FASHION PACT – SYSTEMIQ COLLABORATION ON OCEAN PILLAR

RESEARCH INSIGHTS

December 2021

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CONTENT

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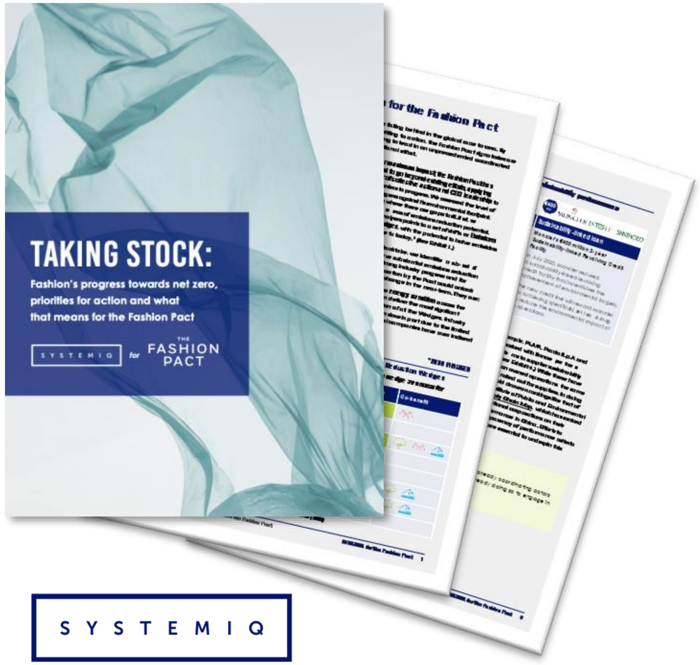
SYSTEMIQ ACTS AS A CORE DELIVERY PARTNER TO THE FASHION PACT

Climate



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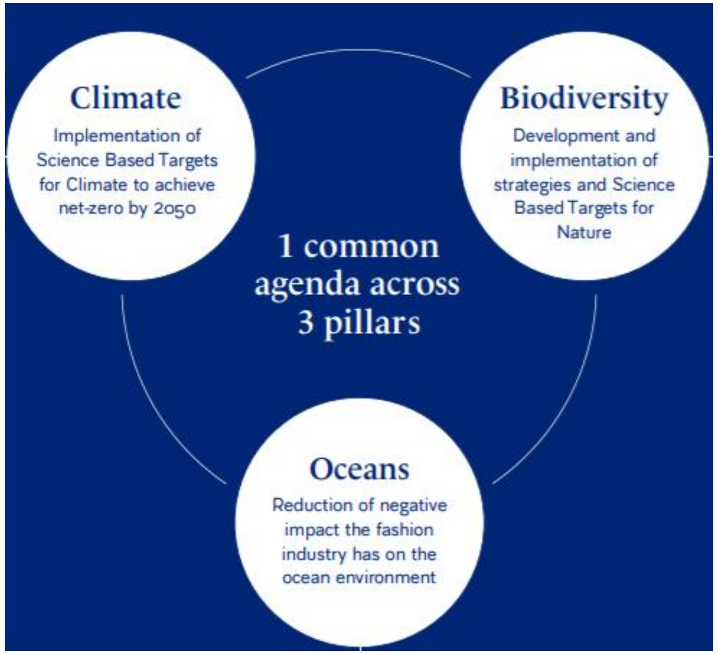
THE FASHION PACT

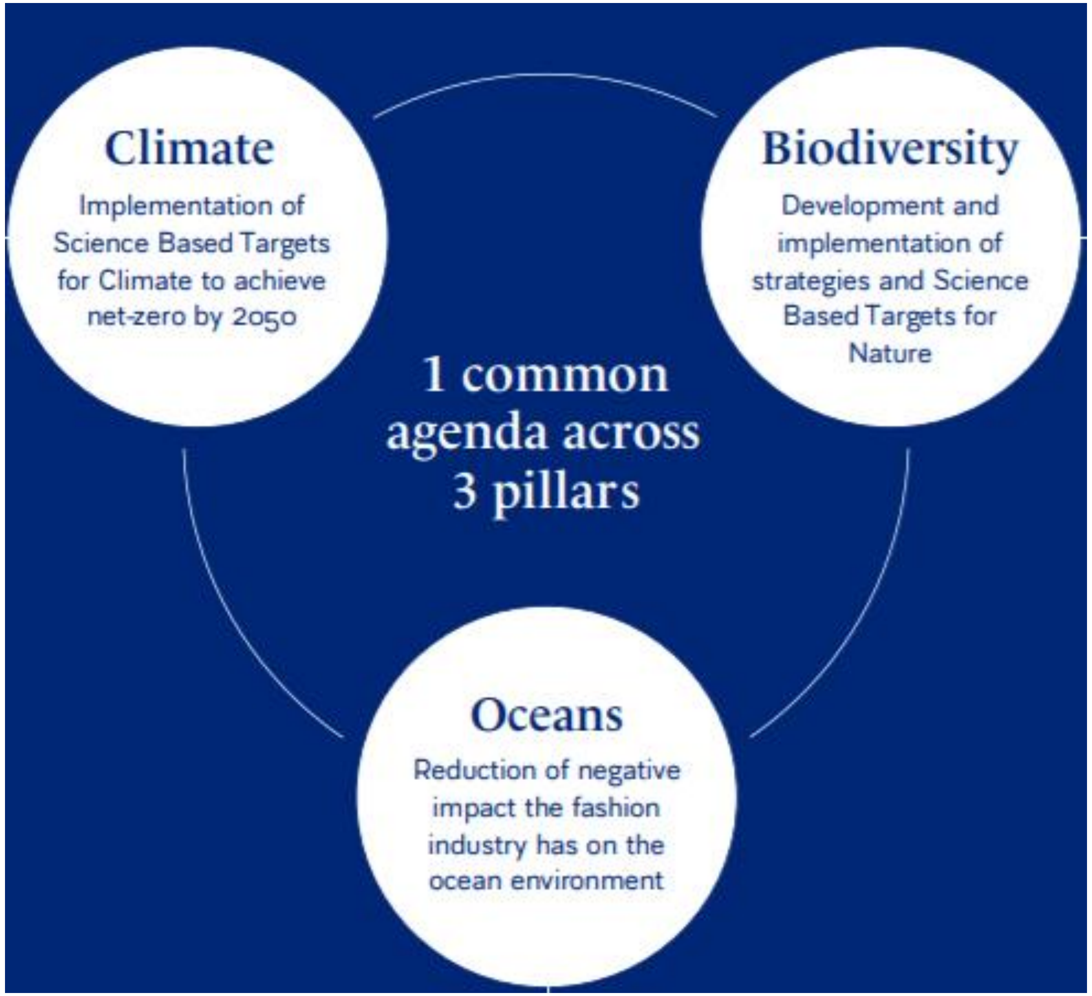


Ocean

KEY DELIVERABLES

- **EXTEND THE SCOPE IN THE PILLAR –** create a solid strategic framing to discuss the need to move forward on expanding the scope of the oceans pillar beyond packaging
- **IDENTIFY WHITE SPACES FOR COLLECTIVE ACTION –** Map potential focus areas where ocean impacts, fashion sector contribution and lack of progress intersect
- **PROPOSE FUTURE JOINT ACTIONS** -- Scope out potential high-impact joint actions that build on the Pact's strengths

THIS DOCUMENT AIDS DECISION-MAKING ON FURTHER OCEANS PILLAR ACTIVITIES



This document supports the Fashion Pact in **expanding action on the oceans pillar beyond packaging**, by

- **Identifying and analysing the interlinkages** between the fashion sector, planetary boundaries and ocean health
- **Assessing the contribution** of the fashion sector to the environmental pressure on ocean planetary boundaries
- **Suggesting the most important focus / impact areas** based on latest science

The research will support the selection of further targets and joint actions within the oceans pillar.

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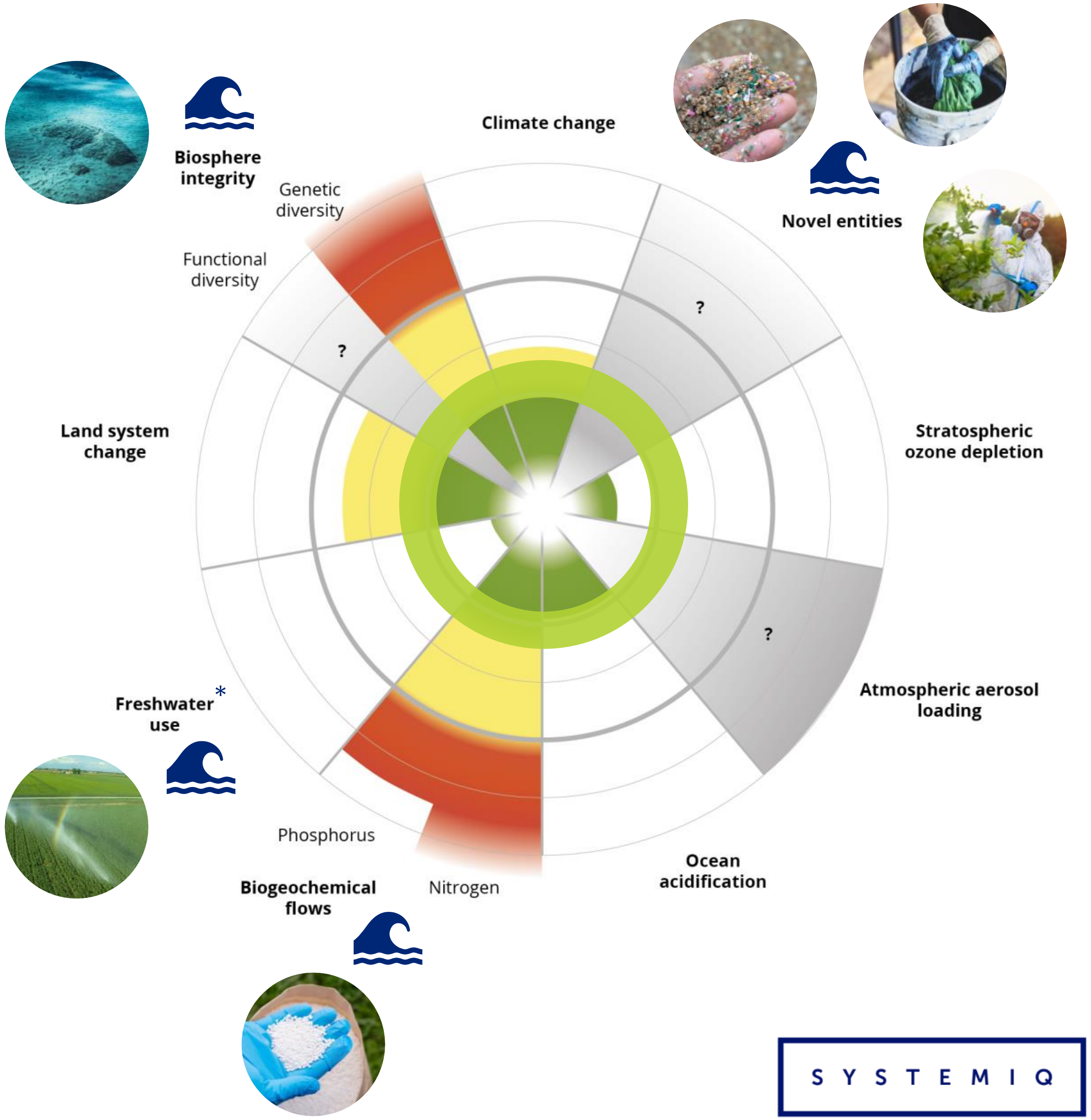
THE FASHION PACT ALREADY HAS A SOLID FOUNDATION ON OCEANS – BUT FURTHER ACTION IS NEEDED

FASHION OCEAN IMPACTS	*Targets*	*Joint Action*
PACKAGING ▪ Curbing pollution through elimination of problematic & unnecessary plastic & use of recycled content ▪ Covered in existing ocean pillar targets and two joint actions	☑	☑
CLIMATE CHANGE ▪ Halting ocean acidification by limiting global warming to 1.5 degrees Celsius ▪ Covered in climate pillar targets and three joint actions	☑	☑
OTHER OCEAN IMPACTS	☐	☐



*(Blue) freshwater use included beyond oceans
Source: Steffen et al. 2015

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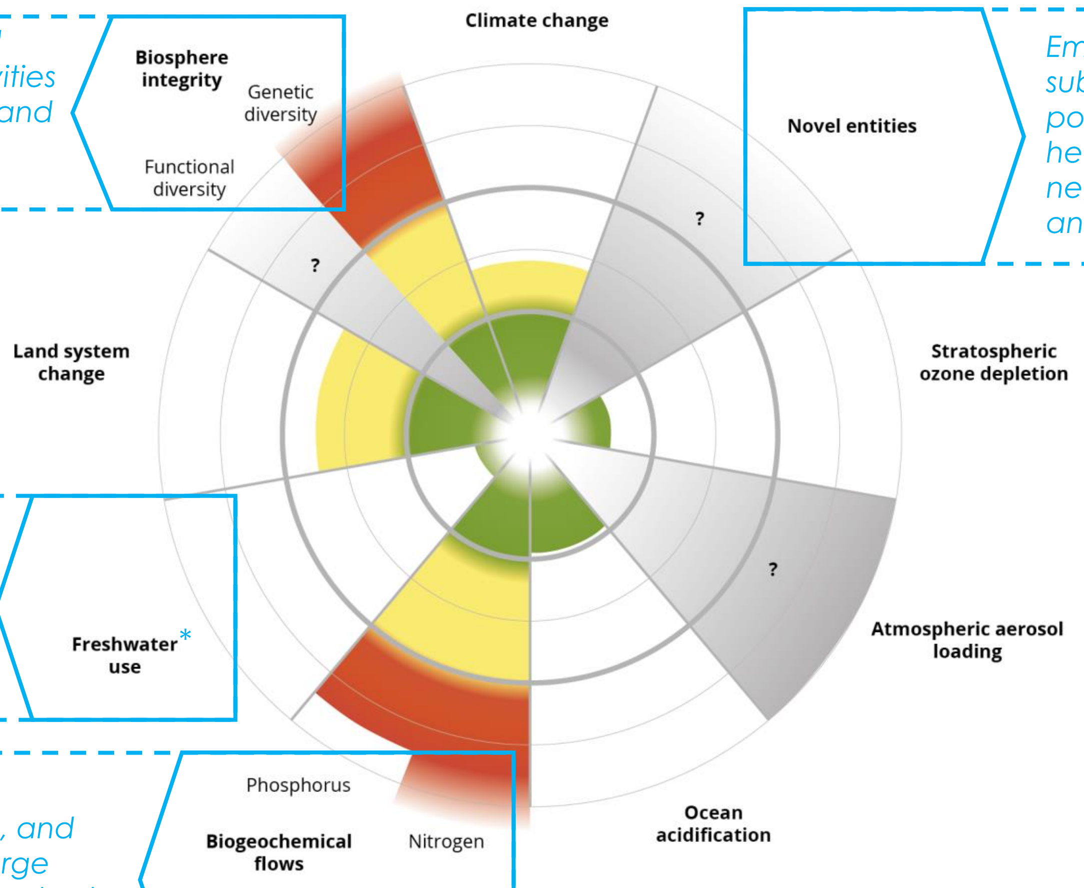
WE USE THE PLANETARY BOUNDARIES FRAMEWORK TO ANALYSE THE FASHION SECTOR'S CONTRIBUTION TO OCEAN HEALTH

The demand for food, water, and natural resources for human activities is causing severe biodiversity loss and leading to changes in ecosystem services on land and in sea.

Emissions of toxic and long-lived substances such as synthetic organic pollutants (e.g. microplastics) and heavy metal compounds (e.g. mercury) negative effects on marine organisms and the physical environment.

The consequences of human modification of water bodies include both global-scale river flow changes and shifts in vapour flows arising from land use change. Fresh water is becoming increasingly scarce.

Nitrogen and phosphorus are both essential elements for plant growth, and used as fertilisers in agriculture. A large share of the applied fertilisers get washed into the sea, and can push marine systems across ecological thresholds.



Ocean

*Freshwater use included beyond oceans (blue water)
Source: Steffen et al. 2015

SOLUTIONS WITHIN THESE LEVERS WERE ASSESSED BASED ON A SET OF CRITERIA

Analysis of planetary (sub)-boundaries & fashion impact on oceans

- What is the **current state of the PB** & how does it relate to ocean health?
- What is the **fashion sector linkage** to the PB & which operating/ regulatory risks exist?
- **How much** of the env. pressure on the PB **does the sector contribute**?
- Where are the **geographic hotspots** & what are differences between these?
- What are the **most important solutions** to reduce these environ-mental pressures & how important is it for the FP to work on them?

Prioritization of solutions across boundaries based on six key criteria

- Solutions are known & available
- Solutions are scalable
- Solutions lack attention & progress
- Solutions require collective action to overcome barriers
- Solutions have high potential to alleviate pressure on oceans
- Solutions are not overed by other FP Joint Actions

Development of additional ocean pillar joint actions and targets

- Based on the prioritized solution spaces (four in total), a **concrete proposal for additional joint actions and targets** for the Fashion Pact's oceans pillar has been developed
- **Proposed joint actions were narrowed down from a long list and assessed** based on their need for collective action, impact potential, system benefits (e.g. human health), potential to fill a white space, need for CEO leadership and feasibility
- **The proposed joint actions & targets are not part of this documentation** – but will be presented to the signatories in due course

Covered in this document

Not covered in this document

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AGENDA

- Overview Approach & Objective
- **Executive Summary Findings**
- Planetary Boundary Findings

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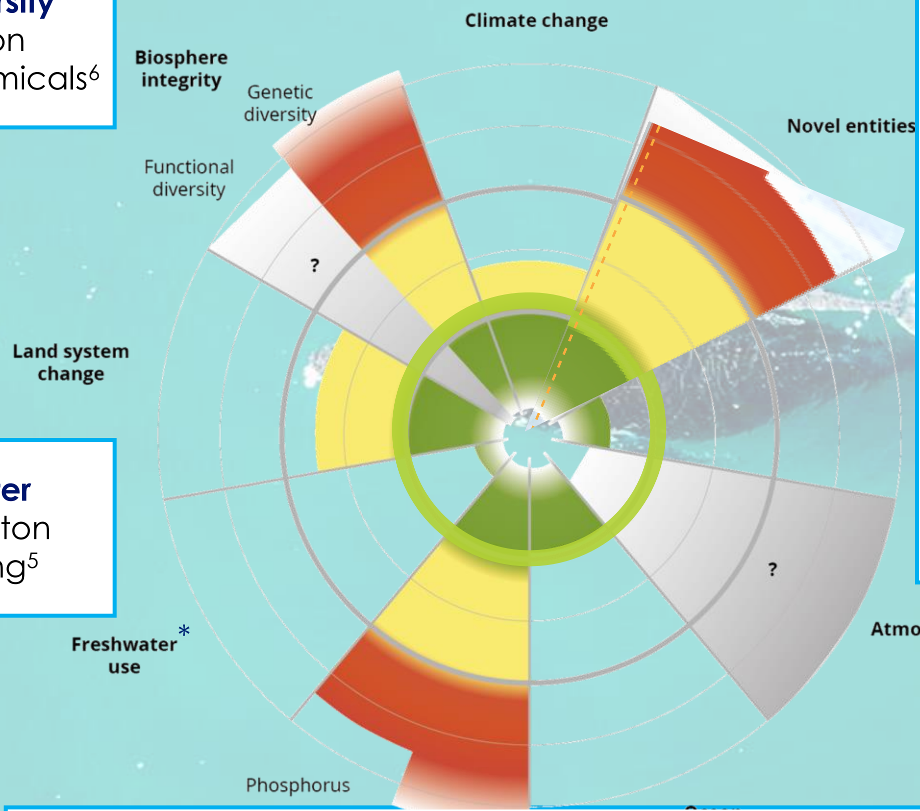
OVERVIEW OF THE FINDINGS

- The review of the four "ocean" planetary boundaries in scope has revealed that **the fashion sector and ocean health are strongly intertwined,** and that the sector impacts marine biodiversity mostly through the pollution it causes today
- Some of the **greatest relative impacts of the sector can be found across the planetary boundary 'novel entities'** – especially on the use of hazardous chemicals – which is due to be rated "red" by the Stockholm Resilience Centre
- There is a **concentration of impacts in tiers 4 and 2** of the value chain (raw material extraction & wet processing), and outside of luxury goods, action in **Asian production hotspots** will be key for delivering systems change; whilst all raw materials are affected, **cotton and leather production** do seem to cause higher impact on some of the boundaries
- **Inaction is associated with significant risks** across the boundaries, and regulation in the EU is expected to tighten
- As the solutions oftentimes cut across boundaries however, it is **important to approach action more holistically at the solution level** rather than choosing any single planetary boundary to focus on going forward
- Both **sustainable consumption and sustainable production are needed** to minimize impacts on oceans, a narrow focus on production won't go far enough with a growing population and rising middle class – **demand-side circular economy levers** (incl. new business models) are key
- We assessed a set of nine solution spaces based on their ocean impact potential, availability, scalability, current progress/attention, and need for collective action. Based on this analysis, we recommend to focus on the adoption of **wet processing best practices & innovation**, **on-site wastewater management/treatment** and **national/basin-level water governance, stewardship and infrastructure** for joint action in sustainable production
- Furthermore, scaling **regenerative agriculture is also hugely important for ocean health** but is already being addressed by the climate pillar where it should be considered a high priority for the Fashion Pact.

