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Cigarette smoking

An assessment of tobacco's global environmental footprint across its entire supply chain, and policy strategies to reduce it

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Cigarette smoking: an assessment of tobacco's global environmental footprint across its entire supply chain, and policy strategies to reduce it/ Maria Zafeiridou, Nicholas S Hopkinson, Nikolaos Voulvoulis

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Abstract

Cigarette production and consumption have seen dramatic growth in recent decades and although the health effects of smoking are widely recognized, its impacts on the environment are largely overlooked. From tobacco cultivation and curing, to cigarette manufacturing, distribution, consumption and discarding, every stage in the global tobacco supply chain involves considerable resource inputs, and results in the production of wastes and emissions. Consequently, tobacco puts pressure on the planet's already stressed natural resources and its fragile ecosystems, threatening the livelihoods and future development of communities around the world.

Tobacco's total environmental footprint is comparable to that of entire countries and its production is often more environmentally damaging than that of essential commodities such as food crops. For the six trillion cigarettes manufactured annually, 32.4 Mt of green tobacco are cultivated on 4 million ha of arable land and are then processed into 6.48 Mt of dry tobacco worldwide. Globally, the tobacco supply chain contributes almost 84 Mt CO_2 eq emissions to climate change, 490,000 tonne 1,4-DB eq to ecosystem ecotoxicity levels, over 22 billion m^3 to water and 21 Mt oil eq to fossil fuel depletion annually.

As a result of the shift of tobacco production from richer to poorer regions, these environmental impacts are not felt equally around the world. Developing countries and the most vulnerable communities bear most of the burden.

The environmental damage that tobacco causes, on top of its negative health, social and economic impacts, makes it incompatible with the global development agenda. Reducing and ultimately eliminating cigarette production and consumption should be an integral part of strategies to achieve the Sustainable Development Goals (SDGs) (including goals 12, 13, 14, and 15).

Abbreviations

1,4-DB	1,4-dichlorobenzene
ASH	Action on Smoking and Health
BAT	British American Tobacco
CNTC	China National Tobacco Corporation
CO2	Carbon dioxide
CSR	Corporate Social Responsibility
eq	Equivalent
ESG	Environmental, Social and Governance
FAO	Food and Agriculture Organization
Fe	Iron
GHG	Greenhouse Gas
Pj	A petajoule, equal to 1 million billion (10^{15}) joules of energy
ha	Hectare
IPCC	Intergovernmental Panel on Climate Change
JTI	Japan Tobacco International
LCA	Life cycle assessment
m2a	Square meters per annum
m3	Cubic metres
MFA	Material flow analysis
Mt	Million tonnes
N	Nitrogen
P	Phosphorus
PMI	Philip Morris International
SDG	Sustainable Development Goal
SDSN	Sustainable Development Solutions Network
SO2	Sulfur dioxide
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
WHO	World Health Organization
WHO FCTC	WHO Framework Convention on Tobacco Control

Introduction

One of the wealthiest industries globally – the tobacco sector – has seen dramatic growth in recent decades and despite the falling prevalence of smoking in high-income countries, has continued to grow as the uptake of smoking increased in developing regions (Leppan, Lecours & Buckles, 2014). In a year, the industry produces six trillion cigarettes that are consumed by one billion smokers worldwide (Eriksen et al, 2015a). The direct health effects of smoking are now well recognized and documented, it is responsible for about seven million deaths annually (WHO, 2017b). However, the environmental impacts of the tobacco industry, are often overlooked and have been under-researched. Yet, from tobacco cultivation and curing, to cigarette manufacturing, distribution, consumption and discarding, the negative environmental impacts of smoking are substantial and far-reaching, including the use of scarce arable land and water for tobacco cultivation, use of harmful chemicals on tobacco farms, deforestation, carbon emissions from the manufacturing and distribution processes and production of toxic waste and non-biodegradable litter (Novotny et al., 2015; ASH, 2015; Novotny & Slaughter, 2014). An appreciation of the true environmental costs of tobacco both to society and the planet is important in prompting effective policy action aimed at tobacco control and prevention, as well as facilitating sustainable development in countries around the world.

This report provides an overview of the environmental impacts of cigarette smoking across tobacco's global supply chain. It specifically focuses on manufactured cigarettes and the equivalent roll-your own cigarettes (RYO), which together account for about 90% of tobacco product sales (Euromonitor, 2016). The remaining 10% include products such as cigars, chewing tobacco, and cigarillos (Euromonitor, 2016), as well as a number of very niche products like tobacco-based pesticides and bio-fuel (Booket et al, 2010). Due to a lack of robust data on the production and use of these less common tobacco products, they were excluded from the analysis. Therefore, although the report uses interchangeably the terms tobacco, tobacco supply chain, tobacco consumption, and smoking, it refers specifically to cigarette smoking and its supply chain.

