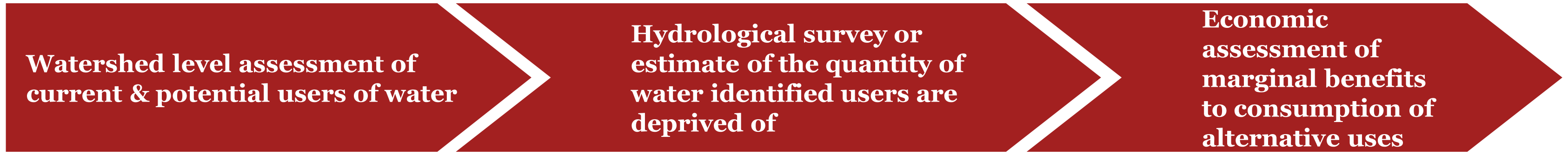
5. *Economic Opportunity Cost*

Environmental outcomes

Economic opportunity costs of water consumption occur when corporates use of water deprives another user of water, and that other user has a higher value for the water, or can create a higher social value from that water.

Total economic value includes the private gains from consumption, as well as the social benefits associated.

The WSI provides an indication of the quantity of water which is deprived from other users. To identify the opportunity cost specific users who are directly deprived must be identified.



Valuation of societal costs

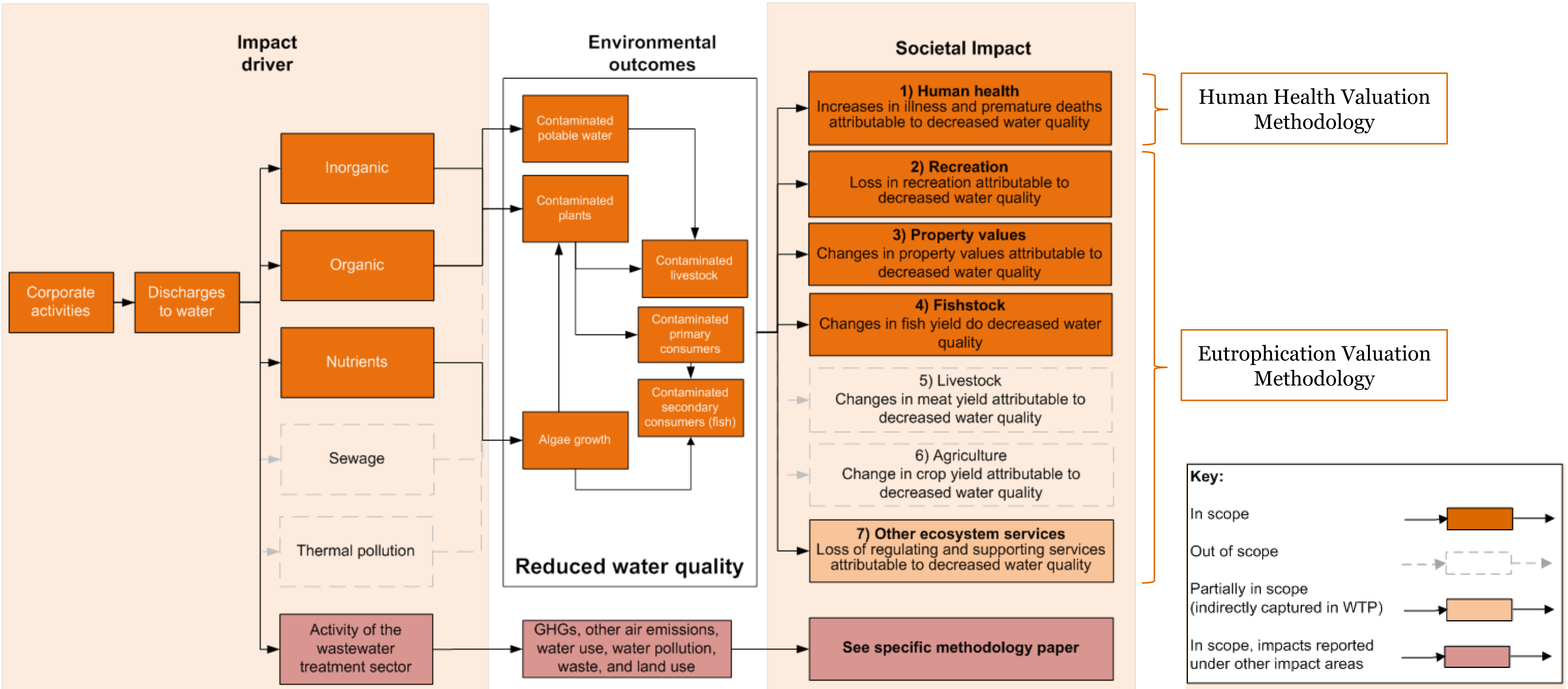
- The impacts associated with inefficient allocation of water resources are equal to the difference in societal gains between the corporate's use and the most efficient user of the water.
- To identify the optimal allocation the societal gains should be considered at the margin (societal gains/unit of water consumption, at a given level of water provision).

Overview of valuation methods:
Water pollution

Water pollution

Impact pathway

Our water pollution valuation methodology covers environmental impacts associated with corporate-driven emissions of major pollutants species, including nutrients, heavy metals and organics. The impact pathway below illustrates the relationship between an organisation producing water pollutants, the environmental outcome and the subsequent impact on people.