THE HEALTH OF OUR OCEANS AND THE FASHION SECTOR ARE STRONGLY LINKED

~15% of **marine biodiversity loss** is from pollution such as toxic chemicals[6]

~6% of **fresh (blue) water withdrawal** for cotton and wet processing[5]



~3% of **fertiliser use & pollution** from clothing fibre crops[4]
++ (++ livestock/leather)

~13% average **water pollution** in G20 countries coming from the textile industry[3]

~5% of **pesticide use & pollution** from cotton production, more for insecticides[2]

~3% of **microplastic leaking into oceans**, textiles 3rd largest contributor[1]

? Macroplastic/-textile ocean leakage unknown

Note: The "novel entities" planetary boundary is due to be rated as having crossed into the "red zone" by the Stockholm Resilience Centre
Sources: Steffen et al. 2015, 1 Pew (2020), 2 Transformers Foundation (2021), 3 Parschiv, Tudor and Petrariu (2015), 4 IFA (2017), 5 Quantis (2018) and Aquastat (2017), 6 Diaz et al (2019). All figures are global unless stated otherwise.

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THE RESEARCH REVEALS THAT THERE ARE SIGNIFICANT RISKS TO INACTION ON THE SECTOR'S CONTRIBUTION TO OCEAN HEALTH

	Value chain stage* T4	T3	T2	T1	Use	Key materials	Regulatory/operating risks	Biological/human health risks
 **Novel entities: Microfibres**		✓	✓		✓	*All common raw materials*	Little regulation, but EU looking to regulate in mid-term (4-5 years)	Feeding disruption to marine life, respiratory stress to humans. Further research needed
 **Novel entities: Pesticides**	✓					Predominantly cotton	Stringent EU regulation, toxic & persistent pesti-cides still used elsewhere	Exposure can lead to wide-scale marine life loss & short- and long-term health risks
 **Novel entities: Process chemicals**			✓			*All common raw materials*	Stockholm Convention & EU REACH. New EU due diligence regulation upcoming	CMR** properties for humans and aquatic life, highly toxic depending on chemical
 **Biogeo-chemical Flows**	✓					Predominantly cotton & leather	EU targets for significant reduction of nutrient use & pollution, little outside	Excess nutrients esp. harmful for marine ecosystems, human risks lower than pesticides
 **Freshwater use**	✓		✓		✓	*All common raw materials*	Serious supply risks in regions with high water stress esp. for cotton	Destruction of marine life, severe risks of drought and famine for humans

*The impacts in end-of-life (EOL) are currently under analysed & understood – better transparency is needed
** CMR: Carcinogenic, mutagenic or toxic to reproduction
Source: SYSTEMIQ analysis

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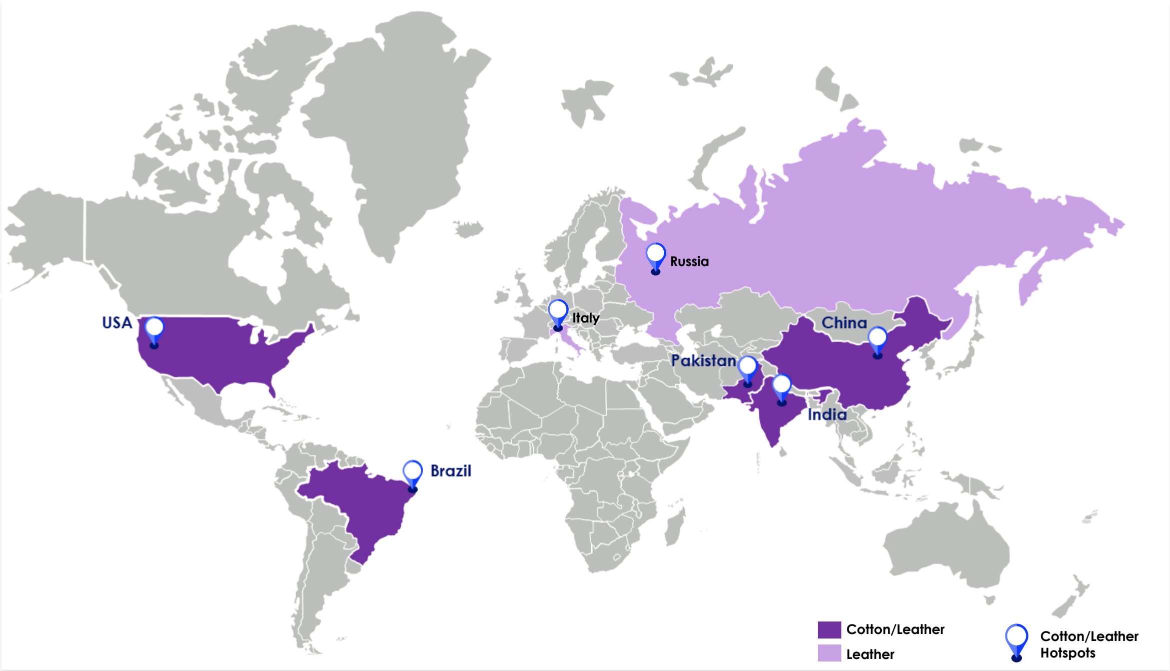
ANALYSIS OF THE OCEAN IMPACT HOTSPOTS SHOW THAT ASIA IS KEY FOR SYSTEM CHANGE

Cotton & leather production hotspots (T4)



- The impact on oceans through fibre production is largely driven by cotton and leather production
- The 5 biggest cotton production countries are currently **China, India, U.S., Brazil and Pakistan,** and the five biggest leather production countries are **China, Brazil, Russia, India and Italy**
- Esp. fertilizer & pesticide run-offs, as well as water use, affect oceans

Wet processing hotspots (T2)

- Wet processing is largely concentrated in Asia with **India, Pakistan, China, Vietnam and Bangladesh** accounting for the top 5 producers[1]
- **> 20% of water pollution in Indonesia, Turkey and China** comes from the textile industry[2]
- Wet processing intersects across multiple Planetary boundaries including **chemical pollution, freshwater use and microfibres**

Sources: 1) Planet Tracker (2020) – facility data from Open Apparel Registry, sample used of 1075 facilities (out of 42,000), data only shows publicly listed companies, 2) Parschiv, Tudor and Petrariu, 2015. Note: key hazardous chemicals used in leather tanning and processing include chromium, sulphuric acid, synthetic tannins, azo dyes and phenolic compounds

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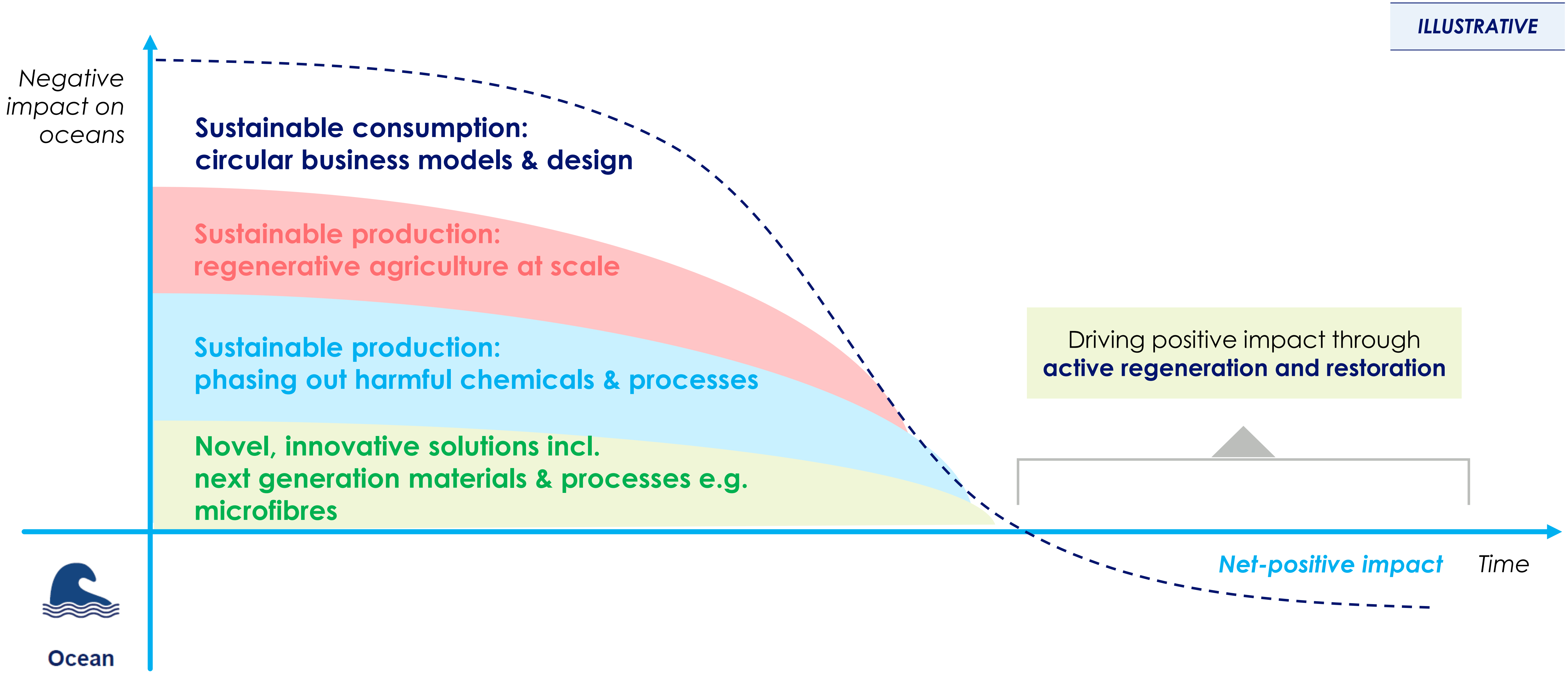
FOUR MAIN LEVERS CAN TRANSFORM THE SECTOR TO MEET TFP OCEAN AGENDA



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COMPARATIVE ASSESSMENT OF SOLUTIONS FOR OCEAN BOUNDARIES REVEALS FOUR PRIORITY SOLUTION SPACES

See solution deep-dive slides for rationale

#	*Ocean impact solutions*	*Planetary Boundaries*	*Value chain*	*Planetary boundary priority level*	*Solutions are known & available*	*Solutions are scalable*	*Solutions are lacking progress*	*Solutions are lacking attention*	*Solutions need collective action*	*Solutions have ocean impact potential*	*Overall assessment: priority level*
1	**On-site chemical & wastewater mgmt (incl. recycling)**	Novel entities (microplastic & haz chems), freshwater	T3-2	**HIGH**	**HIGH**	**MEDIUM**	**HIGH**	**MEDIUM**	**HIGH**	**HIGH**	**HIGH**
2	**Design changes to reduce harmful pollution**	Novel entities (microplastic and haz chems)	T2 & Use phase	MEDIUM/ HIGH	LOW	LOW	HIGH	MEDIUM	MEDIUM	HIGH	LOW
3	**Agricultural efficiency improvements**	Biogeochemical flows, freshwater, pesticides	T4	HIGH	HIGH	MEDIUM	MEDIUM	MEDIUM	LOW	MEDIUM	LOW
4	**Regenerative agriculture***	Biogeochemical flows, freshwater, pesticides	T4	HIGH	HIGH	MEDIUM	HIGH	MEDIUM	HIGH	HIGH	HIGH
5	**Organic agriculture***	Biogeochemical flows, freshwater, pesticides	T4	HIGH	HIGH	LOW	HIGH	LOW	MEDIUM	HIGH	MEDIUM
6	**Material substitution (new & known materials)**	Biogeochemical flows, freshwater, novel entities	T4-1	HIGH	MEDIUM	LOW	MEDIUM	LOW	MEDIUM	MEDIUM	LOW
7	**Process innovation**	Novel entities (chemical pollution), freshwater use	T3-2	**HIGH**	**MEDIUM**	**MEDIUM**	**HIGH**	**MEDIUM**	**MEDIUM**	**HIGH**	**HIGH**
8	**Water governance, stewardship & infrastructure**	Freshwater, Novel entities (microfibres)	T4-2	*Depends on region*	**MEDIUM**	**MEDIUM**	**MEDIUM**	**MEDIUM**	**HIGH**	**MEDIUM**	**MEDIUM**
9	**Demand-side circular economy**	All	All	**HIGH**	**HIGH**	**MEDIUM**	**HIGH**	**HIGH**	**HIGH**	**HIGH**	**HIGH**

High priority

Lower priority

*Regenerative and organic agriculture is covered within the climate pillar & will therefore, despite the potential, not be addressed within the oceans pillar

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- Overview Approach & Objective
- Executive Summary Findings
- **Planetary Boundary Findings**
  - **Novel Entities**
    - Microfibres
    - Chemicals
    - Pesticides
  - Biogeochemical Flows
  - Freshwater Use
  - Biodiversity

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EXECUTIVE SUMMARY – NOVEL ENTITES

- Novel entities is one of the PBs with the least amount of scientific consensus. There is **no quantification of a global boundary**, nor a control variable to measure how close the Earth is to 'overstepping' the boundary. However, it can be expected that the boundary will soon be declared a 'red zone', meaning that the **high risk of disruption to Earth systems** warrants immediate precautionary action.
- There are three main ways where the fashion industry intersects with the Novel Entities 'boundary': i) excessive use of pesticides for natural fibre production, ii) widespread use of **hazardous chemicals during textile production** and iii) large scale **microplastic emissions** from the production and consumer use of synthetic garments
- All three categories are having negative impacts on aquatic organisms and marine biomes primarily through bioaccumulation of toxins that can lead to **carcinogenic, mutagenic and endocrine disruptive properties**. Human health impacts are under investigation but may have carcinogenic properties that are causing concerns with consumers. At the moment, there is no comprehensive knowledge about the exact risks of novel entities on environment and human health and no impact quantification.

Microfibres

- Textiles accounts for ~**3% of total microplastic emission** with an estimated **40 kilotons** released into marine biomes annually, the third largest source of microplastic release into the ocean. 50% of emissions occur during wet processing production while the other half occurs from consumer washing of garments
- Microfibre (MF) release into oceans **primarily occurs in upper-middle and lower-middle income countries** due to i) high levels of garment production (India, China, Brazil etc.) and ii) a lack of municipal wastewater treatment plants to capture MFs
- There are four known interventions that **could reduce textile microfibre release by ~70-80%:** i) textile redesign and substitution of high-shedding fibres, ii) mandatory treatment of factory effluent, iii) installation of household washing machine filters and iv) improve municipal wastewater treatment in upper-middle, lower- middle and low income countries.
- Industry progress on all four interventions remains slow due to i) a lack of consensus on MF shedding rates, ii) a lack of consumer awareness, iii) a lack of scalable design solutions (e.g. waterless dyeing) and iv) prohibitive costs for suppliers to implement wastewater treatment solutions

EXECUTIVE SUMMARY – NOVEL ENTITES

Pesticides

- Pesticide use for the **fashion industry contributes to ~5% of global pesticide use** and this number can go as high as 45% in India which shows the significant contribution of the fashion sector to pesticide pollution and the local relevance
- It is especially worrisome that the **key cotton-producing countries (especially US, Brazil, China, India) have not introduced stringent pesticide bans and that enforcement is often lacking.** Next to lack of bans and enforcement thereof, **lack of education/training, risk aversion and pesticide subsidy lock-ins lead to the excessive use of pesticides.**
- While the used pesticides are not equally harmful, pesticide overuse and subsequent runoff into environments has **detrimental effects on marine biomes: from depleting fish stocks, to causing cancer in mammals** – next to the potentially lethal effects on farmers
- Solutions to the pesticide issue can be clustered in three areas: **reducing the usage of pesticides through efficiency improvements**, such as Integrated Pest Management, **eliminating the use of synthetic pesticides through organic farming practices**, and **choosing alternative materials** with limited pesticides dependency. Scaling these solutions requires access to training, financial support, stringent pesticide policies and clear demand signals, amongst others.

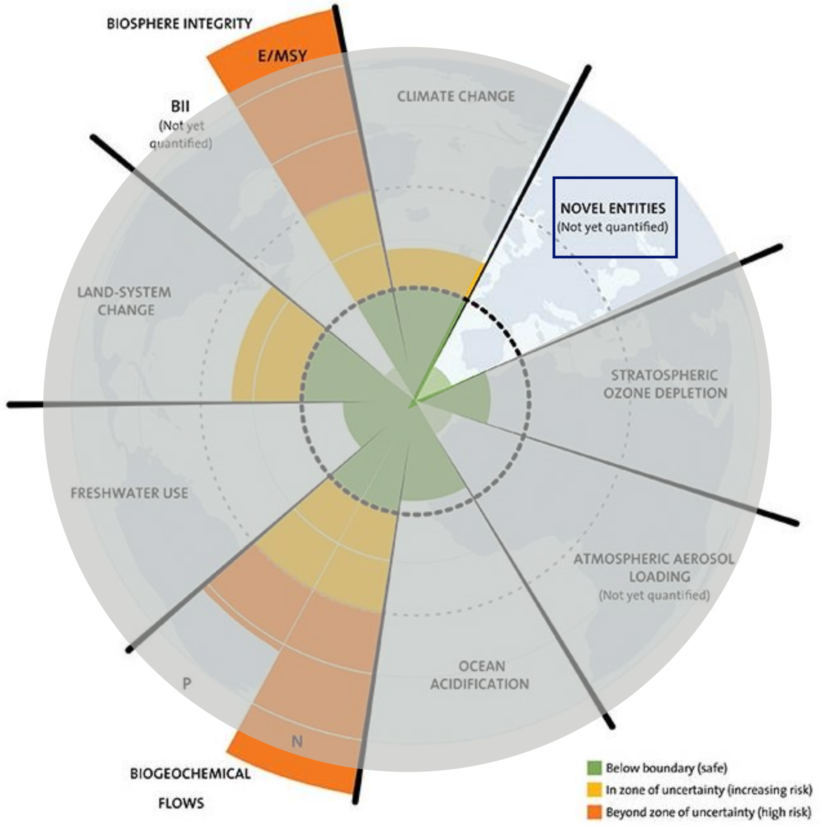
Hazardous chemicals

- Annually the fashion industry consumes around ~**43 million tonnes of chemicals** to produce textiles (~2% of global chemical production) however the industry accounts for **~13% of wastewater pollution** in key textile producing countries (as high ~29% in Indonesia)
- Hazardous chemicals used in textile production have the highest risk of freshwater and ocean leakage during **the wet processing T2 stage** where garments are dyed, finished and bleached, all using varying amounts of hazardous chemicals (e.g. azo dyes)
- Untreated textile toxic wastewater is high in pH (alkaline), changes the colour, leads to high toxic concentrations of **heavy metals (lead, mercury etc), aromatic compounds (azo dyes) and other volatile compounds.** Chemical changes from the wastewater results in **impaired photosynthetic, promotes CMR* and disrupts endocrine function in aquatic life and humans**
- Solutions to reduce use and risk of hazardous chemicals can be clustered into four key buckets: **better treatment of factory effluent** to reduce leakage to the environment, **better chemical management** and substitution of hazardous chemicals with safer alternatives, **scaling dry processing techniques** and innovations and **adopting non-linear chemical use models**. Scaling these solutions requires financing, supplier training and further research into circular chemical models.