It has been produced also in response to the decision made by the Seventh Session of the Conference of the Parties (COP) to the World Health Organization Framework Convention on Tobacco Control (WHO FCTC) *"to prepare a report for COP8 on the environmental impact of tobacco lifecycle which collects technical knowledge on strategies to avoid and mitigate this impact, as well as recommend policy options and practical orientations to address it, identifying interventions that benefit public health and environment"* (WHO FCTC, 2016).

The report presents findings of research on the full cradle-to-grave life cycle impacts and resource needs of tobacco globally, undertaken at Imperial College London (Zafeiridou, Hopkinson & Voulvoulis, 2018)[i] and offers additional analysis and recommendations for policy actions. The latter builds on existing evidence of the environmental issues associated with tobacco, including the WHO-published overview for World No Tobacco Day (WHO, 2017), and goes beyond the currently available research by producing a systematic life-cycle assessment of the entire global cigarette smoking supply chain and considering a range of environmental impact categories, from climate change to resource depletion and impacts on ecosystem health.

i Using publicly available data, Material Flow Analysis (MFA) was used to quantify the flows of natural resources and materials used at the different stages of cigarette production and consumption, capturing both inputs (direct and indirect) and outputs, and Life Cycle Assessment (LCA) was used to capture the environmental emissions of the tobacco global supply chain, with all associated environmental impacts quantified using SimaPro 8. Calculations were done based on data from 2014, and Ecoinvent datasets. See also Table A1 in Appendix A.

The report first introduces the growing pressures on our planet's resources and natural ecosystems, and how these impact on the world's ability to achieve the Sustainable Development Goals (SDGs). Having set the context, it then presents the results of the global environmental impact assessment of the tobacco sector. Several case studies demonstrate how these impacts are unequally felt by countries around the world and discusses implications of the research findings to the delivery of the SDGs. Importantly, the report identifies that changes in tobacco production and consumption will have virtually proportionate shifts in its impacts across the board, either aggravating or easing the damage it causes to the health and development of society and the state of the natural environment, depending on the trend. Mitigation opportunities are considered in relation to SDGs 12 (responsible production and consumption), 13 (climate action), 14 (life below water) and 15 (life on land). Both the outcomes of the analysis of the environmental impacts of tobacco and the identified policy mitigation opportunities presented in this report are consistent with the findings of the WHO-published overview for World No Tobacco Day (WHO, 2017).

Setting the context

The planet under stress

Our planet is currently facing unprecedented pressures on its natural resources and fragile ecosystems, with serious implications across all economic sectors and industries. Resources are being used at an alarming rate, with humanity's rapidly rising consumption of products and services driving environmental pressures including raw material use, greenhouse gas emissions, land use, water use, waste generation and energy use. Environmental degradation is putting at risk people's access to food, energy and water (e.g. UN, 2015a; Steffen et al, 2015; IPCC, 2014a). If we are to eradicate poverty and hunger and allow people to live healthy prosperous lives now and in the future, we need to appreciate the interdependence of human and natural systems, and act urgently upon this understanding by balancing the world economy with social progress and environmental sustainability (Whitmee, 2015), and ultimately transitioning to a sustainable and resilient path. Urgent global challenges that we face today include climate change driven by growing levels of anthropogenic greenhouse gases and the associated ocean acidification and warming (IPCC, 2014a), the loss of biodiversity in water and on land with subsequent loss of ecosystem services (Cebellos et al, 2015), and growing freshwater scarcity, often the result of pollution, over abstraction, the warming climate, and exacerbated frequently by deforestation and the intensification of agriculture (UN-Water, 2018). There is increasingly an urgent need to evaluate all of humanity's consumption patterns and tobacco products are a prime candidate for this, considering that they produce considerable harm for little or no benefit. Smoking contributes to all of the aforementioned global challenges, and therefore has the potential to impede the global development agenda, which strives to end the global burden of poverty and disease, protect the planet and ensure prosperity for all (UN, 2015a).

Tobacco control and sustainable development

The WHO FCTC was developed in response to the growing global tobacco epidemic and sets out guidelines to assist Parties in the implementation of various aspects of the treaty. The environmental consequences of tobacco consumption and exposure to tobacco smoke are referenced in the Preamble and Objectives of the Treaty (Article 3) as well as specifically with respect to protecting the environment and the health of persons in relation to the environment from the effects of tobacco production (Article 18) (WHO, 2003). Its objectives reinforce a

number of other global treaties and agreements aiming to address today's global challenges, including combatting climate change (UNFCCC, 1994) and the implementation of the United Nations sustainable development agenda with its seventeen internationally agreed SDGs (UN, 2015a). Tobacco control under the FCTC is explicitly acknowledged as an integral part of achieving Global Goal 3, which strives for healthy lives and well-being for all (UN, 2015a). The incompatibility of the production, promotion and sale of tobacco with the human right to health was highlighted in the recent Cape Town Declaration on Human Rights and a Tobacco-Free World (World Conference on Tobacco or Health, 2018).