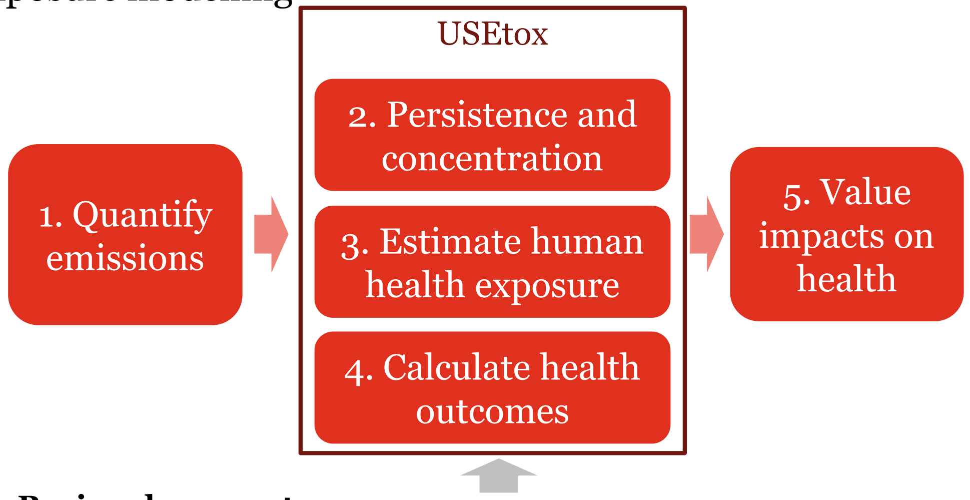


Water pollution

Summary of calculation approach

Toxic effects on human health

- Effects of ingestion via contaminated drinking water and foodstuffs
- Based on EU approved USEtox, combining chemical fate and exposure modelling

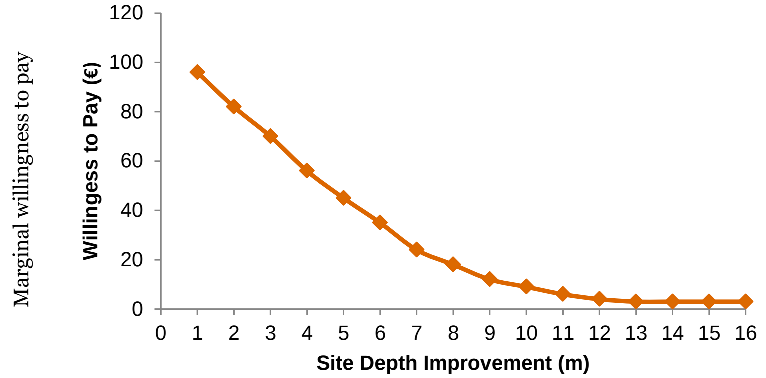


Regional parameters:
Fresh vs. sea emissions, volume and flow, temp. and rain
Population parameters:
Diet composition and access to treated water
Chemical parameters:
Solubility, degradation rates, bioaccumulation and does response function

Eutrophication

- Excess nutrients in fresh (phosphorus) and sea (nitrates and phosphorus) water result in algae blooms, affecting ecosystems, fishing and recreation
- Estimates of the willingness to pay for improved water quality are used to estimate well-being impacts

1. Calculate emissions
2. Estimate eutrophication potential based on regional parameters
3. Benefit transfer of WTP estimates adjusting for income and preference differences



Water pollution
Valuation modules

1. Human Health
2. Eutrophication

1. Human Health

Prioritising pollutants

- The human health module of the water pollution valuation methodology considers the potential health impacts associated with individual water pollutants. Specific water pollutants are selected from a USEtox database of over 3,000 organic and inorganic chemical species, which can contribute to a diverse range of potential health impacts.
- The pollutants that are most material to a given company value chain vary significantly depending on the industry and location in which it operates. It is therefore critical to identify the key chemical pollutants to be assessed during the scoping phase of a project.
- A top down analysis using country level data on point source emissions in the Netherlands (CBS, 2011) and the US (EPA 2010,2011) identifies heavy metals to be the most significant source of human toxicity in the US, representing about 85% of the total impacts from point source emissions. This provides the rationale for the 16 priority pollutants that we typically cover in all E P&L analyses:

Antimony	Mercury
Arsenic	Molybdenum
Barium	Nickel
Benzene	Polycyclic aromatic hydrocarbons
Cadmium	Thallium
Chromium	Selenium
Copper	Vanadium
Lead	Zinc

1. Human Health
Environmental outcomes

USEtox is used to model the movement of each pollutant through the environment, the human exposure to each pollutant and the associated human health outcomes.

The output of the model is a set of pollutant-specific **Characterisation Factors (CF),** which give the number of health harms per unit of pollution emitted (cancer & non cancer per kg of pollutant):

$$CF = FF \times XF \times EF$$

Step 1: Calculate the Fate Factor (FF)

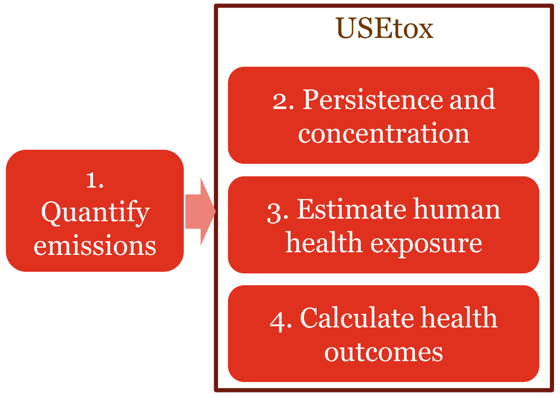
- Amount of pollutant available for eventual intake by humans (calculated from the residence time)

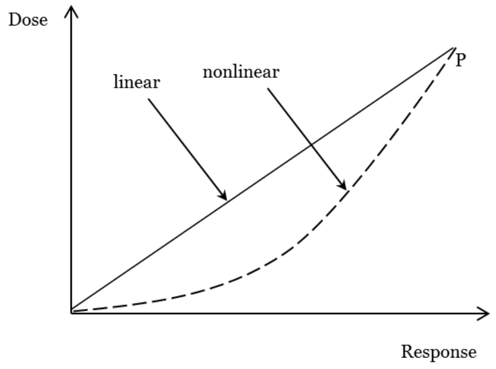
Step 2: Calculate the Exposure Factor (XF)

- The rate of direct (ingestion and inhalation) and indirect (ingestion and dermal contact) intake of a substance
- Estimate the number of people exposed to a pollutant (amount and extent of exposure)

Step 3: Calculate the Effect Factor (EF)

- The EF is based on linear dose response function and describes the incidence of adverse health effects in the exposed population





1. Human Health

Valuation of societal costs (1/2)

The severity of health harm is approximated using DALYs and the monetary value of these DALY totals (based on WTP).