EXECUTIVE SUMMARY OF NOVEL ENTITIES

Definition of boundary

Novel entities include the emissions of toxic and long-lived substances such as **persistent organic pollutants, heavy metal compounds and radioactive materials**



Scope

The boundary covers compounds that can have **potentially irreversible effects** on living organisms and the physical environment including organic pollutants, radioactive materials, nano-materials, micro-plastics and other man-made substances

Current state

No quantification of one single chemical pollution boundary exists although the latest science suggests that novel entities are at **high risk of crossing Earth system thresholds,** meaning mitigation action must be prioritised

Scientific & policy consensus

- **Lack of consensus** on which thresholds should not be crossed
- **Great diversity** of the substances released to the environment
- **High degree of uncertainty** about individual and interacting behaviour between different substances in the environment

Pathways

- **No global pathway** to reduce use of novel entities and chemical pollution
- Certain **sectoral roadmaps** to reduce use of hazardous chemicals (e.g. ZDHC for textiles)

Metrics

- No **global metrics** defined for novel entities and chemical pollution
- **Voluntary targets** for specific sectors (e.g. ZDHC commitment for textiles)

Ocean link

- Chemical run off into freshwater and oceans can lead to biodiversity loss, economic loss (fishing/tourism) and ability for the ocean to sequester carbon

KEY NOVEL ENTITY CATEGORIES FOR THE FASHION SECTOR

NOVEL ENTITIES

	Pesticides	Hazardous chemicals	Microfibres
Overview	Pesticides used during the production of natural fibres (primarily cotton)	Hazardous chemicals are used in synthetic feedstock production, fibre treatment, dyeing and processing	Microfibres emissions from the production and consumer use phase of natural & synthetic materials
Value chain step	**T4** Raw material production	**T4 – T1 (T2 focus)** Raw material production, raw material processing, material production, assembly	**T2-1 and consumer phase** Wet processing (dyeing & finishing) and consumer laundering of garments
Sector contribution	5% of global pesticide use	~43 million tonnes chemicals are used annually (~2% of global chemical use)	3% of total microplastic release*
Ocean link	Run off into freshwater ways and oceans. Toxic to aquatic life	Run off into freshwater and oceans – high pH, promote CMR**, disrupts endocrine functions in aquatic life	Effluent from T1&2 wet processes and consumer laundering are key pathways into oceans.

- The industry's impact on the Novel Entities boundary can be broken into three distinct categories that span the value chain: **pesticides hazardous chemical use and microfibres**
- All three categories impact marine biomes via leakage into freshwater ways
- All three categories have both local effects to marine biomes (e.g. reduction in species to a specific waterway) and global consequences (e.g. transfer of microplastics across the food chain)

Source: EMF, 2017, Transformers Foundation, 2021, Pew, 2020
*Fashion's contribution to the microplastic release varies by study between 3 and 35%, this work uses the latest Pew Study as the key reference. No data on natural fibres
** Carcinogenic, mutagenic or toxic to reproduction

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- Overview Approach & Objective
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- **Planetary Boundary Findings**
    - **Novel Entities**
        - **Microfibres**
        - Chemicals
        - Pesticides
    - Biogeochemical Flows
    - Freshwater Use
    - Biodiversity

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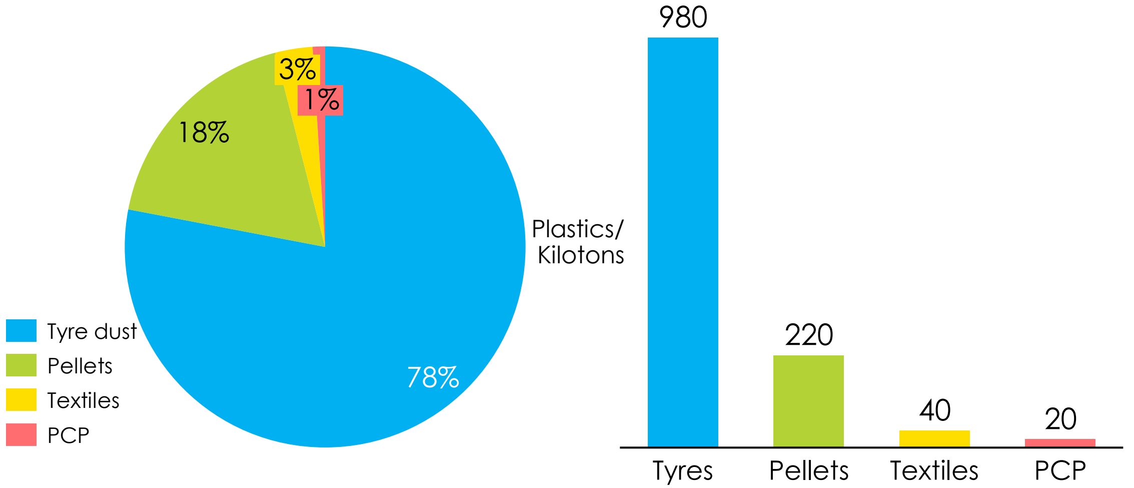
WHAT IS THE LINK BETWEEN MICROFIBRES AND FASHION?

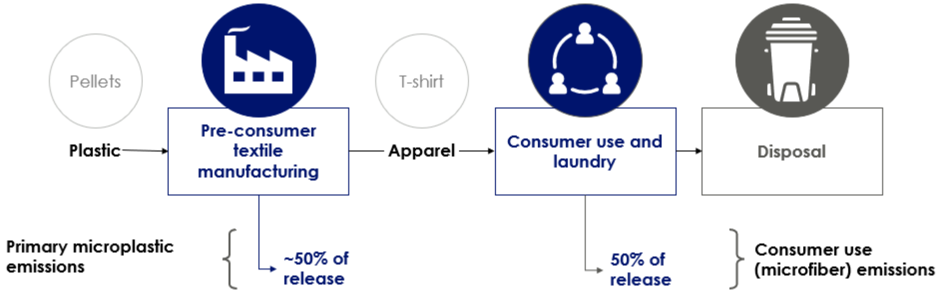
Microplastics overview and fashion intersection

- Microfibres can originate from all textiles and therefore can be comprised of both synthetic and natural materials between **1-5 mm in size** that enter the environment as microsized particles.
- Regarding microfibres from synthetic materials (know as microplastics), fashion contributes **~3%** of ocean plastic leakage, the **third largest source** after tyre dust (78%) and plastic pellets (18%).*
- Microfibres enter water systems during **i) production (T1&2) and ii) consumer washing**
- Effects on marine organisms and the environment include **digestive tract blocks, altered feeding patterns, reduce reproductive output and bioaccumulation**.

2016 microplastic leakage to the ocean by source (Pew, 2020)



Value chain intersection



Primary microplastic wastewater emission from the production phase occurs in T1&2 during dyeing, printing, finishing and pre-washing of textiles

Relevant materials

Synthetic	Mixed/MMC*	Natural
✓	✓	✓

- Microfibre emission comes from all materials however synthetic material shed **microplastics** that do not biodegrade in marine biomes and bioaccumulate in aquatic life
- Most research has focused on the effects of microfibres from synthetic materials but a recent study suggests that **chemically processed natural fibres** may also **harm** the environment but further research is needed

Source: Pew, 2020; Bain, 2020; Vassilenko et al, 2021; Suaria et al, 2020
*Estimations vary on fashions contribution (3-35%) as there is no standardised measurement process for textile shedding

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HIGHER-MIDDLE AND LOW-MIDDLE INCOME COUNTRIES ACCOUNT FOR THE MAJORITY OF MICROFIBRE OCEAN LEAKAGE

Microfibre (from synthetic materials) losses from production/consumer washes vs releases into the ocean

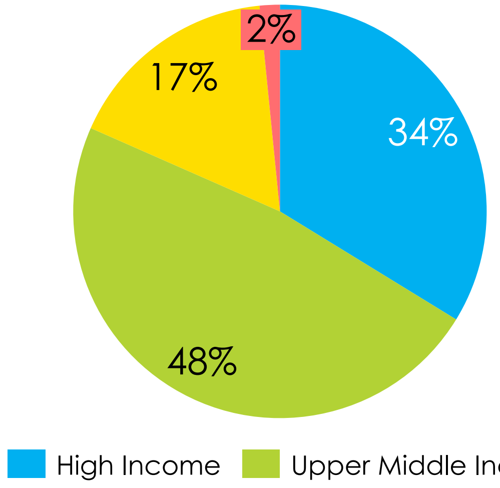


Figure 1: Total microfibre losses during production and consumer washes

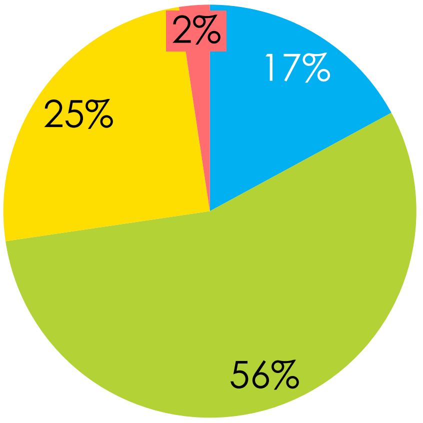


Figure 2: Total microfibre releases into the ocean

Source: Pew 2020

Table 1: Wastewater capture rate of microfibres between loss during production/consumer washes and release into the ocean

	Urban	Rural
High income	74%	50%
Upper middle income (UMI)	34%	19%
Lower middle income (LMI)	10%	0%
Low income	9%	0%

- **Higher- and lower-middle income countries account for the majority of ocean leakage (~73%)**, most notably China and India. Key factors that increase ocean leakage include:
  - Low rates of **municipal water treatment**
  - Low rates of **textile factory effluent treatment**
  - Higher share of **synthetic clothes** compared to high income countries
  - High proportion of **top-loading washing machines** (worse than front loading for shedding)
  - Higher rates of **handwashing garments** not connected to wastewater treatment
- High income countries, while accounting for 34% of microfibre losses during production and consumer washes, **have higher rates of municipal water treatment** (74% urban and 50% rural) that reduces overall microfibre release to oceans (17%)
- Recent studies (Pew, 2020 and Bain, 2021) have begun to incorporate production shedding into overall microfibre emission estimates which account for **~50% of releases into the ocean (Pew, 2020)**
- Many of the largest textile producing countries fall into **UMI and LMI categories** including: China (UMI), India (LMI), Pakistan (LMI) and Brazil (UMI)

Source: Pew 2020; IUCN, 2017; Belzagui et al, 2020

THE EFFECTS OF MICROFIBRE POLLUTION ON AQATIC ORGANISMS ARE STILL UNDER INVESTIGATION...

Effects on marine biomes

- Impacts to aquatic organisms include **reduction in growth, reduced fecundity, weakened immune systems, impaired feeding ability and reduced energy storage**
- Ingestion and transfer of plastic particles up the food chain leads to **change in sex determination, liver damage and reproduction disruption**
- Potential disruptive effect to **oceanic carbon sequestration systems**

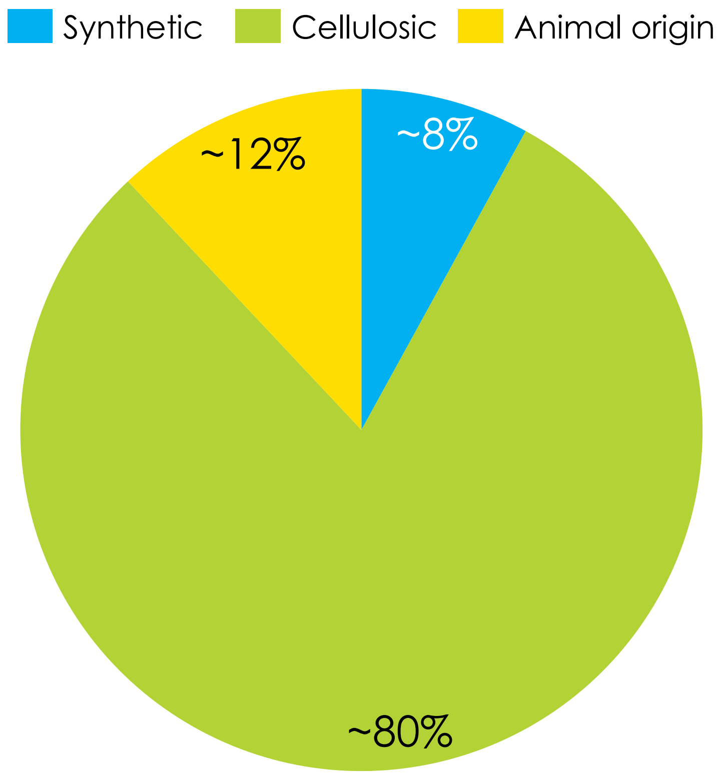
Effects on human health

- MF exposure proven to cause toxicity through **respiratory stress, inflammatory lesions and bioaccumulation**
- Several studies have demonstrated the potential of **metabolic disturbances, neurotoxicity and increased cancer risk to humans**
- Unknown toxicity **effects of food processing or cooking of plastics in aquatic organisms** for consumption

Source: Villarrubia-Gomez et al, 2018; Pew, 2020; National Geographic, 2018; Fauna & Flora International, 2018 ; Rahman, 2021

...HOWEVER RECENT STUDIES SUGGEST THAT MICROFIBRES FROM NATURAL MATERIALS MAY BE UBIQUITOUS AND PERSISTENT...

Oceanic microfibers by material type (Suaria et al, 2020)



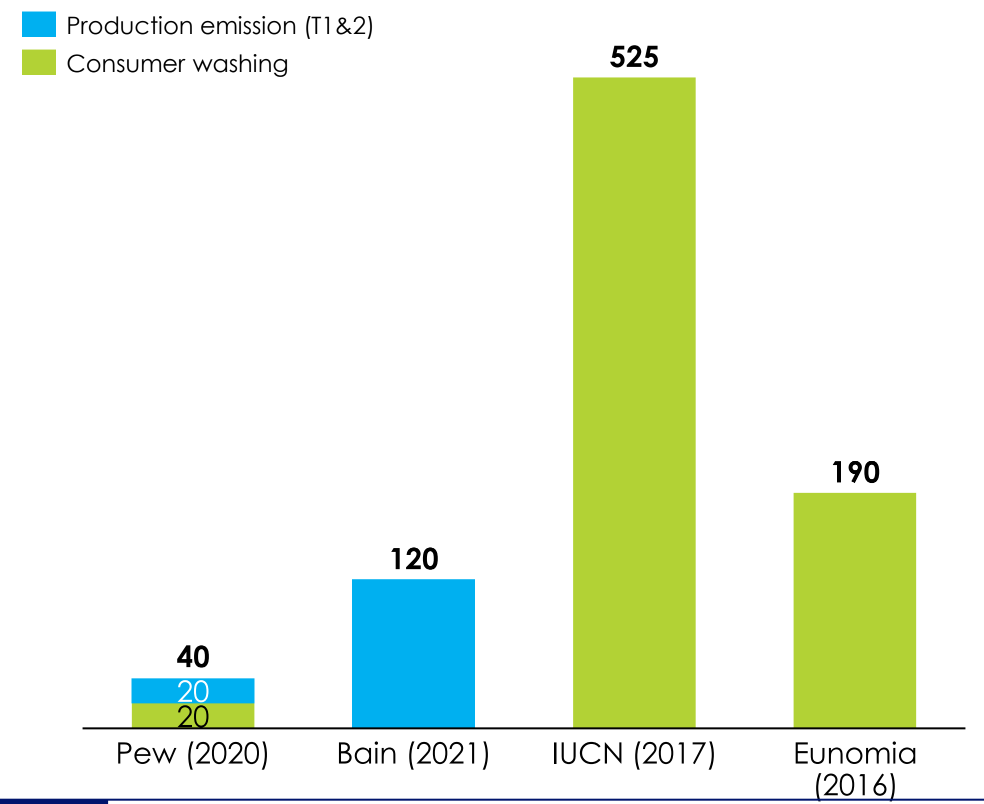
Analysis of ~2000 fibres across 916 seawater samples collected in six ocean basins

- **Microfibres from natural fibres may be more ubiquitous than microplastics from synthetic materials**
  - A recent study found that ~80% of microfibres in six ocean basin samples were cellulosic sources
  - While synthetics make up two-thirds of global fibre production, they account for just ~8% of microfibres in oceanic fibres according to the study's samples
- **Chemical treatment of natural materials may prevent biodegradation in oceans**
  - A recent study of blue denim found that the indigo blue dye as well as performance enhancing chemicals can prevent the natural cellulosic fibre from biodegrading
- **More research is needed to determine:**
  1. To further determine the ratio of total ocean fibres by material type and;
  2. The effects of natural and MMC microfibres on marine species and on human health

Source: Suaria et al, 2020; Athey et al, 2020

…AND STUDIES DIFFER ON FASHIONS TOTAL CONTRIBUTION TO GLOBAL MICROFIBRES RELEASE (FROM SYNTHETIC MATERIALS) …

Annual microfiber emission from synthetic textiles by study, KT



	Pew (2020)	Bain (2021)	IUCN (2017)	Eunomia (2016)
% of global MF emissions	**3%**	**-**	**35%**	**20%**

- **Key differences of recent microfibre textile studies include:**
  - i. **Value chain stage of microfibre (MF) shedding :** Most studies have focused on the emissions of MFs during the consumer phase
  - ii. **Fashion's percentage share of global MF emissions:** Estimates range from 3 to 35% of global MF primary emissions.
  - iii. **Average shedding rate per kilo of textiles washed:** Older studies use average shedding rates as high as ~900 mg/kg* (IUCN, 2017) while new studies use far lower rates of ~100 mg/kg (Pew, 202)
- **High variability in textile microfibre estimates has led to:**
  - i. **A lack of consensus** of fashion's contribution to MF emissions and, as a consequence,
  - ii. **Delayed industry action to reduce emissions**
- **Recent lower estimates of textile MF emissions should not deter action as:**
  - i. There maybe **additional distribution pathways** that have not yet been modelled that could increase magnitude of leakage to oceans e.g. transfer through air
  - ii. Smaller total mass does **not** mean less total particles that can interact with aquatic organisms
  - iii. Harmful effects on aquatic and human health demonstrate the need for **immediate action**

* Studies use an average microfibre shed rates to estimate overall emission this is expressed as milligrams per kilogram of textile washed (mg/kg)

REDESIGNING TEXTILES WILL HAVE THE HIGHEST LONG TERM IMPACT BUT EFFECTIVE FACTORY WWT WILL STOP ADDITIONAL SHEDDING IN THE SHORT TERM

Intervention	Solutions are known & available	Solutions are scalable	Solutions are lacking progress	Solutions are lacking attention	Solutions need collective action	Ocean impact potential	Examples of initiatives /solutions	Barriers to progress
Redesign & shifting to low shedding textiles	Low	Low	High	Medium	Medium	High	▪ **Industry partnerships to investigate MF loss** incl. the Microfibre Consortium; Patagonia/Arc'teryx partnership ▪ **Individual brand commitments/action** e.g. Patagonia	▪ Low consensus on shedding rates ▪ Solutions not scaled ▪ Increased global use of synthetic materials
Factory treatment of effluent	High	Medium	High	Medium	High	High	▪ **Innovation in effluent treatment:** reverse osmosis that can capture MFs ▪ **Development of industry standards for ETPs*** e.g. ZDHC	▪ Prohibitive costs of ETPs for suppliers ▪ Low supplier awareness ▪ Lack of enforced regulation in producing countries
Installing household washing machine filters	Medium	Medium	Medium	High	Medium	Medium	▪ **Internal/external machine filtration systems** e.g guppy bags ▪ **In built filtration systems:** Grundig first machine to include MF capture technology	▪ Low consumer awareness ▪ Solutions not scaled
Extend municipal wastewater treatment	Medium	Medium	Medium	Medium	High	Medium	▪ **National strategies to increase WWTPs** e.g. India	▪ Progress determined by domestic governments (outside control of industry)

Notes on MF solution buckets categorisation under the 9 overarching solution buckets (see slide 16):
1. Redesign & shifting to low shedding textiles > 2. Design changes to reduce harmful pollution
2. Factory treatment of effluent > 1. On-site chemical and wastewater management
3. Installing household washing machine filters > deprioritised as customer focused
4. Extend municipal WWT > 8. water governance, stewardship & infrastructure

GLOSSARY MICROFIBRES

Term	Definition
Novel Entities	Novel entities include the emissions of toxic and long-lived substances such as **synthetic organic pollutants, heavy metal compounds and radioactive materials**
Microfibres	A piece of natural or synthetic thread that is less than five millimetres in length
Microplastics	Microplastics are fragments of any type of plastic less than 5 mm in length this can include synthetic fibres, tyre dust, plastic pellets, personal care products etc.
Bioaccumulation	Bioaccumulation is the gradual accumulation of substances, such as pesticides or other chemicals, in an organism. Bioaccumulation occurs when an organism absorbs a substance at a rate faster than that at which the substance is lost or eliminated by catabolism and excretion
Chemical oxygen demand (COD)	Chemical oxygen demand (COD) is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution i.e. a 'high' COD indicates the water is high in chemicals in the process of oxidising
Biological oxygen demand (BOD)	Biochemical oxygen demand (BOD) is the amount of dissolved oxygen (DO) needed (demanded) by aerobic biological organisms to break down organic material present in a given water sample, i.e. a 'high' BOD indicates there is less oxygen present in the water supply for aquatic organisms

AGENDA

- Overview Approach & Objective
- Executive Summary Findings
- **Planetary Boundary Findings**
  - **Novel Entities**
    - Microfibres
    - **Chemicals**
    - Pesticides
  - Biogeochemical Flows
  - Freshwater Use
  - Biodiversity

WHAT IS THE LINK BETWEEN HAZARDOUS CHEMICALS AND FASHION?