Over and above the direct effects of smoking on human health, the tobacco sector's negative impacts are directly related to many of the other SDGs. These include those related to reducing inequalities (SDG 10); responsible consumption and production (SDG 12); and environmental sustainability by combatting climate change (SDG 13), conserving, protecting and restoring life below water (SDG 14) and on land (SDG 15). Furthermore, given the interconnectedness of the Global Goals, tobacco also has implications across most of the other SDGs. For example, SDG 13 on climate action is connected to SDG 1 (no poverty), SDG 6 (clean water and sanitation), and SDG 7 (affordable and clean energy). The protection and restoration of terrestrial ecosystems in SDG 13 is connected to ending hunger (SDG2), sustainable economic growth and decent work (SDG 8), and to reducing inequality (SDG 10). Conservation and protection of life below sea is also linked to SDGs 10 and 12 (Le Blanc, 2015). Therefore, reducing and ultimately eliminating tobacco consumption has numerous positive implications for the wider development agenda, and it should be an integral part of the solution for a world free of poverty, hunger and disease, and where all life can thrive (WHO FCTC & UNDP, 2017; Small et al, 2017).

This report focuses on SDGs 12, 13, 14, and 15 (Table 1) putting tobacco's environmental impacts and the proposed policy action to reduce them in the context of these four Global Goals.

Table 1: UN Sustainable Development Goals (SDGs) 12, 13, 14, 15

SDG	Call for action
	**Ensure sustainable consumption and production patterns**
	**Take urgent action to combat climate change and its impacts**
	**Conserve and sustainably use the oceans, seas and marine resources**
	**Sustainably manage forests, combat desertification, halt and reverse land degradation, halt biodiversity loss**

Source: UN, 2015a

The economic and social impacts of tobacco

The tobacco industry, both directly and through its front groups and third-party advocates, has argued that it provides substantial benefits to national and rural economies around the world and also presented itself as investing in programmes aimed at reducing social inequality (BAT, 2017b; BAT, 2017c; Tobacco Manufacturers' Association, 2017; Philip Morris, 2016b). Although, a thorough discussion of the economic and social impacts of the tobacco sector is beyond the scope of this report, they are briefly considered here to help put these claims and the environmental footprint of tobacco into context and paint a more complete picture of its costs to society.

The principal benefits that the industry claims to provide include substantial contributions to local economies though tax payments, job creation, and the development of rural areas thanks to the commercial value of the crop (Keyser, 2007; The World Bank, 1999). However, growing evidence suggests that the losses that economies bear as a result of tobacco consumption outweigh the contributions (ASH, 2016; Warner, 2000; Chaloupka & Warner, 2000). Thus, smoking is linked to poverty through its contribution to loss of income, productivity, disease and death. Tobacco farmers, particularly the small-holders in developing regions, have often been found to struggle to make a living by growing such a labour and input intensive crop (WHO, 2004a; and see case study C). The developing world as a whole has been demonstrated not to benefit from the foreign tobacco sales as the revenues are returned straight to corporations (Warner, 2000). A study of the economic burden of the global trade in tobacco (Barnum, 1994) that factored in costs of morbidity, mortality and the indirect costs of smoking, found that tobacco use results in a global net loss of US$ 200bn per year (and that is excluding the full extent of tobacco's environmental externalities).

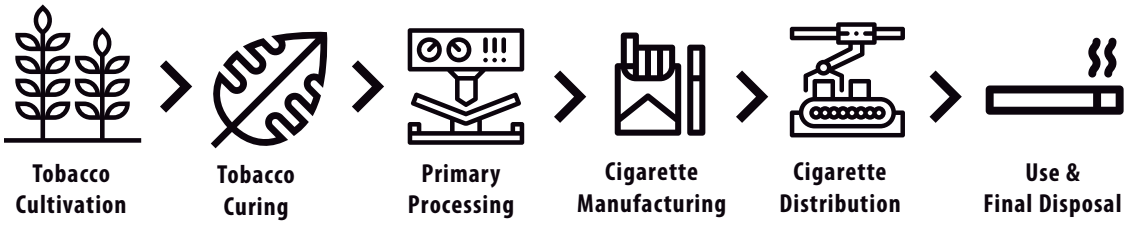
The concern about job losses as a result of tobacco control has also been addressed by several independent studies demonstrating that should tobacco consumption drop, most countries would see no net job losses, as alternative jobs would be generated by the money not spent on tobacco. An exception is a number of countries in Sub-Saharan Africa that are currently heavily dependent on tobacco cultivation, and in which cases policy action would be required to mitigate potential job losses, in particular diverting farmers' efforts towards alternative crop production (The World Bank, 1999).

Taken as a whole, the tobacco industry's argument that it provides benefits to society and economies through the production and sale of a deadly product are contradictory (WHO, 2004b), and evidence shows clearly that, when all costs are considered, it is in fact a liability.