Step 1: Estimate the DALYs for each health harm

- The critical effects are used to estimate the DALY for each substance.
- Average DALY values for cancer and non-cancer effects (of **11.5** and **2.7** respectively) were applied when critical effects were not identified in the database.

Step 2: Applying a monetary value of a DALY

- A monetary value of a DALY is calculated by:
- $\boldsymbol{Value\ of\ DALY = \frac{VSL}{Number\ of\ DALYs\ lost}}$, where the OECD VSL (Value of Statistical Life) estimate **of $3.4m** (2012) is used.
- DALYs are weighted as the value of a year of disability-free life differs for all ages. A higher value is placed on avoiding disabilities between early teens to mid fifties (Prüss-Üstün et al., 2003).
- The number of DALYs is calculated by multiplying the proportion of life lost (PLL) by the life expectancy (as shown in the example below).

Age of premature death	Life expectancy	Proportion of life lost	DALYs lost	VSL	Value of DALY
47	78	23.4%	18.3	$3.4m	$185,990

1. Human Health

Valuation of societal costs (2/2)

Step 3: Compute the total cost of human health impact for each toxic pollution

- For each pollutant, the change in the number of health effects arising from a release of a pollutant into the water course is multiplied by the relevant DALY value (PPP-adjusted if desired) to give the total cost associated with the emissions in the country:

$$\boldsymbol{Impact_{c1,fw,mw,z} = Metric\ quanitity_{c1,fw,z} \times Characterization\ factor_{c1,fw,z} \times DALYs_z \times DALY\ value_{c1} + Metric\ quanitity_{c1,mw,z} \times Characterization\ factor_{c1,mw,z} \times DALYs_z \times DALY\ value_{c1}}$$

- The Global pollutant cost can be calculated by:

$$\boldsymbol{Global\ impact_z = \sum(impact_{c1,fw,mw,z}, impact_{c2,fw,mw,z}, impact_{c3,fw,mw,z}, \ldots impact_{cn,fw,mw,z})}$$

- The Global water pollution cost can be calculated by:

$$\boldsymbol{Global\ impact_{total} = \sum(Global\ impact_z, Global\ impact_y, Global\ impact_x, \ldots Global\ impact_n)}$$

Where: *c1* is the location, *fw* is freshwater, *mw* is marine water & *z, y and x* are the values for specific pollutants.

2. *Eutrophication*

Environmental outcomes

The valuation module for nutrients estimates the eutrophication potential of nutrients in fresh and marine water.

The value of eutrophication is estimated using published data on what individuals would pay (**WTP**) to avoid these harms.

The eutrophication potential of excessive nutrients released into the water course is calculated.

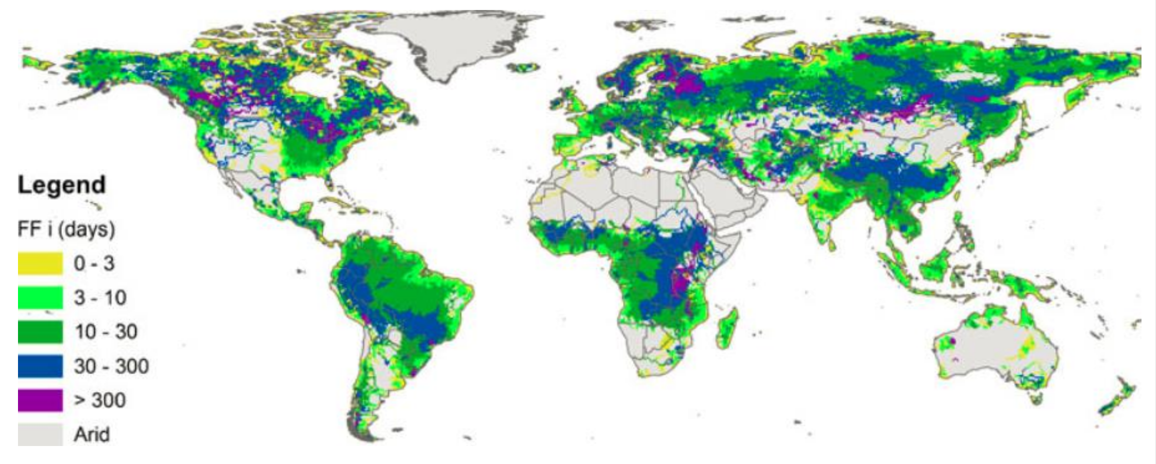
- For freshwater the eutrophication potential of Phosphorus (P) is calculated
- For marine water the eutrophication potential of Phosphorus (P) and Nitrogen are calculated

Step 1: Determine the environmental outcomes of phosphorus in freshwater

- Helme's phosphorus model is used to derive spatially explicit fate factors for P emissions to freshwater
- The eutrophication potential of P is calculated per **1kg of P** released into freshwater

Step 2: Determine the environmental outcomes of P and N in marine water

- The Life Cycle Assessment Handbook (ISO LCA standards guide) states that **1kg of P has 7x** more eutrophying potential than **1kg of N** in marine water (Redfield Ratio).



Source: Helmes et al., 2012

2. Eutrophication

Valuation of societal costs

A welfare based approach is used to calculate the damage values associated with eutrophication (Ahlroth, 2009).