Hazardous chemicals overview and fashion intersection

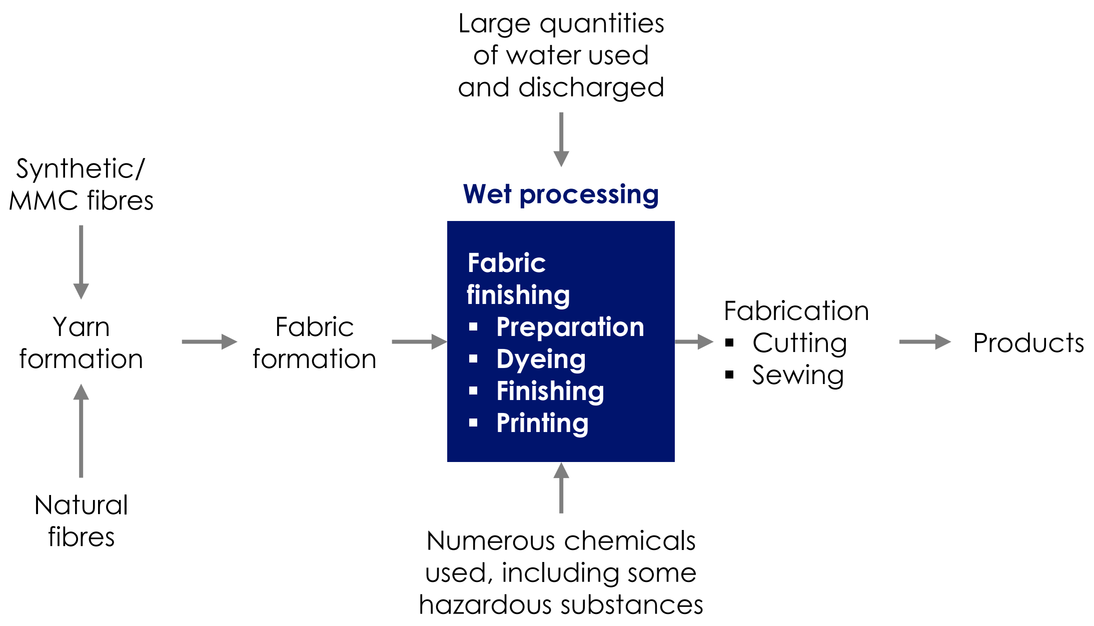
- Annually, **43 million tonnes of chemicals** are used to produce textiles (~2% of global chemical production)
- **~100-150 litres of water** are used per kg of fabric during wet processing
- Untreated textile wastewater is high in pH (alkaline), changes the colour, leads to high toxic concentrations of **heavy metals (lead, mercury etc), aromatic compounds (azo dyes) and other volatile compounds**
- Chemical changes from the wastewater results in **impaired photosynthetic, promotes CMR* and disrupts endocrine function in aquatic life and humans**

Relevant materials

Synthetic	Mixed/MMC*	Natural
✓	✓	✓

Chemicals are used in all types of textile materials during processing and finishing including dyes, water resistance agents, anti-creasing and softeners

Value chain intersection (chemical leakage into waterways)



- Chemicals are used across the **entire value chain** from feedstock production (pesticides and polymerisation) to production/assembly through to chemical leakage during the use phase and EOL.
- However, most hazardous chemical leakage waterways occurs during the **wet processing (T2)** of garment including scouring, (de)sizing, bleaching, dyeing and printing**

Source: Fashion for Good, 2018, EMF, 2017, UNEP, 2019, Glasa, 2015
Carcinogenic, mutagenic or toxic to reproduction
** Pesticide environmental leakage is analysed separately

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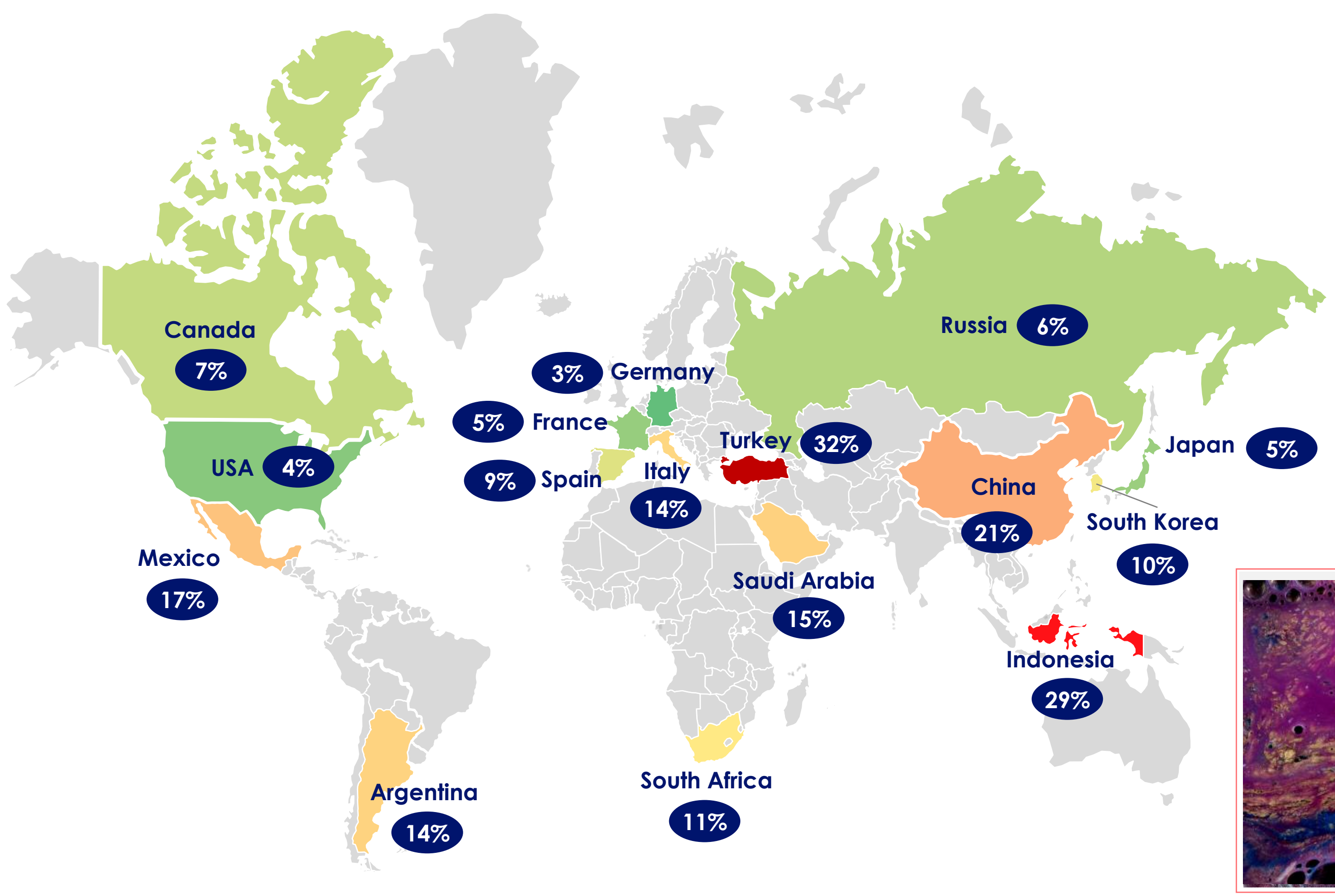
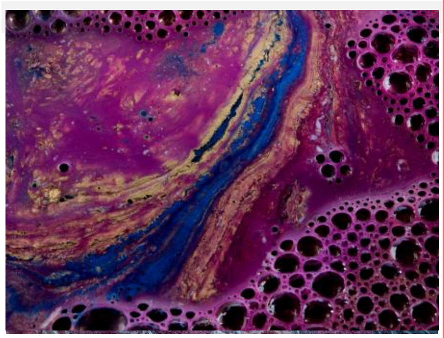
WHERE ARE THE LARGEST SOURCES OF TEXTILE WATER POLLUTION?

Textile industry water pollution across G20 countries

Water pollution, textile industry (% of total BOD emissions) across G20 countries





- **The largest textile producing countries have the highest water pollution levels** including Indonesia, Turkey, China and India* e.g. Chinese textile industry produced 1.84bn tons of effluent in 2015,
- **The discharge of hazardous chemicals into marine biomes leads to:**
  - i) large scale environmental damage and biodiversity loss and
  - ii) economic loss e.g., Citarum river in Indonesia has lost 60% of all fish species and destroyed fishing livelihoods
- **Wet processing has the highest hazardous chemical contamination risk** with freshwater and marine biomes
- **Low implementation and enforcement of factory effluent treatment plants (ETP)** leads to water pollution e.g., one study for Bangladesh estimates that between just 40-80% of textile plants use ETPs

Source: Parschiv, Tudor and Petrariu, 2015

* The data does not include India however, as one of the main textile producing countries, it has significant textile water pollution

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HAZARDOUS CHEMICALS ENTER WATER SYSTEMS DURING WET PROCESSING

Main water pollutants during wet processing

Sizing → De-sizing → Scouring → Bleaching → Mercerising → Dyeing → Printing → Finishing

- **De-sizing**: Biochemical oxygen demand from sizes, enzymes, starch and waxes.
- **Scouring**: Sodium hydroxide, surfactants, soaps. fats, pectin, oils, sizes and waxes
- **Bleaching**: Hydrogen peroxide, sodium silicate, organic stabilizer and alkaline conditions.
- **Dyeing**: Metals. salt, surfactants, Colour and alkaline/acidic conditions
- **Printing**: Colour, metals, urea, formaldehyde and solvents
- **Finishing**: Softeners. solvents, resins and waxes.

- The industry uses over **15,000 chemicals** across the entire value chain with an estimated **43 million tonnes of chemicals** applied to textiles annually (EMF, 2017)
- The chemicals used can be broken down into seven groups: **solvents, surfactants, repellents, dyes and pigments, flame retardants, plasticisers/phthalates, biocides and pesticides** (see annex x)
- Key hazardous chemicals used include **POPs*** (e.g. azo dyes), **PFAS*** (e.g. anti-stain agent), **NPEs*** (e.g. surfactants, dye dispersing agents), **heavy metals** (e.g. cadmium, mercury and lead)
- Remaining chemicals leak into the environment from **consumer washing and mismanaged end of life disposal** e.g. open landfilling and burning

Pal, 2017

- Persistent organic pollutants (POPs), Per- and polyfluoroalkyl substances (PFAS), Nonylphenol Ethoxylates (NPEs)

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… AND TEXTILE WASTEWATER DOES NOT JUST HAVE AN HARMFUL IMPACTS ON AQUATIC ORGANISMS….

TEXTILE WASTEWATER

Human beings

- Tumours, cancers and allergies
- Skin and eye irritation

Marine systems

- Ecotoxicity in aquatic organisms such as dolphins, fish and snails
- Endocrine disruption
- Promotes CMR
- Disrupts photosynthesis activity

Biodiversity

- Contamination of soil and deterioration of water quality resources

Terrestrial systems

- Perturbation in photosynthetic activity
- Bioaccumulation in the food chain
- Contamination of soil
- Contamination of agricultural products

Source: Pal, 2017

… THERE ARE FOUR KEY SYSTEM LEVERS TO REDUCE THE INDUSTRY'S HAZARDOUS CHEMICAL USE…

Intervention	Description
Scale and innovate materials and processes	Scale innovations such as new materials, safer chemistries, and waterless processing to **reduce** use of hazardous chemicals
Adopt and integrate non-linear chemical use models	Adopting and scale **reuse** models (e.g. recycled fibres) and explore circular business models for chemicals e.g. chemical leasing, less complex chemical waste streams, replace of aqueous chemicals etc.
Substitute use of hazardous chemicals	**Substitute** hazardous chemicals with available alternatives (and innovate where necessary)
Develop and implement high quality wastewater treatment facilities	**Safe disposal** and treatment of hazardous chemicals during wet processing and removal of liquid discharge where possible

ENSURING ALL SUPPLIERS HAVE EFFECTIVE EFFLUENT TREATMENT AS WELL AS COORDINATED CHEMICAL MANAGEMENT ARE THE HIGHEST PRIORITY LEVERS…

Intervention	Solutions are known & available	Solutions are scalable	Solutions are lacking progress	Solutions are lacking attention	Solutions need collec. action	Ocean impact potential	Examples of initiatives /solutions	Barriers to progress
Factory effluent treatment	High	Medium	High	Medium	High	High	▪ **Zero Liquid Discharge (ZLD)** ▪ **ZDHC wastewater guidelines** ▪ **Innovations:** reverse osmosis, SeaChange Technologies ▪ **National regulations**	▪ Prohibitive costs of ETPs for suppliers ▪ Low supplier awareness ▪ Lack of enforced regulation in producing countries
Effective chemical management and substitution of hazardous chemicals	Medium	Medium	High	Medium	Medium	High	▪ **ChemSec Marketplace –** search engine for safer alternatives to hazardous chemicals ▪ **EU textile chemical restriction list** ▪ **Chemical management toolkits/information systems:** ZDHC, SAC FEM, Bluesign, C2C, CleanChain	▪ 'Regretful' substitution ▪ Lack of safe alternatives (e.g. to APEOs, phthalates & PFCs) ▪ Cost of alternatives
Scale and innovate materials and dry processing	Medium	Medium	High	Medium	Medium	High	▪ **New materials:** switch to materials that minimise use of harmful chemistry ▪ **Safer chemistries:** safer finishing chemical and biobased dyes ▪ **Waterless processing:** waterless dyes/finishing chemicals, dope dyeing ▪ **Innovative processes**: dope dyeing, reusing process baths	▪ Solutions not scaled ▪ Costly to innovate ▪ Lack of consumer pressure ▪ Increase in chemical complexity ▪ Plant logistic complications
Adopt non-linear chemical use models	Low	Low	High	High	High	Medium	▪ **Fibre recycling innovation** across cotton, polyester, nylon and blends ▪ **Chemical Circularity,** Laudes Foundation	▪ Prohibitive costs (e.g. ZLD facilities) ▪ Lack of incentives/policy to shift business models

Notes on MF solution buckets categorisation under the 9 overarching solution buckets (see slide 16):
Factory treatment of effluent > 1. On-site chemical and wastewater management
Effective chemical management> 1. On-site chemical and wastewater management
Scale dry processing > 7 Process innovation
Adopt non-linear chemical use models > 7 Process innovation

GLOSSARY HAZARDOUS CHEMICALS

Term	Definition
Chemical oxygen demand (COD)	Chemical oxygen demand (COD) is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution i.e. a 'high' COD indicates the water is high in chemicals in the process of oxidising
Biological oxygen demand (BOD)	Biochemical oxygen demand (BOD) is the amount of dissolved oxygen (DO) needed (demanded) by aerobic biological organisms to break down organic material present in a given water sample, i.e. a 'high' BOD indicates there is less oxygen present in the water supply for aquatic organisms
CMR substances	CMR substances are substances that are carcinogenic, mutagenic or toxic to reproduction (CMR). They are of specific concern due to the serious long term effects that they may exert on human health.
Endocrine function	The hormones created and released by the glands in your body's endocrine system control nearly all the processes in your body. These chemicals help coordinate your body's functions, from metabolism to growth and development, emotions, mood, sexual function and even sleep.
Eutrophication	Eutrophication is characterized by excessive plant and algal growth due to the increased availability of one or more limiting growth factors needed for photosynthesis such as sunlight, carbon dioxide, and nutrient fertilizers.
Persistent Organic Pollutants (POPs)	Persistent organic pollutants are carbon-based chemicals that persist in the environment for a long time, are damaging to the environment, wildlife, and people, and can be spread over long distances. Example of textile use cases include azo dyes.
Per- and polyfluoroalkyl substances (PFAS)	PFAS substances have performance enhancing characteristics when applied to textiles such as strength, durability and heat-resistance. They are difficult to breakdown in the environment and lead to bioaccumulation in human and aquatic life that can cause liver, kidney and immune deficiency.
Nonylphenol Ethoxylates (NPEs)	NPEs are used in textile production as wetting agents, detergents, and emulsifiers. This toxic chemical then remains in the garment, released once washed, breaking down to form toxic nonylphenol (NP)

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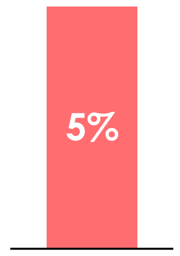
FASHION INDUSTRY IS RESPONSIBLE FOR ~5% OF GLOBAL PESTICIDE USE

Pesticides overview and fashion intersection

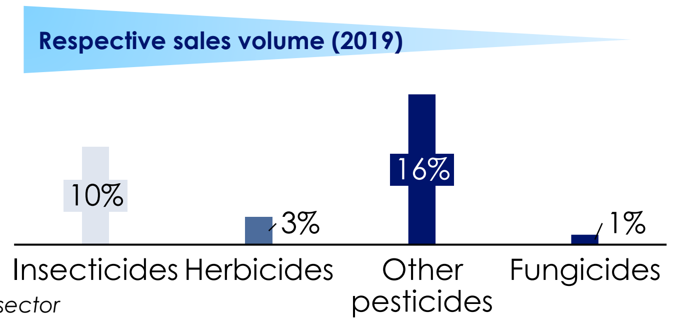
- Fashion accounts for **~5% of the world's pesticides** (incl. fungicides, herbicides, insecticides) – mainly used for cotton.
- **In the cotton production hotspots, cotton crops are often one of the largest pesticide users and risks of pollution are significant.**
- While the EU has banned many hazardous pesticides, the cotton-producing countries **continue the use of highly toxic and persistent pesticides**
- Lack of education, high pesticide subsidies, risk aversion and lack of pesticide ban enforcement contribute to high pesticide use
- This leads to high risks of pesticide pollution and runoffs into the environment
- **Pesticide runoff into oceans results in marine fauna and flora loss**

Cotton production and pesticide use

Share of global pesticide sales for cotton (2019)*

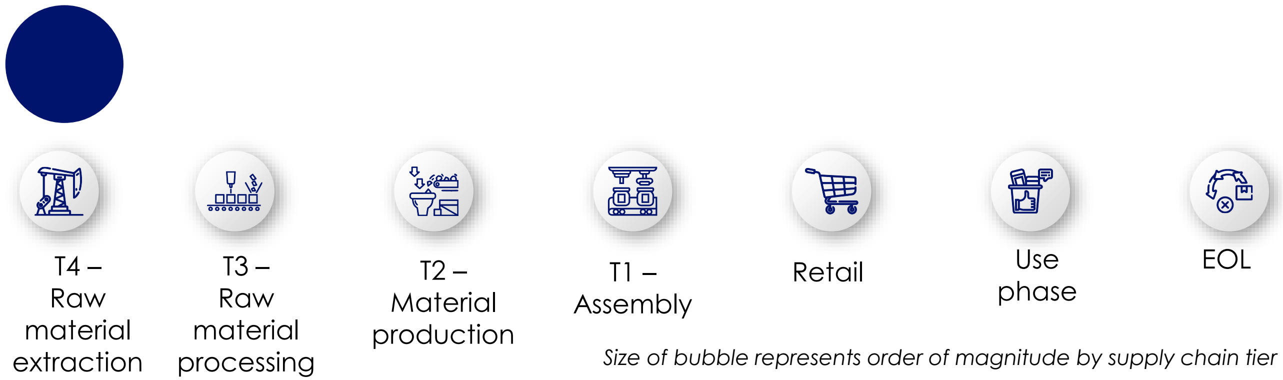


This includes the following pesticides used for cotton as share of total:



**As compared to 3% GDP of fashion sector*

Value chain intersection



Size of bubble represents order of magnitude by supply chain tier

Relevant materials

Synthetic	Mixed/MMC*	Natural
		✓
		Natural fibres (mainly cotton, but also jute and linen), leather

Similar to fertilizer, pesticides are used for agricultural practices and are therefore not relevant to synthetic fibres. Most MMC's raw materials (e.g. bamboo, eucalyptus) do not require pesticide use.