The tobacco supply chain

From tobacco cultivation, curing, processing, cigarette manufacturing and distribution, to use and final disposal (Figure 1), the tobacco industry's supply chain is global and extensive, but fragmented across regions, and at every stage a range of resources and materials are required.

Figure 1: Global cigarette production and consumption supply chain



The cultivation of tobacco, which takes place across 125 countries (Eriksen et al, 2015b), involves such activities as seedling production, soil management, irrigation, the use of agrochemicals (pesticides and fertilisers), harvesting and the burning of the crop residue (Goger, Bamber & Gereffi, 2014; US GAO, 2003; Terrapon-Pfaff, 2012). Post-harvest, tobacco leaves are cured to reduce moisture content and to ensure their preservability. The majority of tobacco destined for cigarette production is flue-cured though some (Burley type) is air cured (Campaign for Tobacco Free Kids, 2001).

Flue-curing involves drying green tobacco in closed buildings with furnaces driving heat into the barn. The typical energy sources for heat are wood or coal and these are the main inputs at this stage of tobacco production (Goger, Bamber & Gereffi, 2014). Following curing, primary processing involves grading and blending of tobacco leaf, the removal of non-tobacco material, stemming, additional drying, packing, and temporary storage, ultimately ensuring that moisture content is controlled to prevent deterioration. The main inputs at this stage include energy and water use at the processing and storage facilities. Within two to three years, processed tobacco is then shipped to manufacturers where it is transformed into cigarettes (Universal Corporation, 2017a). The cigarette manufacture process involves inputs such as cigarette filters, cigarette paper, packaging and flavourings; and requires the production of considerable amounts of energy (Goger, Bamber & Gereffi, 2014). The distribution of manufactured tobacco products to consumers includes domestic and international transportation of cigarettes to warehouses and retail outlets using road, marine, and air transport (Ecoinvent, 2013) (Figure 2).

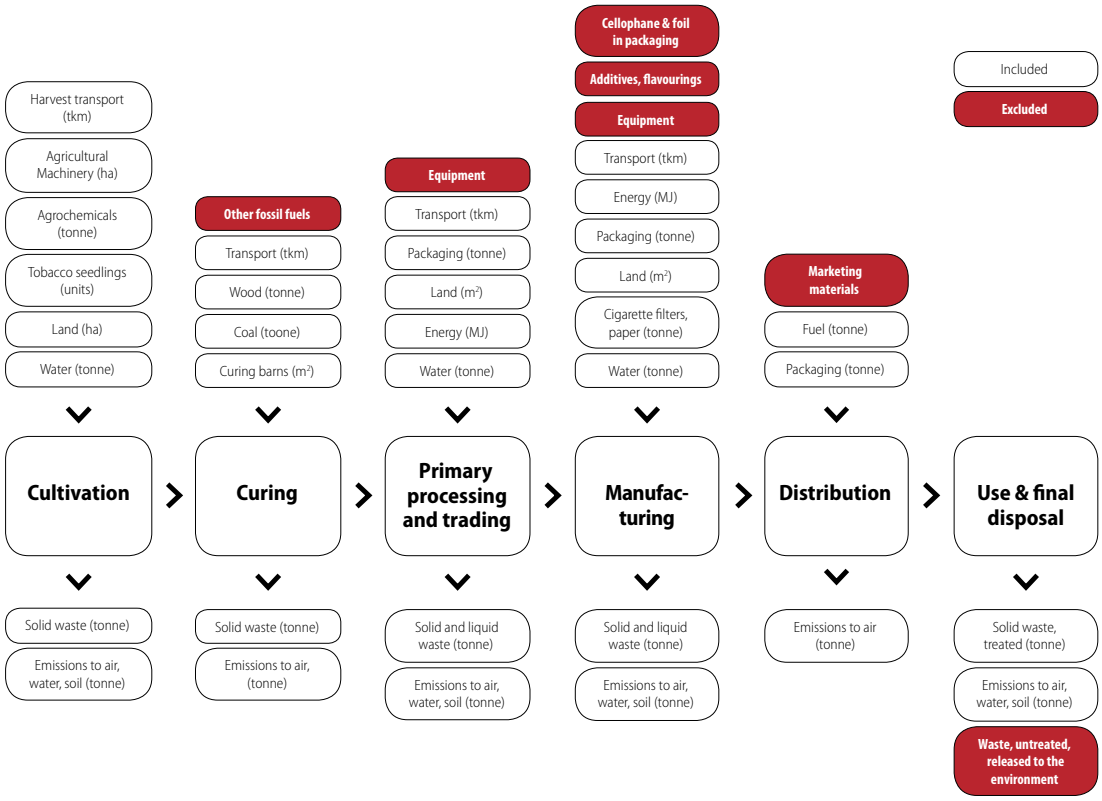
In addition to the six trillion cigarette sticks, the outputs of the supply chain included 25 million tonnes of solid waste (including hazardous waste and the post-consumer waste such as cigarette butts) on top of the millions of tonnes of greenhouse gas emissions (Figure 3, and see Table A2 in Appendix A).[ii]