Step 1: Valuing eutrophication in freshwater

- Ahlroth's damage value of P was calculated using a **structural benefit transfer** of 8 studies. Respondents provided their WTP and an average WTP per unit of emissions was calculated
- Ahlroth assumes constant marginal WTP which results in a price of **$136 per kg of P** (adjusted by PPP if desired when applied to other countries).

Step 2: Valuing eutrophication in marine water

- The central estimate price per kg of P in marine water is **$68 per kg** and **$9 per kg** for **N** (adjusted by PPP if desired when applied to other countries).
- Additional locally specific values can be obtained from the literature where the impacts of eutrophication in marine water may be significant.

Step 3: Sum the societal impacts of all excess nutrients (country specific impact):

$$\boldsymbol{Impact_{c1.fw,mw,N,P} = Metric\ quanitity_{c1,fw,P} \times Eutrophication\ potential_{c1,fw,P} \times WTP_{c1,fw,P,} +}$$
$$\boldsymbol{Metric\ quanitity_{c1,mw,N} \times Eutrophication\ potential_{c1,mw,N} \times WTP_{c1,mw,N} +}$$
$$\boldsymbol{Metric\ quanitity_{c1,mw,P} \times Eutrophication\ potential_{c1,mw,P} \times WTP_{c1,mw,P}}$$

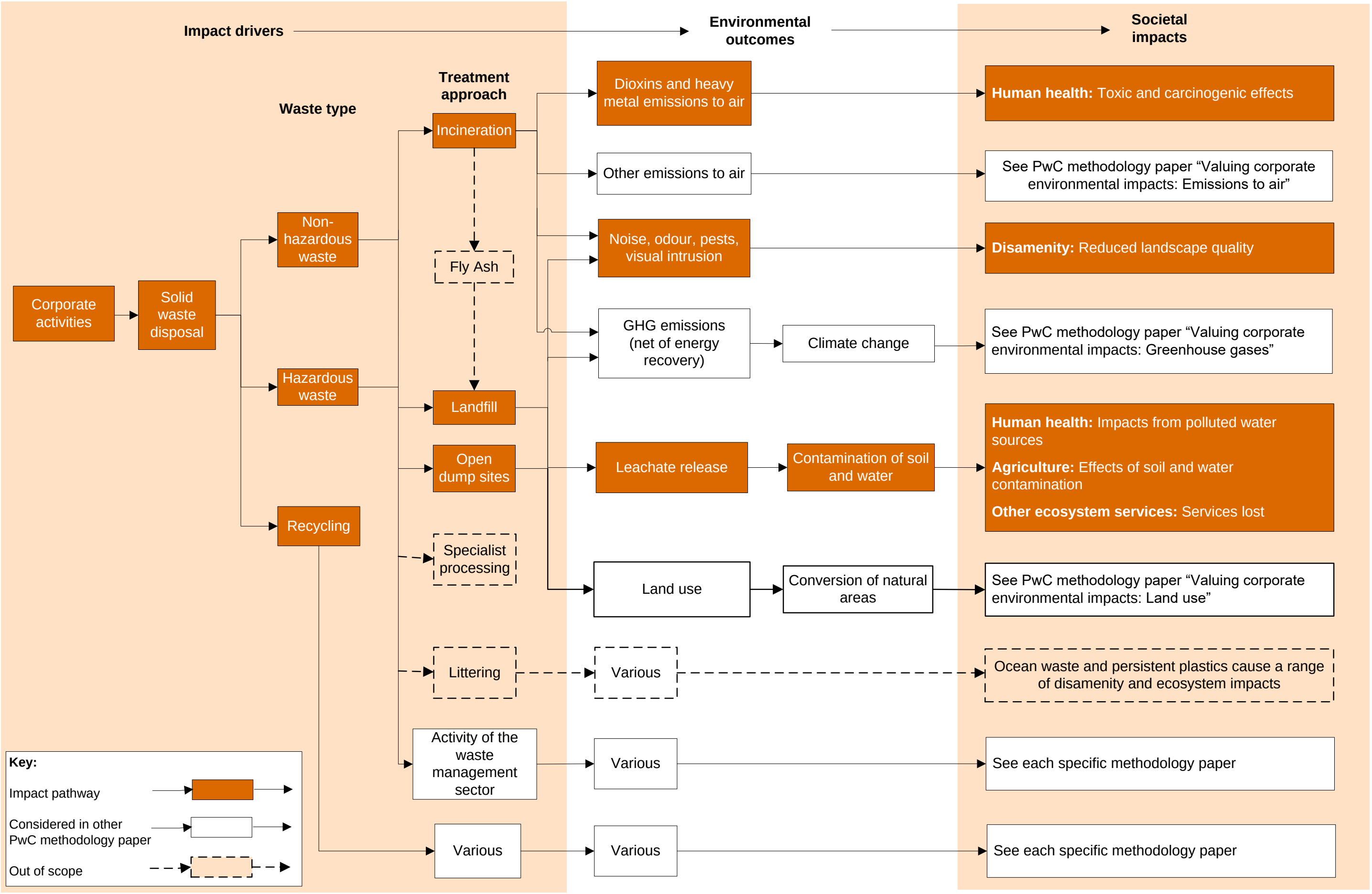
Where: *c1* is the location, *fw* is freshwater, *mw* is marine water, *N* is Nitrogen & *P* is Phosphorus .

Overview of valuation methods:
Solid waste

Solid waste

Impact pathway

Our waste valuation methodology covers impacts associated with the disposal of both hazardous and non-hazardous solid waste. The impact pathway below illustrates the relationship between an organisation producing these two waste types, the environmental outcome and the subsequent impact on people.