Source: Transformers Foundation 2021, FAO (2020)/Our World in Data, PAN UK (2018)

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NEGATIVE EFFECTS ON MARINE BIOMES AND HUMAN HEALTH ARE SERIOUS

Effects on marine biomes

- Exposure can lead to **wide-scale marine life loss, abnormalities/mutations (fish larvae) and carcinogenic effects**
- Effects depend on exposure time & type (lethal or sub-lethal), as well as toxicity, persistence, degradant creation (break down into smaller compounds), fate
- **Climate change has been found to exacerbate risks** of pesticides in marine environments
- Animals higher in the food chain are more affected, but fish and shrimps have also been found to suffer
- Examples are sea lions in California, Great Barrier Reef & Coral Reef Fish in Australia, ban of fishing in Guadeloupe

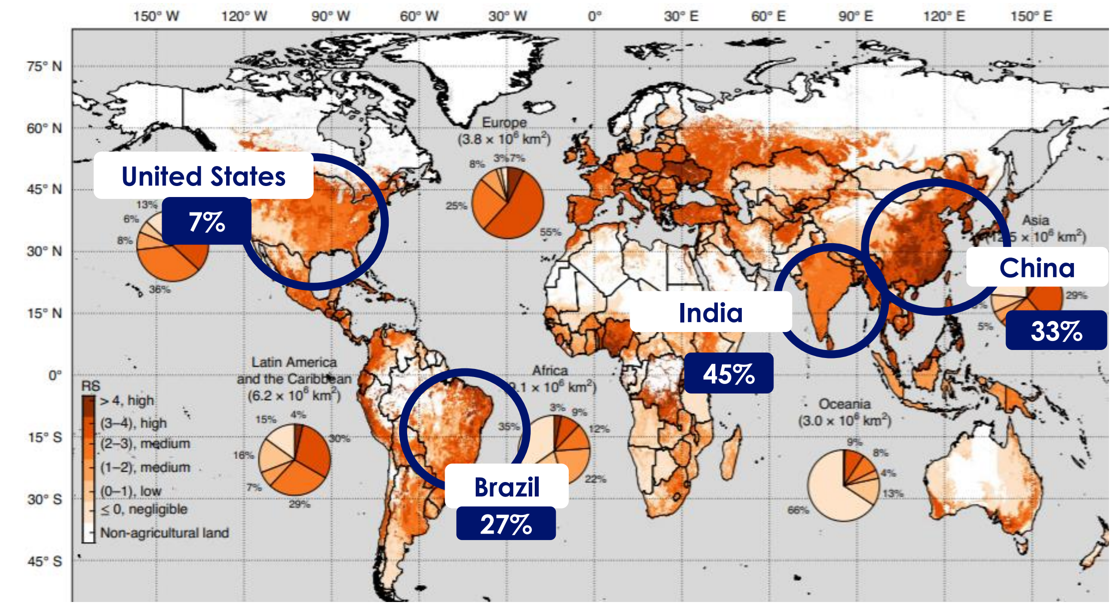
Effects on worker/human health

- **Short-term and long-term health risks are possible**, and risks depend on the level of exposure to the pesticide and the type (oral, inhalation, dermal)
- Short-term risks are e.g. eye/skin irritation or blisters
- Long-term risks may include birth defects, cancer risks, changed hormone functionality, immune system issues, and neurological problems
- Studies among cotton farmers in Africa and Asia have found pesticide poising rates of farmers of 25%-57%, and it is also stated that 1000 people die every day from acute pesticide poisoning and other health risks (not only from cotton though)
- **Studies have reported increased cancer risks due to pesticide use** (e.g. leukaemia, solid tumour)
- Children are more sensitive to pesticide exposure than adults

Source: Beyond Pesticides (2021), Özkara et al. (2015), Transformers Foundation (2021)

MOST COTTON-GROWING COUNTRIES HAVE HIGH RISKS OF PESTICIDE POLLUTION

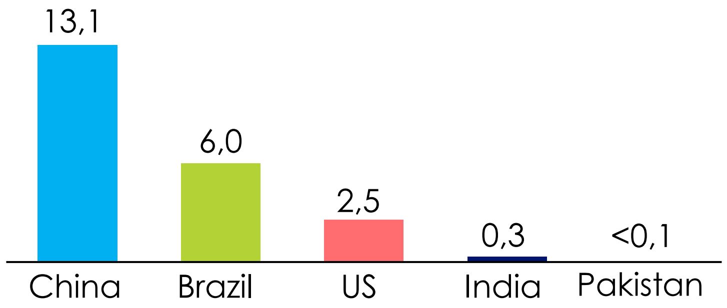
Risk of pesticide pollution collides with cotton production hotspots



Map shows the risk of pesticide pollution determined through **pesticide residues in environment**

%

Percentage displays the share of pesticides in the respective country that is used on cotton crops. For Pakistan, this data was not available.



Average pesticide use per hectare of cropland for all crops (2017)

*Data is for all crops, not just cotton; for cotton these numbers are assumed to be significantly higher!

Data on pesticide use for cotton indicates severity of problem

- **Map of pesticide risks show that most cotton production hotspots are all at medium to higher risk levels**
- While environmental impacts are known (e.g. fish stock depletion), there are no specific impact measurements
- The fashion industry is the 4th **largest market of agrochemicals in general**, and the third largest market for pesticides
- **Regional differences are large**: in Africa many countries use low levels of pesticides, while China has the highest use per hectare
- **Regulatory variations & lack of enforcement** contributes to use of highly toxic pesticides in cotton production hotspots. While EU has banned many pesticides, this isn't true for cotton hotspots.

Source: Tang et al. (2021), Alliance for Science (2018), GITAM (n.d.), US Department of Agriculture (2014)

ELIMINATION HAS BIGGEST POTENTIAL, BUT EFFICIENCY INCREASE IS A QUICK WIN

Intervention	Solutions are known & available	Solutions are scalable	Solutions are lacking progress	Solutions are lacking attention	Solutions need collective action	Ocean impact potential	Examples of initiatives /solutions	Barriers to progress
Efficiency Improvements: Integrated Pest & Weed Management	High	Medium	Medium	Medium	Low	Medium	▪ IPM & IWM are mainly part of preferred fibre standards (e.g. BCI, Organic, CmiA) ▪ FAO-EU IPM programme has provided education to over 100k farmers ▪ IPM/IWM can reduce costs for inputs	▪ Long transition period, lack of finance to bridge this period ▪ Misleading pesticide information and reliance on suppliers/lack of training ▪ Risk aversion
Regenerative Agriculture	High	Medium	High	Medium	High	High	▪ High degree of IPM/IWM included in regenerative agriculture practices, especially focusing on prevention through healthy soils	▪ Subsidies & insufficient finance available for farmers to de-risk transition ▪ Lack of education
Organic Agriculture: Elimination of Synthetic Pesticide Use	High	Low	High	Low	Medium	High	▪ GOTS/Textile Exchange Organic Standard/Regenerative Organic Certificate	▪ No access to standardizing bodies and finance to bridge the transition ▪ Lack of demand / policy Price/yield trade-offs
Alternative Fibre Choices	Medium	Low	Medium	Low	Medium	Medium	▪ Some natural fibres do not require pesticide use or only very little (e.g. bamboo/eucalyptus) ▪ Leather alternatives, such as mycelium or plant-based (e.g. pineapple) leather	▪ Low consumer awareness ▪ Solutions not scaled ▪ Price premium

* Part of regenerative, organic and partially also conventional cotton, goal is to increase input efficiency. Farming practices aimed at improving soil health (e.g. cover crops or crop rotation) also helps to reduce pest risks.

PESTICIDE GLOSSARY

Term	Definition
Pesticides	Substance that is used to suppress, eradicate or prevent organisms that are considered harmful.[1] Includes plant protection products (used on plants in agriculture – e.g. herbicides, fungicides) and biocides (used in other applications). Pesticides include herbicides and fungicides. For cotton, herbicides, fungicides and insecticides are the key pesticides used.
Herbicides	Herbicides are used to control weeds. They are one type of pesticides. Herbicides make up appr. 80% of all pesticides used. Synthetic herbicides were first produced synthetically in the 1940s.
Fungicides	Chemical compounds/biological organisms that are applied to kill fungi/fungi spores. Fungicides are another type of plant protection product and therefore also one type of pesticides. Fungi are among the top causes of crop loss.
Insecticides	Type of pesticide that are used to control/kill insects. They are also used in agriculture, and cotton accounts for 10% of the total insecticides used.
Biocides	Also used to combat harmful organisms but they are not related to agriculture (e.g. rat poison).
Persistent Organic Pollutants	"Forever Chemicals", known to persist in the environment without any degradation.
Growth Regulators	Disrupt how insects grow and reproduce
Defoliants	Pesticides that make leaves fall off of herbicides
Half-live time	Time it takes for a pesticide to be reduced by half

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AGENDA

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BIOGEOCHEMICAL FLOWS EXECUTIVE SUMMARY

- The planetary boundary 'biogeochemical flows' determines human-driven changes to the biogeochemical cycles of Nitrogen (N) and Phosphorus (P) – two of the basic elements of earth. These cycles usually remain in balance without human interventions, but **commercial agriculture and industrialization have led to significant N and P pollution in ecosystems globally**.
- The impact of N and P pollution in oceans are visible today: eutrophication (through excessive nutrient pollution) leads to harmful algae blooms and oxygen depletion, resulting in marine biodiversity loss and in its extreme form in so-called dead zones, such as the Gulf of Mexico. **Next to environmental impacts, eutrophication also leads to loss in tourism revenues, reduced harvests for fishing, & human health impacts, such as shellfish poisoning.**
- Research finds that this **boundary has been crossed by a factor of 2 already**. Hence, we are now in a area of 'high risk' where the detrimental effects of excess N and P flows on oceans and other waterways is dramatic.
- **The increased flows of N & P into waterways and oceans are to 75% driven by fertilizer use and biological nitrogen fixation (BNF)[1].**
- **The fashion industry contributes significantly to these impacts, as the cultivation of clothing fibre crops accounts for 3% of global fertilizer use.** In cotton production hotspots this share is higher: for example, in Pakistan 15% of the fertilizer is used for cotton. This is problematic, as only ~27% of N fertilizer in Pakistan is actually used by plants – leading to significant environmental nutrient runoff. There are also interlinkages to the leather industry, as live-stock feeding and subsequent manure left on fields leads to even more nutrient runoff.
- There are three key approaches to tackle this **: 1) improve the nutrient use efficiency of fibre crops, 2) scale sustainable (organic or regenerative) agriculture to reduce or eliminate the use of fertilizer, or 3) use alternative fibres that require no/little fertilizer**
- **Regenerative agriculture, also referred to as nature positive agricultural production, provides feasible, scalable and cost-efficient solutions to counteract the excessive use of chemical fertilizers.** Next to significantly improving soil health and reducing other negative environmental impacts of agriculture, it can also secure farmers' revenues, provide stable yield output, restore ecosystem's resilience, support carbon sequestration and positively impact human health.

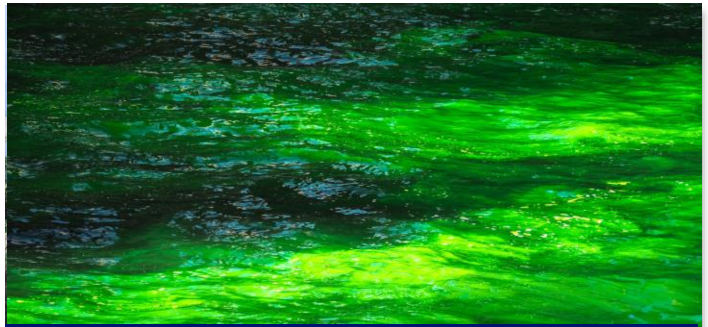
1: BNF is a process in which bacteria present in particular legumes turns Nitrogen gas into N that plants can use – this process has been used for agricultural purposes for over 2000 years by planting these legumes in cropland. Since the industrial revolution, these human-driven nutrient sources were not considered sufficient anymore, leading to the introduction of fertilizer.

SEA SNOT IN TURKEY

Coastal Eutrophication

Gulf of Mexico Dead Zone

Harmful Algae Bloom

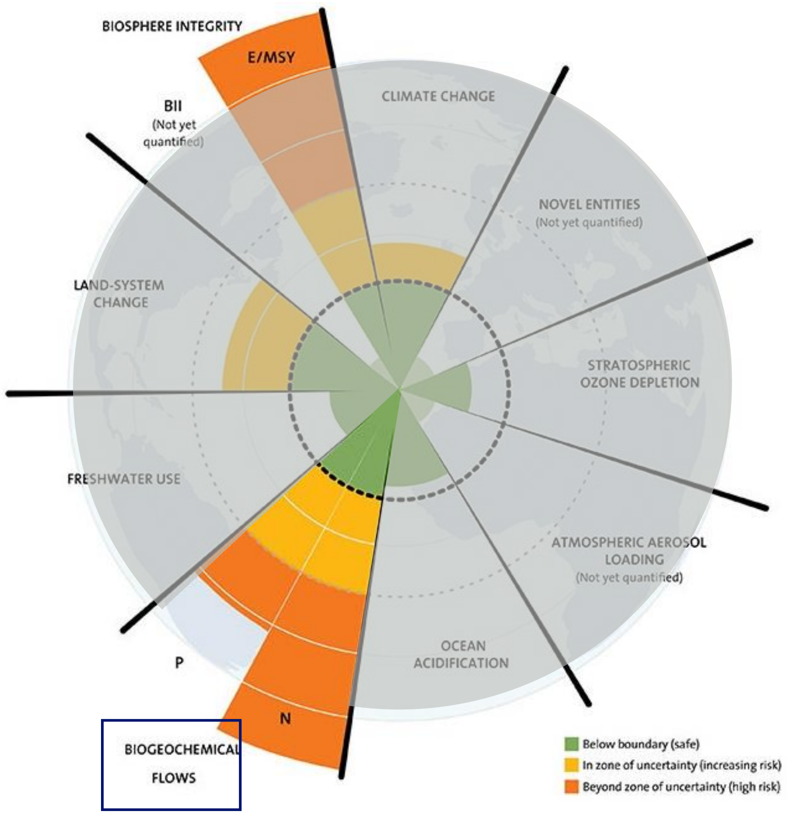


Coastal Eutrophication

THE PB BIOGEOCHEMICAL FLOWS IS IN THE HIGH-RISK ZONE

Definition of boundary

- This PB defines the **changes to biogeochemical flows (mainly nitrogen and phosphorus cycles) driven by agriculture and industrial activities**
- N&P pollution impacts biodiversity, climate & human health



The N & P boundary levels are already transgressed by 2 (P global) and more than 2 (N global and P regional), mainly driven by agricultural fertilizer use

Scope

- **Currently covers N & P flows which are two of the four basic elements of life** (next to Oxygen, Hydrogen, Nitrogen, Phosphorus). It might be extended in the future (e.g. silicone)
- N&P flows are global, but the impacts are mainly local

Current state

Scientists agree that the N&P flows into the environment have crossed the boundary of the safe operating space due to human-driven excess N&P introduction. The boundaries are all in the red zone now.

Scientific & policy consensus

There is a **consensus on the criticality of the N&P PB and that the human-driven flows of N&P are far beyond the 'safe operating space'**. Nevertheless, there are discussions on the exact value of the PB, how these are measured and how the relation to securing food supply can be addressed.

Pathways

Organizations are working on roadmaps for reducing fertilizer use, especially from a food perspective (e.g. FOLU). **The EU has adopted a nutrient reduction target for 2030** (at least 50% nutrient loss reduction and 20% nutrient use reduction).

Metrics

- *N PB* looks at industrial & intentional biological fixation of N, so N in fertilizers & the human-driven biological fixation of N beyond natural processes (e.g. via legume planting)
- *P PB global* measures P flow from freshwater systems into oceans, aims at avoiding large-scale events of low oxygen
- *P PB regional* looks at flow from fertilizers to erodible soils and focuses on eutrophication - hence, the boundary value for P regional is smaller than for P global

Ocean link

Increased nutrient flows from soil into waterways and ultimately marine waters **leads to eutrophication, which results in marine biodiversity losses and in its worst form in so-called dead zones**

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FERTILIZER USE DRIVES THE FASHION SECTOR'S CONTRIBUTION TO PB

Description of boundary and fashion intersection

- The fashion industry's impact on the PB biogeochemical flows **is mainly driven by fertilizer use for the cultivation of cotton**, whereby 66% of Nitrogen fertilizer runs off into soil and water, and 50% of Phosphorus
- Next to crops, **leather drives fertilizer use as livestock feed fertilizer efficiency is very low due manure runoff**
- While the global share of fertilizer used for fibre crops is on par with the sector's GDP contribution, **cotton production hotspots show that the fashion industry has an even higher impact on a local level** (e.g. in Pakistan)
- As N&P flows and subsequent knock-on effects for marine ecosystems are especially visible on a local level (e.g. dead zones in specific areas), **local excess flows should be addressed**

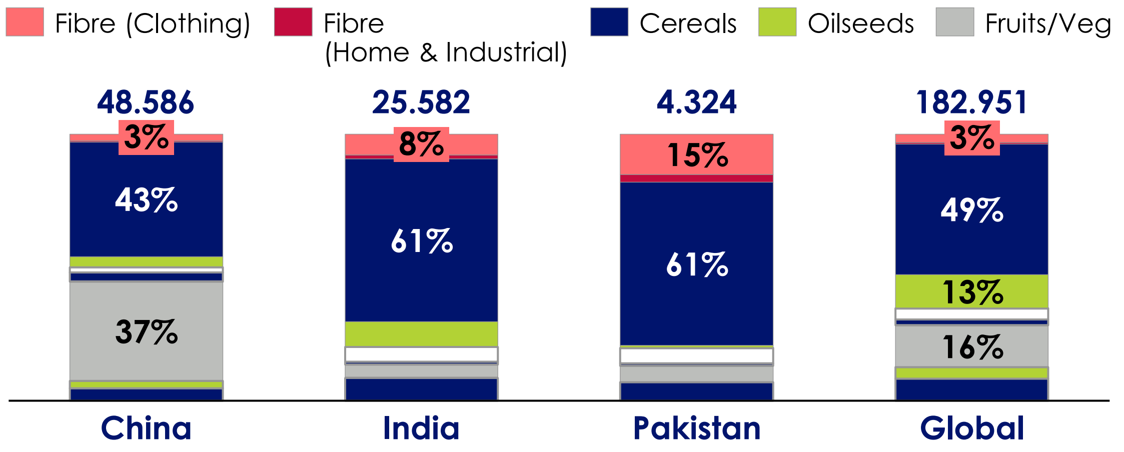
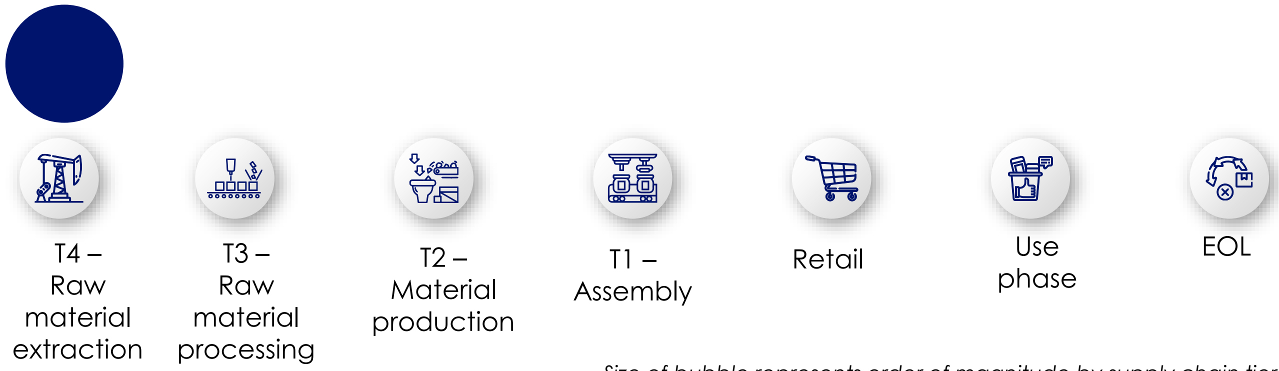