The substantial resource and material inputs required at every stage in the tobacco supply chain mean that it competes for finite and scarce natural resources with commodities which have much greater human value such as food crops. At the same time, the wastes and emissions that occur across the supply chain cause pollution and degradation of terrestrial and aquatic ecosystems and

ii The key inputs and outputs across the supply chain were quantified using MFA. Selected indirect materials and processes, e.g. office supplies, cleaning products, accessories required for cigarette use such as lighters and ash trays were excluded from the study. Additionally, due to a lack of data, a number of direct inputs such as additives and flavourings used in cigarette manufacturing to manipulate the taste and other qualities of tobacco, have not been included in the study.

contribute to climate change. It is important to note here that as tobacco production has shifted from richer to lower income countries, where transnational tobacco corporations have been quick to capitalise on weaker regulatory frameworks and growing populations (Lecours et al., 2012), so have the environmental burden of and the many risks associated with tobacco production.

Figure 2: Conceptual framework and system boundaries of global cigarette production and consumption



Source: Zafeiridou, Hopkinson & Voulvoulis, 2018

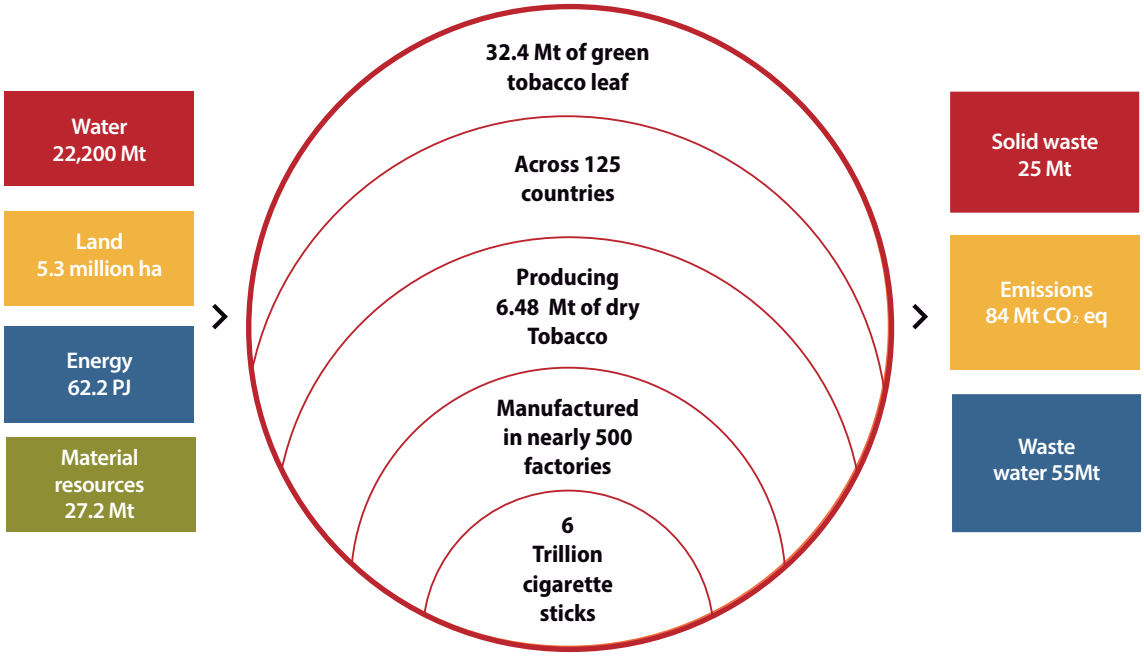
This is on top of the fact that, in most cases, it is not the farmers or local economies that benefit from the sale of tobacco, but the multinational corporations, at the expense of people's lives, livelihoods and development (see section 2). The environmental and social injustice exacerbated by tobacco production should be a crucial consideration for tobacco control policies and the wider strategies on sustainable development. It is discussed in more detail in the case studies and Section 6 of the report.

Besides the main output product of the tobacco supply chain, i.e. cigarettes, all of the above activities result in the production of solid and liquid wastes, as well as emissions to air as a result of both, the production and transportation processes, and the product use. Painting a complete picture of the environmental footprint of cigarette smoking requires a systematic assessment of all the resource inputs, as well as the wastes and emissions produced across the global tobacco supply chain.

Resource and material flows across the tobacco supply chain

In a year, to produce six trillion cigarette sticks (Eriksen et al, 2015a) a total of 32.4 million tonnes of green tobacco leaf were cultivated on 4 million hectares of land, producing 6.48 Mt of dry tobacco. Processed tobacco was then manufactured into cigarettes across about 500 factories worldwide and distributed to 1 billion smokers globally (Eriksen et al, 2015a), resulting in a total use of 5.3 million ha of land, over 22 billion m^3 of water, 62 PJ of energy and total material inputs of 27.2 million tonnes.