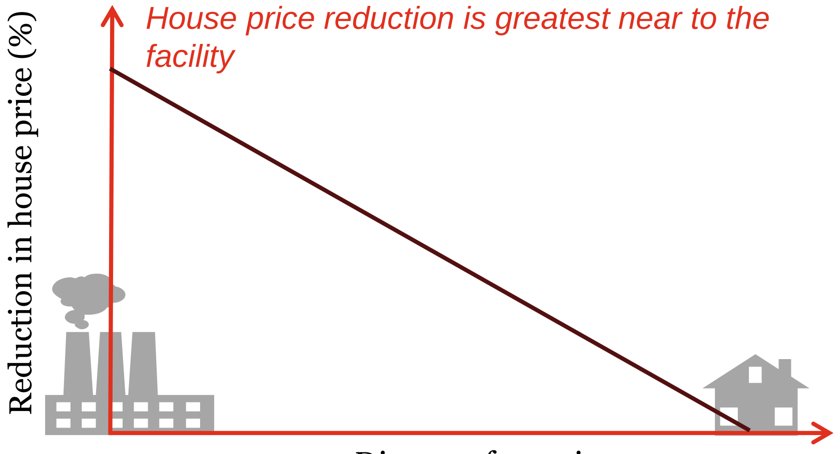


Solid waste

Summary of calculation approach (for disamenity and leachate impacts)

Disamenity

- Waste disposal facilities reduce peoples enjoyment of an area
- Common practice is to estimate the impact based on local house price reductions



- We combine 12 peer reviewed estimates of the function from Europe and America with 5 developing world estimates.

Leachate

- Leachate from landfill can pollute soil and water courses
- US EPA and DEFRA suggest estimating risk of leachate and valuing cost of clean up
- We use recent peer reviewed model (Singh et al, 2012):

Leachate risk - key variables

Source	Composition of leachate – determined by composition of waste
	Precipitation that infiltrates the landfill
Pathway	Escape of leachate – determined by leachate collection system, quality of liner and geology of site
	Aquifer characteristics
Receptor	Presence and use of groundwater near to site

Solid waste
Valuation modules

1. Disamenity
2. Leachate
3. Air pollution
4. GHGs

1. Disamenity

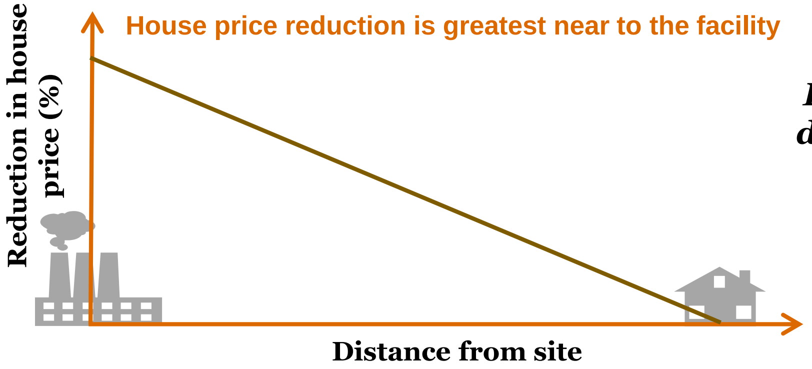
Environmental outcomes

- Negative environmental outcomes of waste management include **noise**, **odour**, **pests** and **visual intrusion**.
- The reduction in the price people are prepared to pay for a house on the basis of its proximity to a waste management site (either landfill or incineration site) reflects the net present value of the disamenity they will incur over the lifetime of the waste management site.
- A linear **hedonic price function** (HPF) is used to describe the change in house price as a function of how far the property is from a waste management facility.
- Hedonic pricing is considered best practice in the academic literature for quantifying disamenity impacts associated with waste disposal facilities.

1. Disamenity

Hedonic Price Function (HPF)

- The linear HPF has been derived from a meta-analysis of academic studies:



Percentage change in house price with distance from waste management site= 4.06r – 11.05

- The total change in house values attributable to the presence of a waste site, can be approximated by integrating this function over the distance at which each house is from the site boundary (Eunomia, 2002), this gives the hedonic function transfer factor, F

$$\textit{Total disamenity cost per site} = -P\,\rho\,2\,\pi \int_0^{2.72} (11.05 - 4.06r)\, r.\delta r$$

$$= -P\,\rho\,2\,\pi\,[5.52r^2 - 1.35r^3]_0^{2.72}$$

- The Hedonic function transfer factor, F, can be derived by defining F:

$$\textit{Total disamenity cost per site} = FP\rho$$

$$FP\rho = 0.86P\rho$$

$$F = 0.86$$

1. Disamenity

Valuation of societal costs

Estimating disamenity per tonne of waste

- In order to express the total disamenity associated with a landfill or incineration site per tonne of waste going to that site, we divide total disamenity by the discounted waste that flows to the site over its remaining lifetime.

$$\boldsymbol{WTP\ per\ tonne\ waste\ (landfill, incinerator) = \frac{P\ \rho\ F\ n}{\sum_1^T W/(1-DR)^t}}$$

Where F = hedonic function transfer factor, n = number of waste sites in the country/location (landfill and incineration), W = annual national waste to landfill/incinerator (tonnes per year), DR = discount rate, and t = remaining site lifetime (years).

Estimating societal impact

- The WTP figure per tonne of waste (calculated above) is then multiplied by the volume of waste from the corporate related to that location.

2. Leachate release

Modelling frequency and severity

- There are a number of variables which influence the likelihood of occurrence and consequent severity of leachate. These can be split by source, pathway, and receptor.
  - **Source** refers to the generation potential of leachate from the waste. This includes the amount and composition of waste as well as local precipitation rates and the presence and type of landfill cover.
  - **Pathway** refers to the how the leachate escapes the landfill and enters the surrounding systems. The presence and quality of a liner, geology of the site, depths of aquifers and distance to waterways are considered here.
  - **Receptor** refers to the way in which the leachate is likely to result in societal impacts. For example, the presence of groundwater used by human or livestock populations, or proximity to sensitive ecosystems are relevant factors.
- The HARAS model (Singh *et al.*, 2012) is used to generate a leachate risk factor estimated on a scale of 1 to 1000 representing the likelihood and likely severity of leachate impacts, based on source, pathway, and receptor characteristics.