Figure 1: Fertilizer Use for Crops in kt nutrients (IFA 2017)

Description of boundary and fashion intersection



Size of bubble represents order of magnitude by supply chain tier

Relevant materials

Synthetic	Mixed/MMC*	Natural
	✓	✓
n/a	Some MMCs require fertilizer for pulp production	**Cotton** (main source), jute, linen, etc, and **leather**

* Man-made Cellulosic fibres

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EXCESS NUTRIENT FLOWS INTO OCEANS CAN LEAD TO HUGE ECONOMIC COSTS – NEXT TO DETRIMENTAL ENVIRONMENTAL ISSUES

Environmental Impact on Oceans

Nutrients that are not taken up by plants runoff from soil into waterways and eventually reach coastal waters, leading to eutrophication

Main symptoms of eutrophication:
Oxygen depletion & harmful algae bloom

- **Loss of subaquatic vegetation**
- **Species composition changes**
- **Dead zones**
- **Coral reef damages**

Ecosystem Collapse
Biodiversity Loss

Indicative environmental impacts, not comprehensive

Eutrophication reduces coastal waters' value of ecosystem services, harms commercial fishing and human health

Coastal tourism: Eutrophication reduces the aesthetics and enjoyability of coastal areas, harmful algae blooms can lead to unpleasant smells. In addition, recreational watersports might not be possible anymore.
Example: algal bloom in Ohio lake causes $37-47 mn in lost local revenue from tourism

Commercial fisheries : reduced harvests and fishery closures due to eutrophication and knock-on effects can significantly impact fishing revenue
Example: Shellfish bed closure in Maine due to algae bloom led to >$2.9 mn losses in revenue

Health impacts: Reductions in (drinking) water quality, accumulation of toxins produced through algae bloom in shellfish and seafood, and direct contact have been stated as potential negative health effects
Example: Florida hospital reported increased illnesses driven by algae blooms

Other impacts that have been mentioned are: drinking water treatment costs, loss of property values of waterfront houses

Excl. human health impacts from N emissions (due to focus on fashion industry impact)

Source: World Resources Institute (n.d.), EPA (2015)

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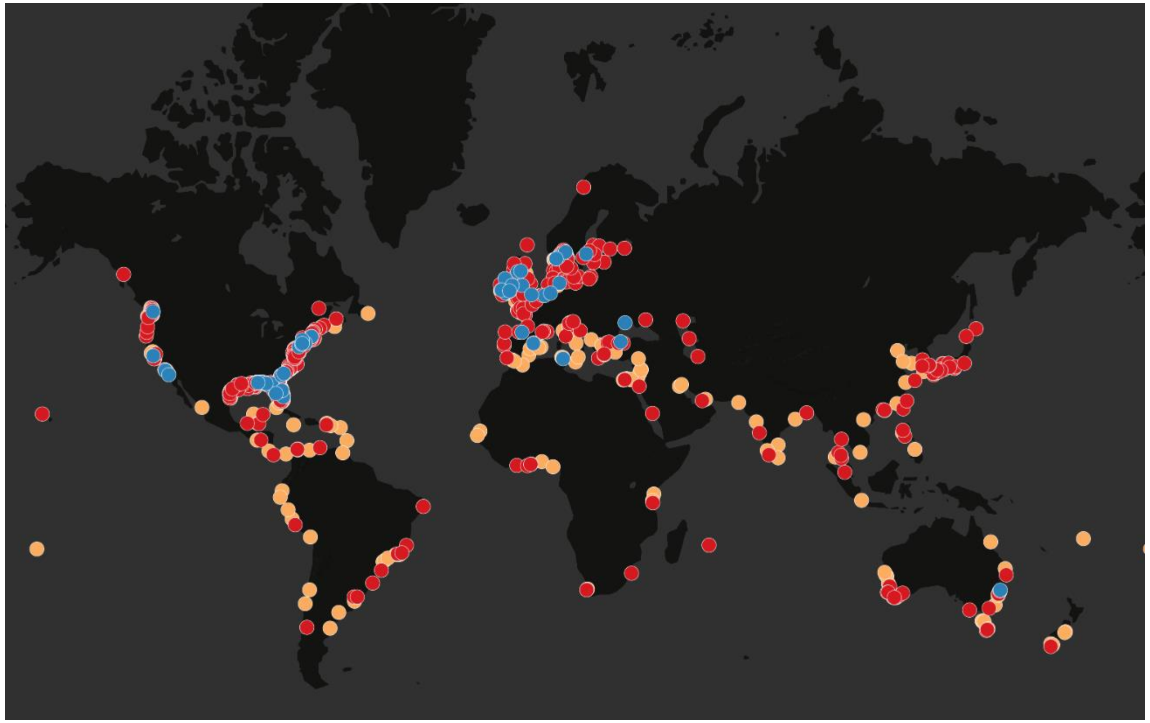
EXCESS N & P USE DRIVES COASTAL EUTROPHICATION GLOBALLY

Eutrophication and hypoxia in coastal areas



Eutrophic: very rich in nutrients, leading to phytoplankton productivity

Hypoxic: oxygen depleted areas

Improved Hypoxic (Systems in Recovery): increase in oxygen after previous low oxygen level

Dead zones in oceans have leaped since the 1960s:

- More than 95,000 square miles affected
- Oxygen level decreases are said to lag 10 yrs behind the increased uses of fertilizer
- Prominent dead zones: Gulf of Mexico, Black Sea, Baltic Sea, Chesapeak Bay
- Areas tend to be located downstream of basins with significant fertilizer applications

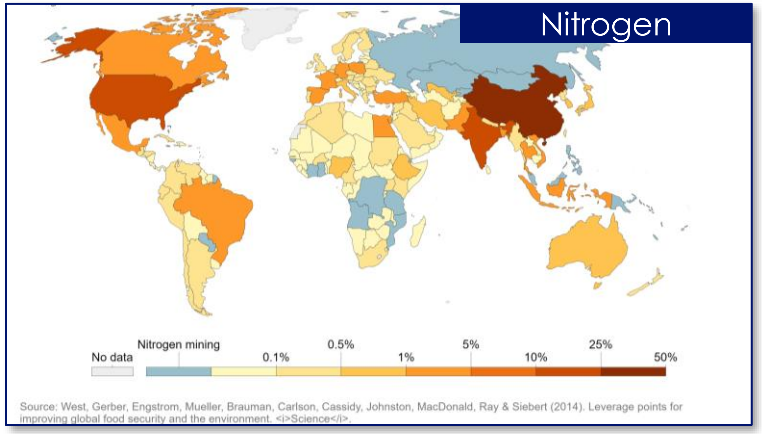
The main cotton production hotspots are also affected of eutrophication, but lack of data exists:

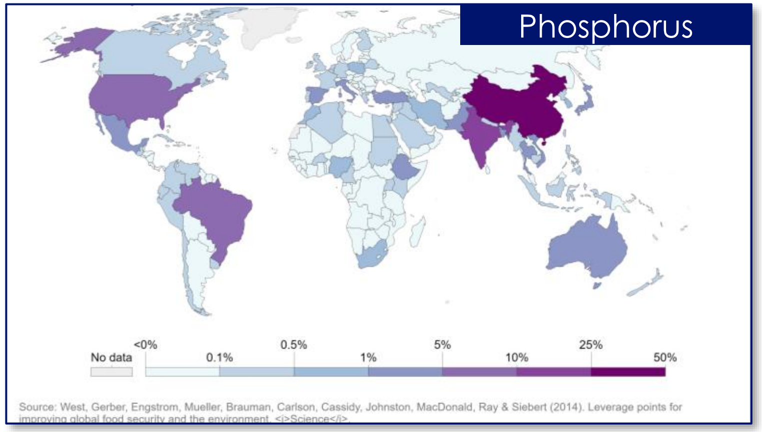
- **China:** Bohai Sea, East China Sea, etc.
- **India:** Harmful algae bloom in East & West Coast of India, 80 algae blooms reported 1998-2010
- **Pakistan:** Limited data exists, but known area with excess N&P is the Indus River
- **US:** Nitrogen flux in Mississippi River has increased by a factor of 4 due to vast farming areas surrounding the river, affecting the Gulf of Mexico
- **Brazil:** Several reservoirs/bays affected (e.g., Guanabara Bay)

ALMOST 2/3 OF APPLIED NITROGEN RUNS-OFF INTO RIVERS, LAKES AND NATURAL ENVIRONMENTS, AND 50% OF PHOSPHORUS RUNS OFF

Fertilizer use is highly inefficient, excess nutrient hotspots are China, India, the US, Brazil and Pakistan

- Excess nutrients that are not taken up by plants run-off into environment, determined by the difference in inputs and the nutrients in crop harvests
- There are countries that oversupply nutrients to croplands, others undersupply it
- Excess nitrogen/phosphorus per hectare of cropland shows us where fertilizer is used inefficiently (e.g. China, Pakistan)
- Total excess nutrient metrics can provide indicators on hotspots of water and ecosystem pollution (e.g. China, India, US)
- **The Nitrogen Use Efficiency (NUE) for cotton is estimated at 37%, which is lower than the average NUE for all crops at 42% - and for livestock this is even lower**





Share of global excess nitrogen and phosphorus from croplands provides indication on pollution hotspots

For P and N, China, India, US and Brazil are the countries with the highest share, and for P also Pakistan – these overlap with the main cotton producing countries

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SOLUTION SPACE COVERS ELIMINATION, REDUCTION & SUBSTITUTION

Intervention	Solutions are known & available	Solutions are scalable	Solutions are lacking progress	Solutions are lacking attention	Solutions need collective action	Ocean impact potential	Examples of initiatives /solutions	Barriers to progress
Efficiency improvements through precision ag/ improved application	High	Medium	Medium	Medium	Low	Medium	▪ Efficiency improvements through **better education/knowledge on fertilizer use** (e.g. time of application) and **precision agriculture** (e.g. remote sensing) ▪ Clear **economic business case**	▪ Subsidies on fertilizer dilute business case ▪ Lack of education in some countries, for example in China and Pakistan
Regenerative agriculture*	High	Medium	High	Medium	High	High	▪ **Regenerative agricultural practices** (partially including organic practices), such as nutrient recycling, zero tillage and crop rotation **reduce the need for synthetic fertilizer**	▪ Subsidies on fertilizer ▪ Certification/outcome metrics ▪ Insufficient finance available for farmers to de-risk transition ▪ Lack of education/ advice
Organic agriculture*	High	Low	High	Low	Medium	High	▪ GOTS/Textile Exchange Organic Cotton Standard, etc.	▪ Price/yield trade-offs ▪ Lack of demand signals
Alternative Fibre Choices*	Medium	Low	Medium	Low	Medium	Medium	▪ **Other natural fibres** (e.g. linen) ▪ **MMCs** offer lower impact fibres as alternative to cotton (e.g. lyocell) ▪ **Leather alternatives**, such as mycelium or plant-based (e.g. pineapple) leather	▪ Uncertainty about environmental impact ▪ Price premium ▪ Lack of mass availability

*For the respective solution space deep dive please see pesticides – as solutions cross planetary boundaries

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BIOGEOCHEMICAL FLOWS GLOSSARY

Term	Definition
Biogeochemical cycle	Cycle by which a chemical substance/element moves between biotic (biosphere) and abiotic (atmosphere, hydrosphere, lithosphere) compartments of the earth. The five biogeochemical cycles are water, carbon, nitrogen, phosphorus and sulphur.
Nitrogen (N)	Nitrogen makes up 78% of our atmosphere and is crucial for all living things. N is a colourless/odourless element and occurs in all organisms, especially in amino acids (proteins) and nucleic acids (RNA and DNA). Nitrogen is essential for plant growth and therefore crucial for food supply. Elemental nitrogen (N) has a strong triple molecule bond and it is therefore difficult for plants and industry to convert N into useful compounds. N exists in various chemical forms: organic nitrogen, ammonium (NH^{+}_{4}), nitrite (NO_2^-), nitrate (NO_3^-), nitrous oxide (N_2O), nitric oxide (NO) and inorganic nitrogen gas (N_2). Plants consume more nitrogen than any other nutrient.
Nitrogen Cycle	Biogeochemical cycle that converts N into a variety of chemical forms as it circulates between the earth's compartments. Conversion takes place through biological and physical processes – the processes are fixation, ammonification, nitrification and denitrification. Human activities have substantially changed the global nitrogen cycle, mainly due to fossil fuel combustion and synthetic nitrogen fertilizers.
Ammonia	Compound of nitrogen and hydrogen (NH_3), colourless gas with a specific odour. 90% of ammonia today is used for fertilizers but in the future will play a bigger role to drive decarbonization of transport and energy. The industrial production of ammonia is associated with significant GHG emissions (appr. 1% of global emissions – 20% of chemical industry emissions).
Phosphorus (P)	Essential nutrient for plants and animals. It is the 12th most abundant element in the Earth's crust and remains mainly on land, in rocks or soil minerals. It is a limiting nutrient (same as nitrogen) which means that its availability controls the pace of plants growth. Human exploitation of P takes place through mining activities. 80% of the minded phosphorus is used to make fertilizer.

BIOGEOCHEMICAL FLOWS GLOSSARY

Term	Definition
Phosphorus Cycle	The P cycle is very different to the N cycle, as the atmosphere does not play a big role in the P cycle. The main reservoir for Phosphorus is in rocks and this is primarily released through rain/weathering. The Phosphorus available in soil is called Phosphate – this is available for plants to take up. One P element can be caught in a P cycle for 100.000 years.
Nitrogen Fixation	This describes the process that takes place when Nitrogen Gas (N_2) is converted into ammonia (NH_3) and is hereby made available for plants to take up. This process happens biologically in the soil through microorganisms, but due to the excessive production of fertilizer is also an industrial process. Human-driven activities contribute to ~51% of total yearly nitrogen fixation but human activities may also indirectly affect the natural biological fixation of Nitrogen by planting legumes in farmland that drive the biological fixation.
Eutrophication	Excessive plant and algae growth due to balance surplus of nutrients (N and P), reinforcing process as bacteria will break down dead algae which in turn leads to nutrient release, continuing the cycle.
Hypoxic & Dead Zones	Hypoxic means oxygen depleted (scientifically this means less than 2 mg/l water). Eutrophication will also produce more bacteria which consume a lot oxygen – water without enough oxygen will cause non-bacterial organism to die & lead to so-called dead zones. The Gulf of Mexico is the largest dead zone, it occurs every spring in the northern Gulf of Mexico. Next to eutrophication as the main cause, climate change also contributes to development of hypoxic waters and dead zones.
Fertilizer	Nitrogen, phosphorus and potassium, or NPK, are the main primary nutrients in commercial fertilizers. Fertilizers are usually made of a mix of nitrogen and phosphorus and most contain other elements as well (e.g., potassium and maybe copper or zinc).

AGENDA

- Overview Approach & Objective
- Executive Summary Findings
- **Planetary Boundary Findings**
  - Novel Entities
  - Biogeochemical Flows
  - **Freshwater Use**
  - Biodiversity

FRESHWATER USE EXECUTIVE SUMMARY

- The global freshwater use planetary boundary is currently within the 'safe' global threshold (2600/4000 km3/year boundary), however this does not account for regional specificity and local basin water risks and stress. The planetary boundary focuses on **blue water** usage.
- Fashion withdraws **244.5 billion cubic metres of freshwater (including footwear)** per annum, **~5-6%** of global annual freshwater withdrawal
- The fashion industry **depends** on water as a key ecosystem service and needs to consider **supply risks** associated with blue water extraction in high water stress regions that can impact production
- The largest sources of freshwater withdrawal are from **cotton production** (21%), **textile processing** (24%) and **consumer laundering** (~10-35%)
- High water stress regions can lead to catastrophic impacts on humans and biodiversity including **the destruction of river eco-systems, droughts and famine as well as global-scale river flow changes**
- Cotton production accounts for the **largest blue water** use during material production stage (60%) due to several regional specific factors that affect overall blue water usage including climate, available rainfall and groundwater, soil type, rate of evapotranspiration and the availability/efficiency of irrigation systems
- During supply chain stages T3-, 40% of water usage comes from wet processing (dyeing and finishing), it estimated that **~100-150 litres of water** are used per kg of fabric that leads to high levels of grey water pollution
- Consumer laundering water usage is between ~**10-35% of the industry's total water use**, the grey water output from consumer washing includes microfibre emission and chemicals from detergents
- The levers to reduce total blue water consumption includes: i) implementation of efficient water management practices, ii) innovation in less water-intensive processes, iii) material substitution and iv) improved water governance and infrastructure

THE FRESHWATER PLANETARY BOUNDARY ONLY TAKES INTO ACCOUNT A GLOBAL THRESHOLD, NOT LOCAL BASIN CONDITIONS

Definition of boundary

The boundary looks at the **human modification of water bodies** including both **global-scale river flow changes** and **shifts in vapour flows** arising from land use change

Scope	**Local context dependent.** In general the water use situation will be highly depend on local basin conditions. Availability, quality and accessibility will differ hugely on a basin level. The PB looks specifically at **blue water use***
Current state	**Within 'safe' global threshold.** Planetary boundary freshwater use amounts of 2600 km3/year (4000 km3/year boundary) however there is no quantification of local basin conditions (see below)
Scientific & policy consensus	**Discussion on sustainability still ongoing, especially at corporate level.** Planetary boundaries defines water use on a very high level, which is not directly transposable to local boundaries.
Pathways	**No clearly identified and quantified industrial targets and budgets yet.** General consensus that sustainable means "withdrawals are in a balance with sustainable replenishment of the resource".
Metrics	**Global**: maximum amount of consumptive blue water use **Basin**: Blue water withdrawal as % of monthly river flow However **no one-size-fits-all metric** – dynamic relationship between withdrawals, consumption, discharge & effluents
Ocean link	**Ocean reliance on freshwater systems.** Marine ecosystems rely on freshwater discharge into oceans and polluted/depleted freshwater resources affect ocean biodiversity.

* Blue water is the water extracted from surface and groundwater reservoirs.