Figure 3: Annual mass flows across the global tobacco supply chain



Note: waste water excludes water losses at the farming and curing stages.

Environmental footprint of tobacco across its life cycle

Resource depletion (land, water, metal, and fossil fuel)

The production and consumption of a tonne of tobacco (equivalent to a million cigarettes) requires, on average, over 3,700 m^3 of water and nearly 8,500 m^2 of agricultural land, and also contributes almost 3.5 t oil eq to fossil fuel depletion and over 0.5 t Fe eq to metal depletion (Table 3).

Globally, the production of 6 trillion cigarettes results in over 22.2 billion m^3 in water depletion,[iii] almost 21 Mt oil equivalent in fossil fuel and nearly 3.3 Mt Fe equivalent in metal depletion, and requires a total of nearly 5.3 million ha of land (including arable land for tobacco crop cultivation, land associated with energy inputs including wood and coal for curing, and the land under manufacturing and other facilities) (Table 2 and Figure 4, also see Appendix B).

By competing for land and water with food and other commercial crops, tobacco contributes to the rising tensions over these resources and threatens poorer communities' livelihoods (see case study A exploring the environmental footprint of the tobacco industry in China). Moreover, the resources that go into the production of the cigarettes smoked in wealthier regions such as the EU and North America, are to a large extent not even their own. For example, in the UK, Canada, Portugal, and Austria, with no or very little domestic tobacco leaf or cigarette production (FAO, 2017a; Stanford University, 2015), smoking cigarettes is done entirely at the expense of other nations' resources and environmental health. In other words, when smoking cigarettes, the developed world is literally burning poorer countries' resources.

iii Most water use in the tobacco supply chain occurs at the farming stage. Sourced from surface or groundwater resources, the consumed water is not returned into the environmental compartment from which it has been withdrawn initially, therefore resulting in water depletion.

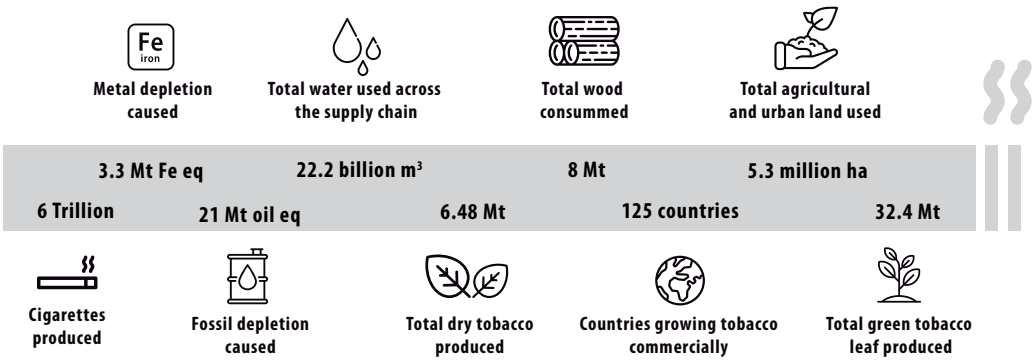
Table 2: Annual resource depletion per tonne of produced and consumed tobacco, and total across the global tobacco supply chain

Impact category	Unit	Per tonne of tobacco	Total (Millions)
Water depletion	m^3	3713	22203
Metal depletion	kg Fe eq	549	3282
Fossil fuel depletion	kg oil eq	3481	20813
Agricultural land occupation	m^2a	8493	50788
Urban land occupation	m^2a	335	2004
Natural land transformation	m^2	11	64

There are also a number of small island developing states (SIDS), which allocate substantial parts of their land resources to commercial tobacco growing. Countries such as Cuba, the Dominican Republic, Fiji, and Jamaica all have at least 600 ha of arable land under tobacco. Even some of the smallest countries in the world – St Vincent & The Grenadines and Mauritius with their combined total land area smaller than the city of Moscow (World Atlas, 2018; World Atlas, 2015), have parts of their scarce arable land allocated to tobacco (FAO, 2017a). In addition to suffering the environmental impacts of tobacco growing, many SIDS bear the burden of high smoking prevalence, e.g. on the small island republic of Kiribati, 64% of adult men and 41% of adult women smoke, while in Palau, 54% of male adolescents (13-15 years old) and 37% of female adolescents consume tobacco products. In other island states such as Cuba, Fiji, and Mauritius the smoking prevalence among adult men is between 40% and 54% (WHO, 2015).

As long as the tobacco sector is allowed to produce cigarettes and as long as they are consumed, the world cannot achieve the Global Goal of sustainable production and consumption because, by definition, SDG 12 is about products that bring a better quality of life while minimizing the use of natural resources and toxic materials, and the emission of waste and pollutants over the product's life cycle (UN, 2015b). It therefore requires fundamental changes in unsustainable patterns of consumption and production, including the elimination of smoking.