2. Leachate release

Valuation of societal costs

Step 1: Estimate societal cost under 'worst case' scenario

- The worst case scenario, as defined in the HARAS model, has a score of 1000. This should be based on a relevant location (e.g. known location within the country in question) with no landfill liner; hazardous waste; high soil permeability; high population density. For example, a worst case site in Illinois in the US was characterized as follows:

$$\textit{worst case societal cost of leachate} = \frac{\textit{Total cost of remediation}}{\textit{Landfill capacity}} = \frac{USD\ 8,950,000}{130,000\ \textit{tonnes}}$$

$$= 69\ \$/\textit{tonne solid waste}$$

Step 2: Adjust for risk and likely severity of leachate impacts in specific location

- Use risk score of the specific location to adjust the societal cost of the worst case scenario:

$$\textit{location specific societal cost of leachate} = \frac{\textit{risk score}}{1,000} \times \frac{\$}{\textit{tonne}}$$

Step 3: Benefit transfer of cost estimate to country of interest, adjusting for PPP.

Step 4: Once the location or country-specific societal costs of leachate per tonne of waste disposed have been established, we can calculate the overall cost arithmetically by multiplying these figures by the volume of waste in each location.

3. *Air pollution*

Environmental outcomes

Air pollution covers the environmental outcomes and subsequent societal cost from incinerating waste. Landfills are not addressed as they produce trivial volumes of non-GHG emissions (EXIOPOL, 2008). The air pollutants from incineration are classed in two categories: dioxins and heavy metals, and traditional air pollutants.

To estimate the societal costs of the traditional air pollutants (NOx, SOx, PM10 & PM25), the EP&L uses the methods described in the air pollution methodology.

Dioxins and heavy metals – quantification of environmental outcome

Step 1: Calculate quantity of emissions

- Reliably measured data on heavy metal and dioxin emissions from incinerators is rare, but if available should be used. More realistically, heavy metal and dioxin emissions per tonne of waste can be approximated using national or regional emissions limits for waste incineration (EXIOPOL, 2009).

Step 2: Calculate the health endpoints and societal costs associated with the emissions

- Dose response functions describe how many health endpoints (response) are likely to be associated with a given level of emissions (dose).

3. Air pollution
Valuation of societal costs

Dioxins and heavy metals – valuation of societal cost

Step 3: Calculate the societal cost of fatal and non-fatal cancer and lost IQ points

- The output of the dose-response calculation is number of cases of cancer and lost IQ points.
- National statistics are used to calculate the portion of fatal and non-fatal cases. Cases which are fatal are valued using the value of statistical life (VSL).
- There is considerable variation in the WTP to avoid cases of non-fatal cancer based on the type of cancer as well as the method and sample of the study (OECD, 2006). We apply a figure which is 10.5% of the VSL (the mid-point of the studies quoted by the OECD).
- A range of values exist in the literature for the societal cost of lost IQ points, these are mostly based on lost earnings or remedial education. We follow the precedent of both Spadaro & Rabl (2004) and ExternE (2004) in taking an intermediate value of USD 17,500 per IQ point (in 2011 prices).

Step 4: Adjust for inflation and for income at PPP if required.

Step 5: Calculate the total societal cost.

- Once the number of health endpoints (e.g. cancer or lost IQ) associated with each tonne of waste, and the societal cost per health endpoint, have been calculated for each relevant location, the results can be multiplied by the tonnage of waste going to each location to calculate the total societal cost of dioxins and heavy metal.

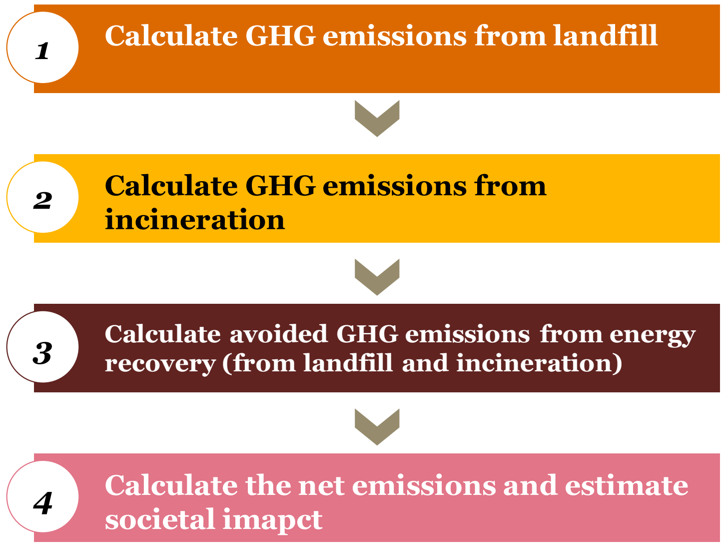
4. Greenhouse gases

Environmental outcomes (1/2)

Net anthropogenic GHGs from waste disposal are calculated in four steps and then valued using the societal cost of carbon from the GHG methodology.

1. **Calculate GHG emissions from landfill**: Landfill gas is usually around 50-55% CH_4 and 45-50% CO_2 (IPCC 2006). The IPCC model used in the EP&L can be adjusted for the different conditions present in landfills, as well as the characteristics of waste, which determine the rate of decomposition and formation of CH4 relative to CO2.

2. **Calculate GHG emissions from incineration**: CO2 emissions per tonne of waste are estimated by applying the carbon intensity of the incineration process to the volume of waste sent to incineration. Alongside the large quantities of CO2 that are released into the atmosphere, much smaller quantities of nitrous oxide (N2O) and CH4 are also released. According to the IPCC (2000) CO2 is the most significant GHG from waste incineration by at least two orders of magnitude and for this reason only CO2 emissions are considered further in the EP&L.