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FRESHWATER USE AND FASHION

Freshwater use and fashion intersection

- **Fashion withdraws 244.5 billion cubic metres of freshwater per annum**, ~5-6% of global annual freshwater withdrawal** - 68% of total freshwater is use from agriculture, 19% for industry, 11% for municipal use
- **Fashion's extraction of blue water has localised effects** depending on the water scarcity and availability in the sourcing region
- **High water stress regions can lead to catastrophic impacts on humans and biodiversity** including destroying river eco-systems, droughts and famine as well as global-scale river flow changes

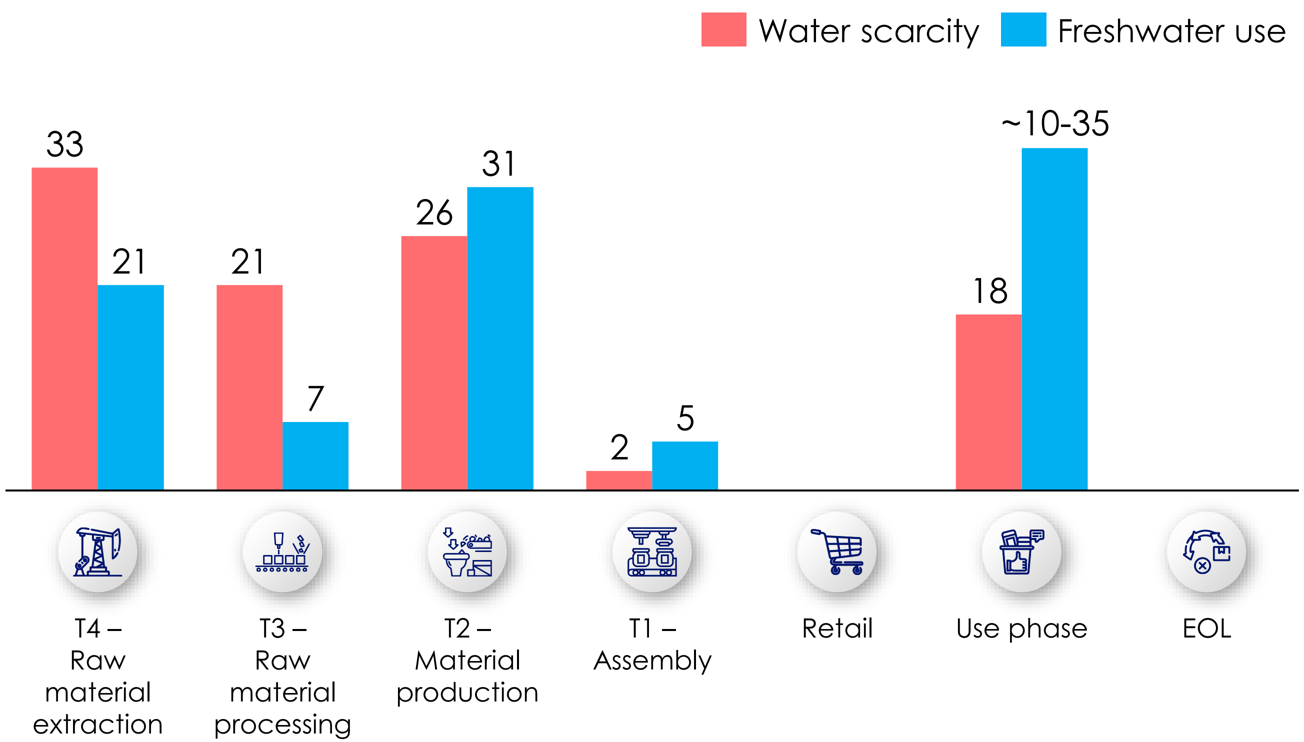
Relevant materials

Synthetic	Mixed/MMC*	Natural
✓	✓	✓

Freshwater use affects all materials across the whole value chain, however total water use different by material type

Value chain intersection

Freshwater (blue water) use across the fashion global value chain*, %



- Significant freshwater use and scarcity occurs **T2 (wet processing), T4 (agricultural production) and during consumer use**
- Consumer washing of garments is assumed to be **in addition** to the 215 billion cubic metres

Sources: GLASA, 2015, UNEP, 2020, Quantis, 2018, EMF, 2017, Aquastat, 2017
* The study is based on data from Quantis that measures freshwater withdrawal, assume this is focused on blue ad grey water extraction, not green water
** Assumed 5.5% of global freshwater withdrawal based on data from the FAO data that reports total global withdrawals at 3.8 trillion cubic metres

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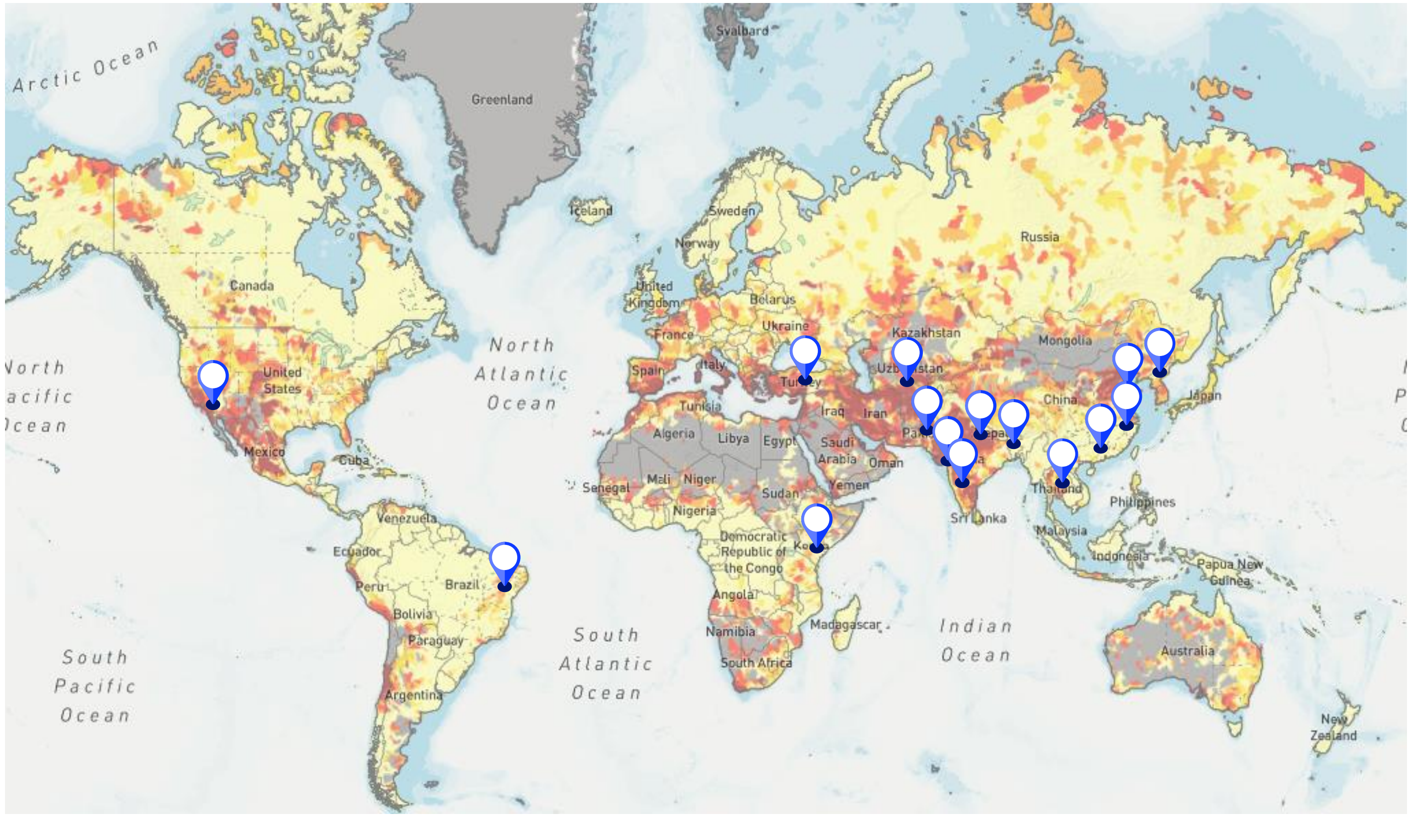
AND COTTON IS LARGELY PRODUCED IN HIGH WATER STRESS REGIONS…

Global Water Stress Map (WRI, 2019)



Key areas of cotton/textile production

Low	Low-medium	Medium-high	High	Extremely high
(<10%)	(10-20%)	(20-40%)	(40-80%)	(>80%)

Arid and low water use

No data

- **High water stressed regions production cotton and textiles** e.g. China, India, US, Turkey, Uzbekistan and Pakistan
- **Water scarcity footprint of global apparel:** China has the highest share (34%), followed by India (12%) and USA (5%) (FICCI, 2018)
- **High water stress regions have catastrophic impacts:** both on humans and biodiversity including river eco-systems destruction, droughts and famine as well as global-scale river flow changes

Source: Map access from WRI Aqueduct, 2019, UNEP, 2020

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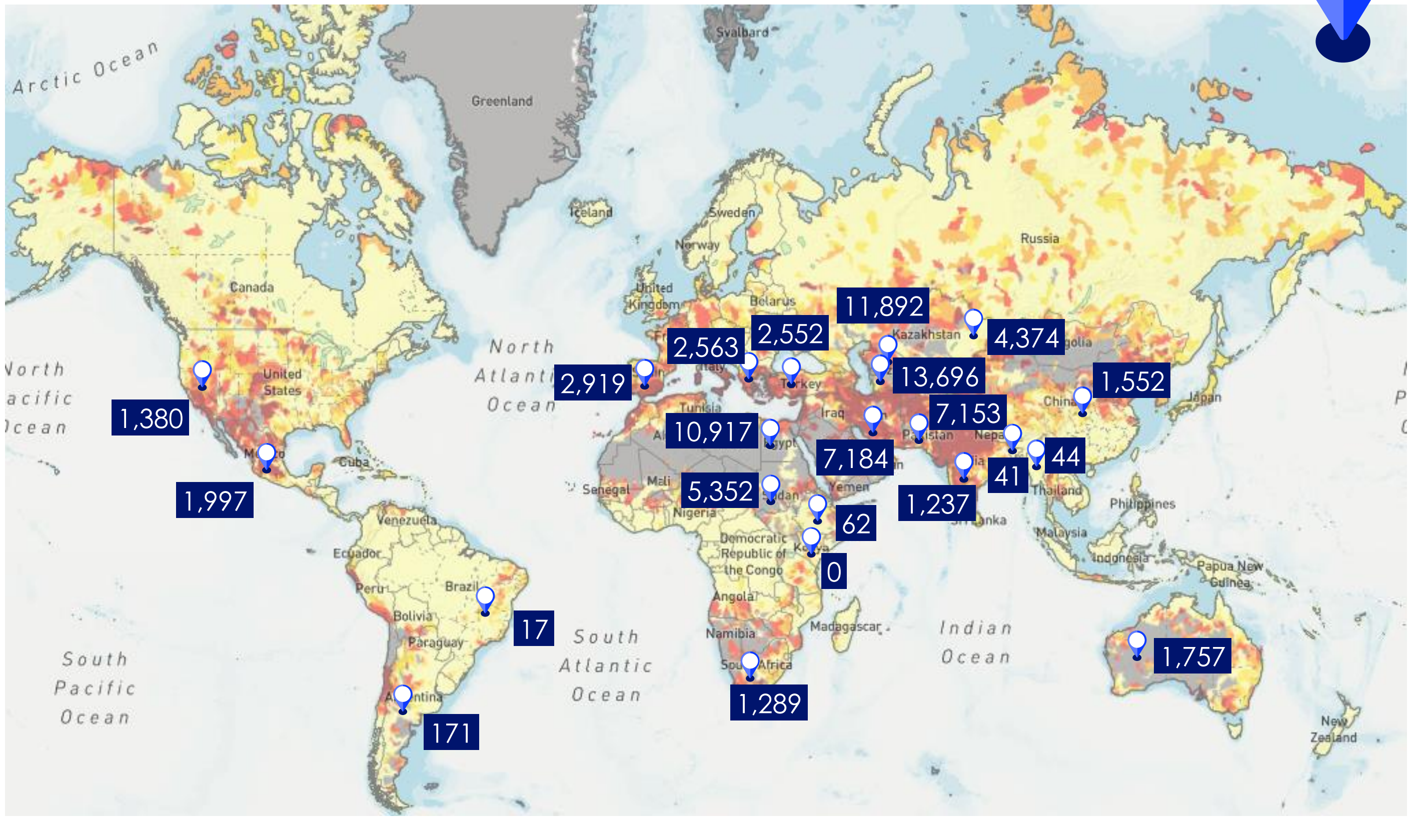
... EFFECTIVE WATER STEWARDSHIP CAN DRAMATICALLY AFFECT THE AMOUNT OF BLUE WATER NEEDED FOR COTTON...

Blue water use per kg cotton lint produced

Litres used per kg lint produced

World 1,931

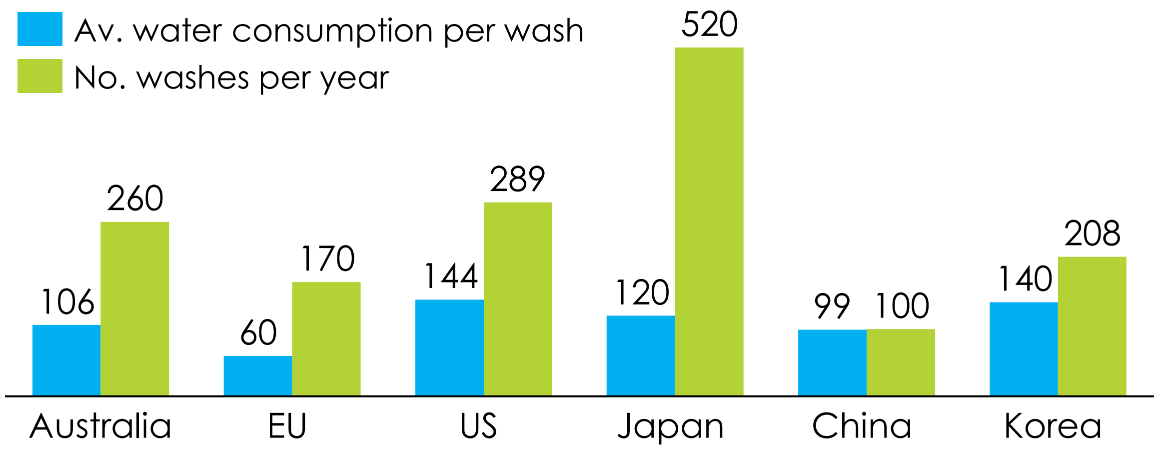


- **~48% of the area used for cotton production** consumes additional blue water (irrigated water) that produces **75% of the annual crop**
- **805-fold variation in water use** between Brazil & Turkmenistan
- **Blue water consumption varies** on the local climate, available rainfall and groundwater, soil type & rate of evapotranspiration
- **Effective water stewardship** includes mapping water resources, efficient irrigation practices, managing soil moisture, managing water quality (regenerative/organic/'better' agriculture)
- **Domestic use of blue water** for cotton can also vary dramatically within country e.g. 60 – 3,400 litres per kg in India

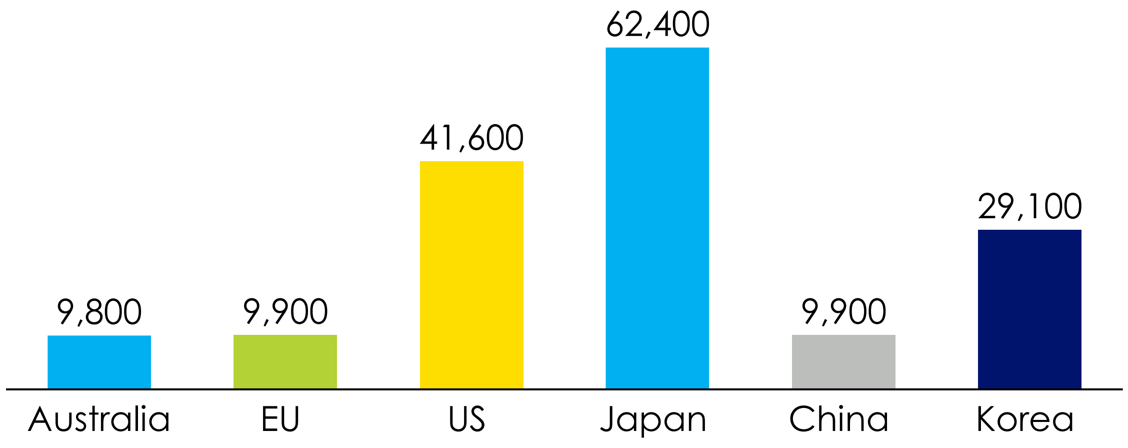
Source: Transformers Foundation, 2021, UNEP 2020

CONSUMER LAUNDERING ACCOUNTS FOR UP TO 35% OF TOTAL WATER USE ACROSS THE TEXTILE VALUE CHAIN

Average water consumption per wash cycle by region (litres) & Average number of washes per annum



Average annual water usage for household laundry by country (litres) per annum



- **Consumer washing of clothing accounts for ~10-35% of total water usage across the value chain*** through use of i) washing machines and ii) hand washing
- **Wastewater from consumer laundering can pollute natural waterways from**
  - I. Chemicals and detergents used to clean the garments and
  - II. Microfibre emission
- **To reduce consumer laundry water consumption, solutions include:**
  - Product care labelling to encourage consumers to washing less frequently
  - More efficient washing machines (current washing machines averagely use 10-20,000 litres per year depending on the region)

Source: BigEE, 2013, UNEP, 2020, Levis, 2015, Eco-age, Paluka and Stamminger, 2010
* Consumer data is assumption driven due to difficulties in predicting consumer behaviour and differences in laundering methods which accounts for the huge range in estimates

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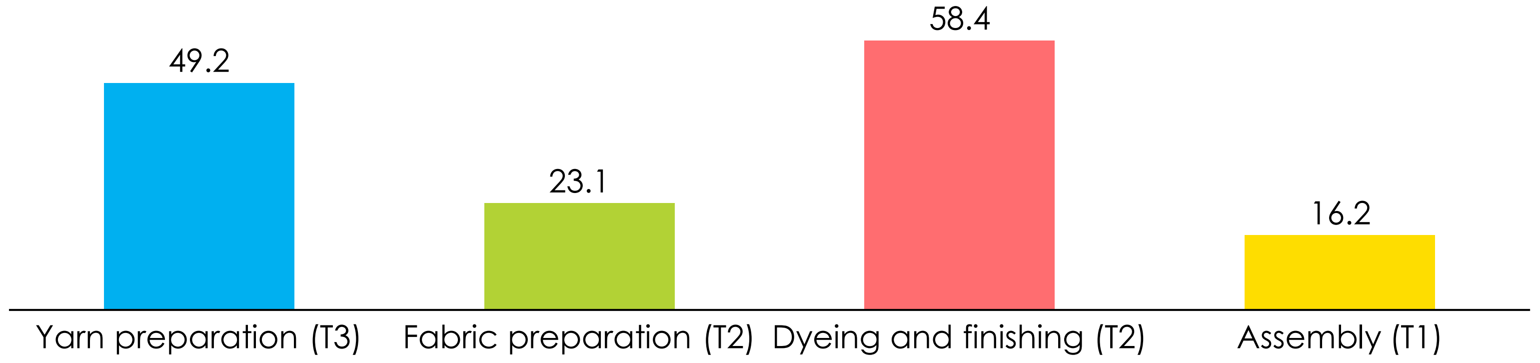
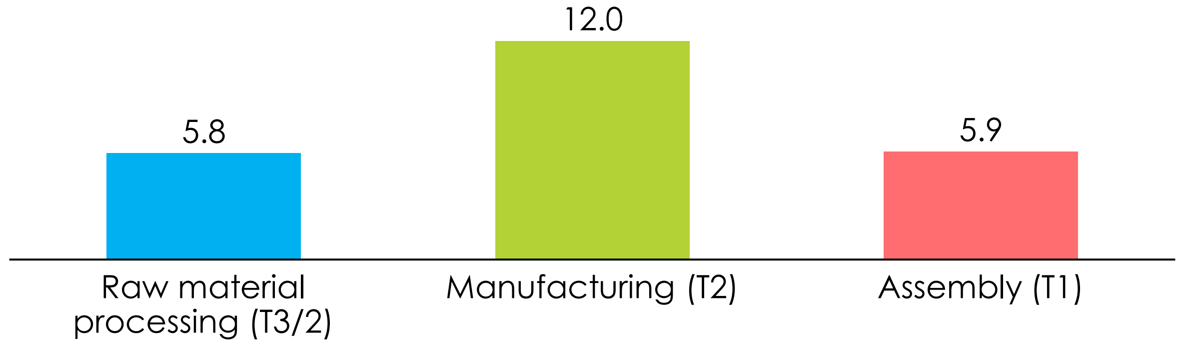
WET PROCESSING AND FOOTWEAR MANUFACTURING ACCOUNTS FOR THE HIGHEST WATER USE DURING SUPPLY CHAIN TIERS 3 TO 1

Freshwater withdrawal across T3-T1 for apparel (109 m3) (2016)



Freshwater withdrawal across T3-T1 for footwear (109 m3) (2016)