Figure 4: Global annual cigarette production in numbers, based on data from 2014



Case study A:

The environmental footprint of tobacco in China

Today, China – the world's top cigarette consuming country – harvests over 3 million tonnes of tobacco leaf to meet the demand of its more than 300 million adult smokers. In order to grow such vast quantities of tobacco the country uses more than 1.5 million hectares of arable land (FAO, 2017a; WHO, 2018a) and requires over 11 million m^3 of fresh water resources. In a year, the production of more than 2.5 trillion cigarettes in factories across the country involves substantial amounts of energy – in 2014 the state-owned China National Tobacco Corporation (CNTC), accounting for the vast majority of cigarette production in the country, reported energy use in excess of 13,000 Gigawatt hours for the year (Hendlin, 2017). Given that China's current energy mix is dominated by coal (U.S. Energy Information Administration, 2017), these cigarette manufacturing facilities are particularly damaging to the environment and the communities exposed to the resulting pollution.

At the same time, habitats in China suffer from severe water scarcity with water tables declining as farmers and industry abstract over and above the rates of replenishment (FAO, 2011), while nearly 134 million people in China suffer from undernourishment with almost 13 million children stunted due to chronic malnutrition (FAO, 2015a). Furthermore, many Chinese cities suffer from persistently dangerous air pollution levels (Chan & Yao, 2008) and the country faces one of the most serious water pollution crises ever documented with 31% of water in major river basins and near-shore coastal waters unfit for potable use or human contact and 80% of groundwater in northern basins unfit for domestic or agricultural uses (Han, Currell & Cao, 2016).

Diverting the resources and energy used in China for cigarette production to, for example, food production, can benefit millions of people and, if planned and executed correctly, can help reduce environmental degradation on top of saving millions of lives in the country. Moreover, the Chinese economy would benefit by averting the substantial and growing health, social and economic costs of smoking, which are projected to increase rapidly and are unsustainable given the negative spillover effects of tobacco consumption across sectors unless rapid action is taken (WHO and UNDP, 2017). The China National Tobacco Corporation's recent investments in Africa suggest a strategy to shift these harms to poorer countries (Fang, Lee & Sejpal, 2017).

Image 1: A child is exposed to secondhand tobacco smoke, China

Source: Yifan, 2007

Image 2: Workers applying a pesticide on a tobacco farm in China

Source: UCLA Fielding, 2013

In addition to the arable and urban land occupied by the tobacco sector's activities, thousands of hectares of woodland are removed to make way for tobacco farming, to produce poles and sticks used in barn construction and as fuel for curing the leaves. A total of 8.05 Mt of wood were found to be used for flue-curing annually (based on tobacco production volumes from 2014)[iv] with nearly 7.8 tonnes of wood required to produce a tonne of cured tobacco. Additionally, at least 6,500 ha of forest land are estimated to be cleared for tobacco cultivation annually[v]. Tobacco-driven deforestation is primarily an issue in developing tobacco growing countries, where it accounts for almost 5% of the total national loss of forests and in countries such as

iv Due to a lack of robust data on the use of unsustainably sourced wood in curing, the deforestation associated with tobacco curing could not be fully captured in the impact assessment.

v Based on the average forest loss rates associated with shifting cultivation in Asia and Africa (FAO, 2015b). Due to a luck of robust data on global rates of forest loss driven by the tobacco sector and large regional variability, this is likely to be an underestimate

Malawi, Zimbabwe and the Philippines it is the main cause of deforestation (WHO, 2017) (see case study B exploring the impacts of tobacco on communities in Southern Africa). In Brazil, agricultural expansion for tobacco growing is estimated to have led to up to 74,440 ha of forest loss between 1990 and 2007, and in Malawi, to about 13,400 ha. In Pakistan, tobacco curing is accountable for nearly 27% of the country's total annual deforestation (based on data for 2008) (Kägi & Schmid, 2010), and in Tanzania, it has led to a loss of about 11,000 ha of the Myombo ecosystem (tropical dry forests and woodlands) (WHO, 2017; Kägi & Schmid, 2010).

Considering how nutrient-demanding the tobacco plant is, making plots unfit for continuous use without considerable inputs of fertilisers and pesticides (unaffordable to many smallholder farmers in developing countries) (Lecours et al., 2012, Clay, 2004) and in cases of inappropriate soil management, leading to desertification (WHO, 2017), further deforestation is expected in these tobacco-growing regions with potentially devastating environmental, social and economic consequences. Sustainable management of forests is essential for ensuring food security and improving livelihoods, to climate change adaptation and mitigation and, overall, achieving the SDGs (FAO, 2016), therefore close monitoring and prevention of woodland loss must be an integral part of the tobacco control policy.