4. Greenhouse gases

Environmental outcomes (2/2)

3. **Calculate avoided GHG emissions from energy recovery from landfill and incineration**. Landfill gas to energy (LFGTE), where landfill gases are captured and burned to generate electricity, avoids emissions from usual sources of electricity generation. Avoided GHG emissions from both LFGTE and waste incineration can be calculated using the equation below (in the case of waste incineration, the energy potential of waste variable is replaced with a variable specific to the energy recovered per tonne of waste incinerated).

$$\textit{Avoided GHG emissions from LFGTE } (tCO2e) = \textit{waste sent to LFGTE } (t) \times \textit{energy potential of waste } \left(\frac{kWh}{t}\right) \times \textit{grid carbon intensity } \left(\frac{tCO2e}{kWh}\right)$$

4. **Calculate net emissions**: Avoided emissions are subtracted from the total emissions from landfill and incineration. Net GHG emissions are then converted to units of CO2e using Global Warming Potential factors estimated by the IPCC (as described in the GHG valuation methodology). Then, in order to value the associated societal impacts, the Social Cost of Carbon is applied as described in the GHG valuation methodology.

Solid waste

Summary of valuation methodology scope

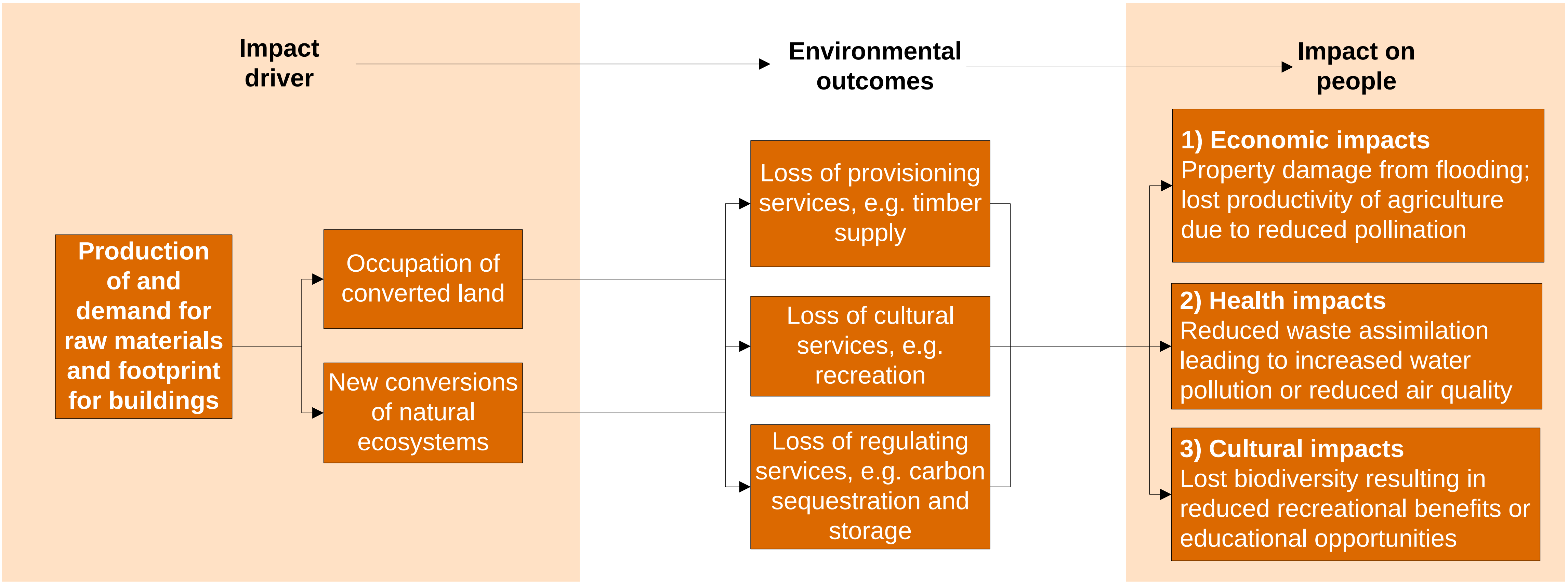
Impact pathway	Quantified in the solid waste methodology				Valued in the solid waste methodology			
	Incineration		Landfill / dumpsite		Incineration		Landfill / dumpsite	
Disamenity	✓		✓		✓		✓	
Leachate	×	Immaterial	✓		×	Immaterial	✓	
Greenhouse gas emissions	✓		✓			Other PwC methodology		Other PwC methodology
Air pollution	✓		×	Immaterial		Other PwC methodology	×	Immaterial
Land use		Other PwC methodology		Other PwC methodology		Other PwC methodology		Other PwC methodology
Recycling		Treated like any industrial process		Treated like any industrial process		Treated like any industrial process		Treated like any industrial process
Specialist processing		Not covered		Not covered		Not covered		Not covered
Littering and ocean waste		Not covered		Not covered		Not covered		Not covered

Overview of valuation methods: Land use

Land use

Impact pathway

Our land use valuation methodology covers the following areas: occupation of converted land and new conversions of natural ecosystems. The impact pathway below illustrates the relationship between an organisation's land use from raw material demand and structural footprint, the environmental outcome and the subsequent impact on people. Within our valuation methodology we consider economic impacts, health impacts and cultural impacts of land use.