- Total annual water withdrawal in T3-1 equates to **147 billion cubic metres** for apparel **and 23.7 billion** for footwear (Quantis, 2016 baseline)
- **40% of T3-1 freshwater** for apparel is used for wet processing including dyeing and finishing – it estimated that **~100-150 litres of water** are used per kg of fabric. Water is added as a solvent with dyes and chemicals to the fabric
- Ah the end of the dyeing process, an estimated 10-20% of the dye typically remains that contributes to hazardous grey water
- For footwear, **T2 accounts for ~77% of freshwater use**, this includes wet processing of leather, chemical treatment (glue adhesives etc) and dyeing
- T3-1 have high risk of grey water exposure to marine ecosystems that include hazardous chemicals (see novel entities boundary for more details)

Source: Quantis 2018, GLASA 2015,

KEY LEVERS TO REDUCE OVERALL IMPACT ON FRESHWATER USE

KEY GOAL: REDUCE TOTAL WATER USE ACROSS THE APPAREL VALUE CHAIN

Intervention	Description	Value chain: T4	Value chain: T2/3	Value chain: Use phase
Implement efficient water management practices	• **Increase efficient water management** (e.g. organic cotton, auditing, site water management training, less consumer washing)	✓	✓	✓
Scale less water-intensive processes	• **Innovate and scale less water-intensive processes** (e.g. on-site water recycling, precision agriculture, waterless dyes, water-efficient laundry machines)	✓	✓	✓
Substitute materials and reduce virgin inputs	• **Substitute** water intensive fibres for alternatives (e.g. replacing cotton with linen) • **Reduce virgin inputs** where possible (e.g. scale textile to textile recycling, especially cotton)	✓		
Improve water governance and infrastructure	• **Increase regulation and governance** on freshwater withdrawals in high water risk regions (e.g. include externality costs of water, removal of subsidies in HWR regions) to drive responsible industrial consumption	✓	✓	✓ (yellow)

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IMPLEMENTING EFFECTIVE WATER MANAGEMENT PRACTICES AND SCALING WATER-EFFICIENT PROCESSES ARE PRIORITY ACTION AREAS

Intervention	Solutions are known & available	Solutions are scalable	Solutions are lacking progress	Solutions are lacking attention	Solutions need collective action	Ocean impact potential	Examples of initiatives /solutions	Barriers to progress
Implement efficient water management practices*	Medium	Medium	High	Medium	Medium	High	▪ **Sustainable cotton initiatives:** BCI, organic cotton ▪ **Product care labelling** ▪ **Wastewater management guidelines** e.g. Bluesign, ZDHC, SAC HIGG FEM ▪ **Water measurement tools:** WRI, Aquastat ▪ **Water stewardship/improvement programs:** SWAR, WWF, CEO mandate	▪ Regional specificity that hinders global action ▪ Splintering of initiatives ▪ Impacts away from the consumer
Scale water-efficient technologies*	High	Medium	High	Medium	High	High	▪ **Innovation in effluent treatment:** recycling of wastewater ▪ **Textile improvement processes** (e.g) AII) ▪ **Safer and waterless chemistry** ▪ **Precision farming and irrigation** ▪ **More efficient washing machines**	▪ Prohibitive ETP costs for single suppliers ▪ Safer chemistry and waterless technologies not scaled
Substitute materials and reduce virgin inputs	Medium	Low	Medium	Low	Medium	Medium	▪ **Fibre innovation –** less water intensive natural/synthetic fibres ▪ **Fibre to Fibre recycling** innovation	▪ Confusion over trade offs with new fibres ▪ Recycling technologies not scaled ▪ Lack of demand for recycled fibres
Improve water governance and infrastructure	Medium	Medium	Medium	Medium	High	Medium	▪ **Implement stricter water governance** ▪ **Removal of favourable subsidies in HWR regions**	▪ Complex socio-economic dynamics ▪ Regional specificity

Notes on MF solution buckets categorisation under the 9 overarching solution buckets (see slide 16):
Water efficient management practices > 1. On-site chemical and wastewater management (T2) & 3. Agricultural efficiency improvements (T4)
Scale water-efficient technologies > 1. On-site chemical and wastewater management & 3. Agricultural efficiency improvements (T4
Substitute materials and reduce virgin inputs> 6 Material substitution
Improve water governance and infrastructure > 8 Water governance, stewardship & infrastructure

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WATER GLOSSARY

Term	Definition
Grey water	The grey water footprint of a product is an indicator of freshwater pollution that can be associated with the production of a product over its full supply chain. It is defined as the volume of freshwater that is required to assimilate the load of pollutants based on natural background concentrations and existing ambient water quality standards. It is calculated as the volume of water that is required to dilute pollutants to such an extent that the quality of water remains above agreed water quality standards.
Blue water	Volume of surface and groundwater consumed as a result of the production of a good or service. Consumption refers to the volume of freshwater used and then evaporated or incorporated into a product. It also includes water abstracted from surface or groundwater in a catchment and returned to another catchment or the sea. It is the amount of water abstracted from groundwater or surface water that does not return to the catchment from which it was withdrawn.
Green water	The green WF is the volume of rainwater consumed during the production process. This is particularly relevant for the agricultural cotton cultivation, where it refers to the total rainwater evapotranspiration (from plantations) plus the water incorporated into the harvested crop

AGENDA

- Overview Approach & Objective
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- **Planetary Boundary Findings**
  - Novel Entities
  - Biogeochemical Flows
  - Freshwater Use
  - **Biodiversity**

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BIOSPHERE INTEGRITY EXECUTIVE SUMMARY

- The planetary boundary biosphere integrity captures the planet's state of biodiversity through two main indicators: one looks at the species extinction rate (for genetic biodiversity) and the other one at the so-called biodiversity intactness index (BII) (for functional diversity) which measures the fraction of original ecosystem diversity that is still without human modification.
- At the moment, the **PB is in the high-risk zone for genetic biodiversity**, while functional biodiversity hasn't been quantified yet.
- **With regard to the fashion sector's contribution, it can be said that the relationship is mostly indirect through other PBs**: novel entities and biogeochemical flows all have a very strong influence on marine biodiversity and hereby increase the transgression of the boundary.
- The fashion sector itself however only directly impacts the PB through the, for example, the sourcing of fish skin and seaweed fibres, but these currently account only for a minority of materials used in the industry – if this sourcing increases, it will become crucial to strive for material extraction in a sustainable manner, e.g., making sure the seaweed can regenerate between harvests.
- Moreover, while the general influence on the PBs biogeochemical flows and novel entities on marine biodiversity are known, it is unclear what the exact extent of the industry's impact on biodiversity is, due to interlinkages with other sectors and also climate warming.
- The PB (marine) biosphere integrity can act as a control variable for the pressure of the other PBs on marine biomes, however decisive action on the other PBs is already needed today to reduce impacts on marine biodiversity. As marine ecosystem services continue to provide materials for the sector, a reinforcing, restorative relation to (marine biodiversity) must be sought after.

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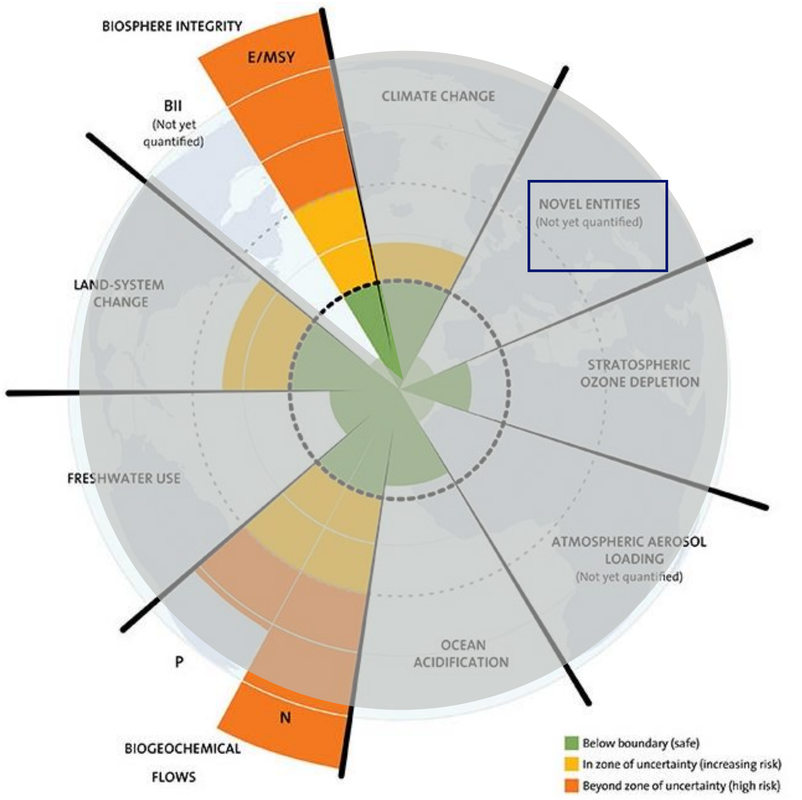
PB BIODIVERSITY INCLUDES TERRESTRIAL, FRESHWATER & MARINE ECOSYSTEMS

Definition of boundary	Two-fold boundary, consisting of **a) genetic biodiversity** which considers species extinction and **b) functional biodiversity**, which concerns the contributions to ecosystem functions.



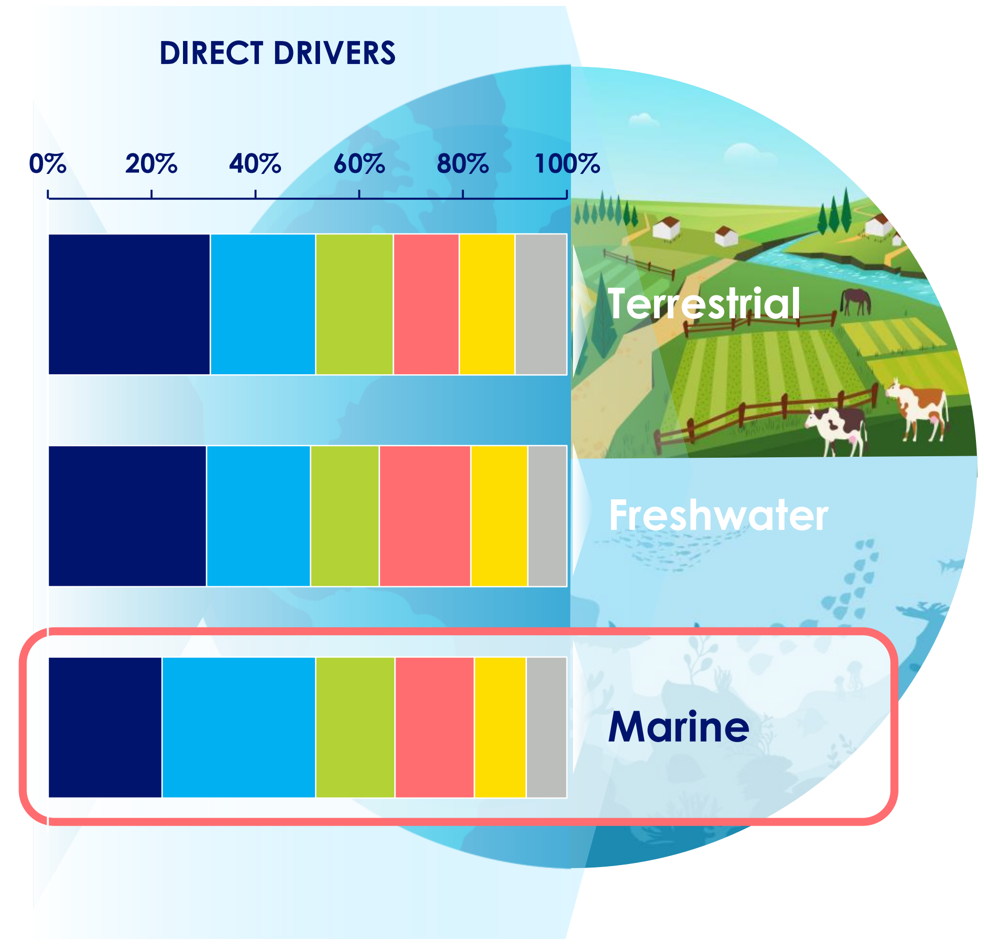
Genetic biodiversity is in the high-risk zone and functional diversity hasn't been quantified yet.

Scope	The PB biosphere integrity was previously called biodiversity loss and considers terrestrial, freshwater aquatic and marine ecosystems. The PB is considered a 'core' boundary as it controls and maintains material and energy flows.
Current state	Genetic biodiversity is in the high-risk zone – this change is irreversible. The state of functional biodiversity, however, is not quantified at a global level yet.
Scientific & policy consensus	The jury is still out on whether a metric for biodiversity at a global level is adequate and about the systemic risks of biodiversity loss for earth-scale changes. The lack of good data availability hinders precise boundary definitions.
Pathways	UN SDGs and Convention on UN Convention on Biological Diversity aim to halt biodiversity loss by 2030, but interactions with other pressures, such as climate change is unclear.
Metrics	**a) Global Extinction Rate** as proxy, but this comes with a time lag and cannot be measured in same detail as genetic biodiversity loss because it is on a species level. **b) Biodiversity Intactness Index** (BII): Measures the fraction of an original diversity in ecosystems and hereby reflects the impact of human modification.
Ocean link	Marine species make up 15% of earth's species. However, the available data on marine biodiversity is most sparse. It is known that 33% of marine mammals are currently threatened and that 33% of fish stock is overexploited.

Source: Steffen et al. (2015), UBA (2020)

RECENT RESEARCH IDENTIFIES 5 BIODIVERSITY LOSS DRIVERS

Drivers of biodiversity loss



Land/sea use change. For land and freshwater this is mainly land conversion for agriculture, followed by logging, forestry and urbanization. Sea use change includes infrastructure, mariculture, aquaculture & bottom-trawling.

Direct exploitation. Concerns direct biomass extraction. Terrestrial: logging, hunting, mining and fossil fuel extraction. Marine: fishing and ocean mining/fossil fuel extraction.

Climate change. Global warming due to GHGs impact species distribution, altered population dynamics and compositions of species assemblages.

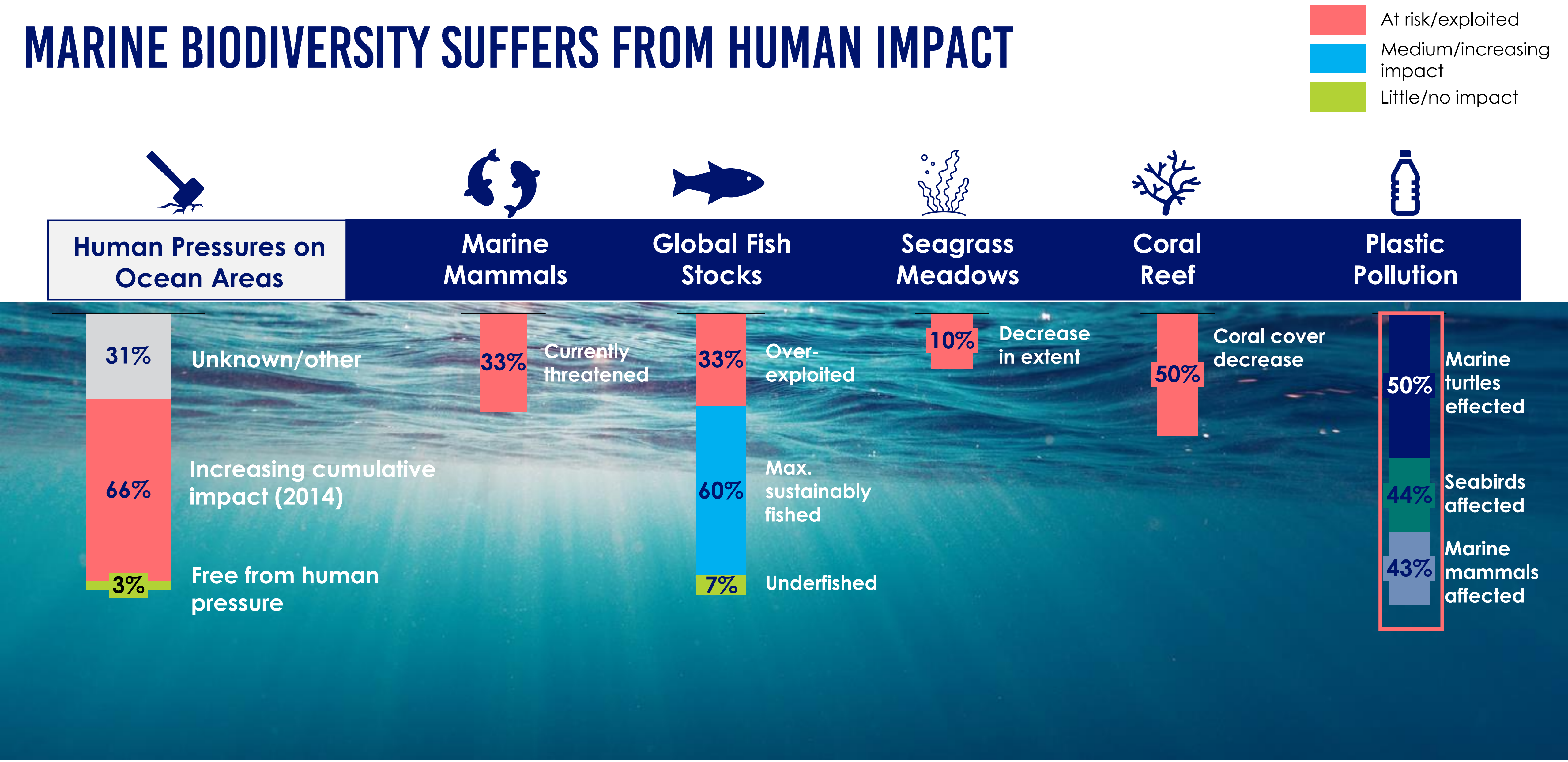
Pollution. Main driver is excessive fertilizer runoff which enters freshwater & coastal ecosystems. Also includes plastics, heavy metals, solvents & toxic sludge.

Invasive alien species mainly through long-distance transportation of goods and people.

Others

Source: Diaz et al (2019) Pervasive human-driven decline of life on Earth points to the need for transformative change, IPBES (2020) Global Assessment Report on Biodiversity & Ecosystem Services

MARINE BIODIVERSITY SUFFERS FROM HUMAN IMPACT



Source: IPBES (2020) Global Assessment Report on Biodiversity & Ecosystem Services

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BIODIVERSITY LOSS IS A KEY RESULT OF THE OTHER PB'S PRESSURES

Fashion Industry

Major (indirect) impacts on ocean

Novel Entities

Chemical Pollution

Pesticides

Microplastic

- Ecotoxicity in aquatic organisms such as dolphins, fish and snails
- Impacts include reduction in growth, reduced fecundity, weakened immune systems, impaired feeding ability, reduced energy storage, change in the ability to adapt
- Exposure can lead to wide-scale marine life loss, abnormalities/mutations (fish larvae) and carcinogenic effects

N&P Flows: Fertilizer

Eutrophication - harmful algae blooms & oxygen depletion, resulting in marine biodiversity loss & in extreme form in dead zones, such as the Gulf of Mexico.

Freshwater Use and Pollution

Minor (direct) exploitation of oceans
Sourcing of fish skin, seaweed fibers, coral, shell

Biosphere Integrity of Marine Biomes

BIODIVERSITY GLOSSARY

Term	Definition
Genetic biodiversity	Genetic biodiversity refers to the genetic composition of species. This specific type of biodiversity especially focuses on diversity on a genetic level – it hereby informs, for example, the ability of species to adapting within changing environments. In the context of the PBs, species extinction is taken as a proxy for genetic biodiversity, because no genetic biodiversity indicator is available.
Functional Biodiversity	Functional biodiversity focuses on the contributions of biodiversity to ecosystem functions (such as ecosystem stability, productivity, nutrient balance). The PB frameworks uses the Biodiversity Intactness Index as a proxy for functional diversity. This Index measures the fraction of original diversity still present in an ecosystem – the part that hasn't been subject to human modification.
Biodiversity Intactness Index	Measures the fraction of an original diversity in ecosystems and hereby reflects the impact of human modification.
Biosphere Integrity	The PB was previously called 'loss of biodiversity', and was then revised to be called 'biosphere integrity' to also recognise the interdependencies between species and ecosystem functioning

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