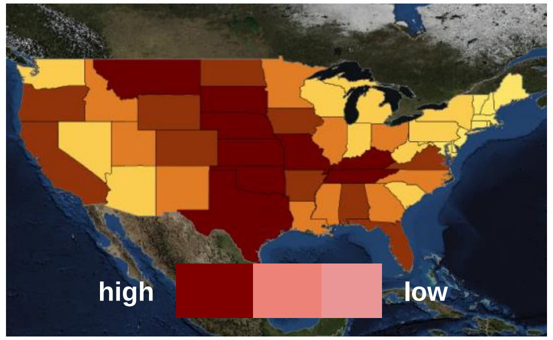
Land use

Summary of calculation approach

1. Calculate land area

- Regional yield data from FAO or national statistics

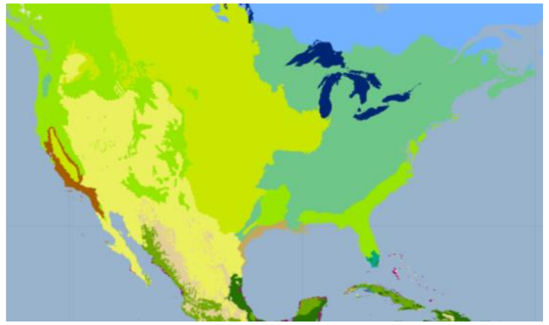
Cattle density per ha in the US



2. Identify type of ecosystem

- GIS analysis for different land types:
  - Tropical forest
  - Temperate forest
  - Grassland
  - Desert
  - In-land wetland
  - Coastal wetland

WWF Wildfinder, 2006



3. Estimate proportion of ecosystem services lost

- Identify which ecosystem services are lost/reduced, based on type of land use change, e.g:
  - Change in carbon -> climate services
  - Change in biomass -> erosion control
  - Change in species richness -> bioprospecting

  Estimation of loss or reduction for each ecosystem service can be based on more than one land use change indicator

4. Calculate and apply lost value of ecosystem services

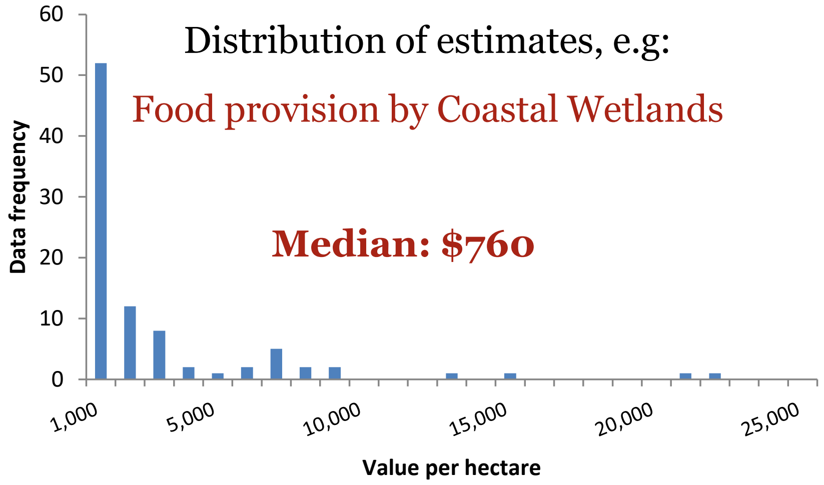
- Benefit transfer, similar to TEEB approach
- Medians from 1,135 global estimates across 14 ecosystem services
- Adjustments for country specific factors:
  - Local services: income, population density
  - Regional services: income, population density
  - Global services: no adjustment

Land use

Calculating lost value of ecosystem services

1,135 individual estimate of ecosystem service values

TEEB database + additional recent studies



Tropical Forests	Desert / Arid grassland
Temperate / boreal forest	Inland Wetlands
Grasslands	Coastal Wetlands

Provisioning	Local	Food
		Fibre, other raw materials
	Regional	Domestic and industrial water
		Ornamental products
	Global	Bio-prospecting & medicinal plants
		Air
Cultural	Regional	Recreation
		Spiritual and aesthetic
		Cognitive
Regulating	Regional	Pollution control
		Erosion control
		Disease and pest control
		Flood control
	Global	Equable climate

Sum of all ecosystem service values

Total Economic Value per hectare

Country specific adjustments

Socio-economic factors:
- Income
- Population density

Environmental factors:
- Biomass
- Species richness
- Soil organic carbon

Land use

Applying the lost value of ecosystem services

Marginal versus average cost of land use

- The **marginal** values estimated today represent the impact of converting an additional hectare ***today***
- However, most corporate land use is on land which was converted in the past
- Land which is ***already*** converted contributes equally to the total value of lost ecosystem services within an area and so should be assigned the **average marginal cost**

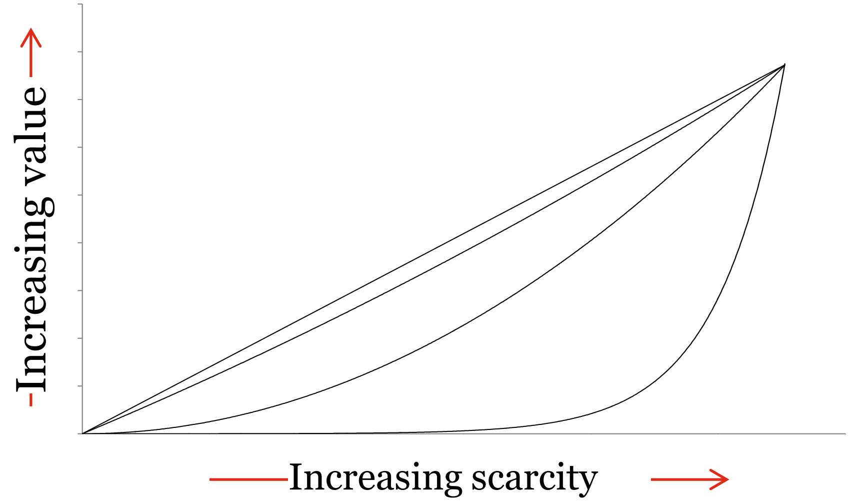
Year 4

Total loss: €6

Average marginal €2

Calculating average marginal cost of land use

- There is little or no research on the relationship between scarcity, ecosystem function, and value
- There is no relationship which would cover all ecosystems at different scales
- The conservative option is a linear relationship:



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