Naturally, the use of the scarce natural resources by the tobacco sector presents an opportunity cost in the form of more essential commodities. For example, the arable land used to cultivate tobacco could produce food crops such as potatoes, tomatoes, maize or wheat – all identified as potentially viable alternatives in a number of tobacco growing countries (Keyser, 2007; The World Bank, 2017a).

Moreover, the yield of these crops is in many cases considerably higher than that of tobacco. For example, a hectare of land in Brazil and in India could produce over 3 tonnes of wheat compared to less than 2 tonnes of tobacco (dry weight) (Figure 5). In China and the USA, the yield of tomatoes is 25 and 41 times greater than that of tobacco, respectively, and in Indonesia and Zimbabwe a hectare of land could produce 19 times more potatoes than the 1–1.2 tonnes of tobacco currently cultivated. Furthermore, studies have shown that farmers who switched from tobacco to alternative crops are making a better living while spending less time and requiring fewer inputs than when growing tobacco (see case study C exploring how the livelihoods of tobacco farmers in Indonesia have changed when they switched to alternative crops).

Case study B:

Tobacco and the environmental injustice in Southern Africa

Malawi, Tanzania and Zimbabwe are among the top tobacco growing countries in the world accounting for more than 5% of the global tobacco leaf supply with between about 99,000 and 148,000 ha of arable land dedicated to tobacco growing in one year (FAO, 2017a). They are also some of the poorest countries in the world with the rates of undernourishment between 26% and 45% in 2015 (The World Bank, 2015). The economic and socio-ecological impacts of tobacco production are already taking their toll on the people, their livelihoods and the environment in these countries, further widening the social inequality gap by exacerbating these poorer communities' struggles.

Green tobacco sickness and pesticide poisoning

Tobacco farm workers (often women and children) are at risk of green tobacco sickness (a form of nicotine poisoning caused when nicotine is absorbed through the skin) and many suffer from pesticide poisoning because they are not in a position to follow the safety procedures for proper handling of these acutely toxic chemicals (sometimes due to lack of knowledge but also due to the protective clothing and equipment being unaffordable to them) (Campaign for Tobacco-Free Kids, 2001).

Soil depletion and deforestation

The high nutrient demands of tobacco plants cause rapid soil depletion and offer no soil replenishment. Consequently, the small-scale farmers responsible for much of the tobacco cultivation in the region who lack access to more technical agricultural practices, resort to clearing new fertile areas of woodlands instead of reusing plots (Lecours et al., 2012). Production expansion for such farmers is only possible through the clearing of additional forest land. For example, in Tanzania, 69% of farmers were found to clear new areas of woodlands every season with only 25% using the same plots for tobacco for two consecutive seasons (Sauer & Abdallah, 2007). As a result of the shifting cultivation and the use of wood on farms and for curing, the three countries suffer from some of the highest rates of tobacco-related deforestation globally with the latter accounting for 12% of the deforestation in Southern Africa (Campaign for Tobacco-Free Kids, 2001). The long-term consequences of these farming practices, including soil erosion, depletion and pollution, are potentially catastrophic for these countries suffering from malnutrition and, at the same time, experiencing double the average rate in population growth (The World Bank, 2018c).

As tobacco leaf production continues to grow, so will the associated use of arable land and water, aggravating competition for these resources with staple crops and therefore, food insecurity in these countries (Hu & Lee, 2015).

Child labour and farmer indebtedness

In addition to the health and environmental impacts, there are also issues surrounding child labour on tobacco farms (30% of the labour force on tobacco farms in Malawi are estimated to be children, some as young as 5 years old (Lecours et al., 2012)) which interferes with their education (Human Rights Watch, 2018). Additionally, the expansion of outgrower contracts has led to the economic exploitation and increasing indebtedness of farmers*, with small producers having very little bargaining power. This only serves to draw small farmers deeper into tobacco production and leaves families trapped in a cycle of poverty (Kulik et al, 2017) (Images 3 and 4).

The growing uptake of smoking

It is important to note that not even 5% of the countries' tobacco crop is consumed domestically. Therefore, the adverse impacts of tobacco that Malawi, Tanzania, and Zimbabwe bear are associated largely with the production supply chain. However, there is evidence that cigarette smoking is growing in Africa, e.g. a study in Malawi found that smoking prevalence is growing among Malawian adolescents as a result of increasing exposure to tobacco advertising, reporting that 29% of male students and 18% of female students were smokers (Kulik et al, 2017). Should the tobacco epidemic continue to spread in the region, these countries will also have the misfortune of experiencing the growing health, social and environmental costs of cigarette smoking.

Malawi, Tanzania, and Zimbabwe, as other low- or middle-income countries, can view tobacco as an important source of income and therefore struggle to resist tobacco industry influence (Hu & Lee, 2015). However, the adverse socio-economic and environmental impacts of tobacco impede their development accumulating into substantial long-term costs that these already disadvantaged communities will have to bear and which will only increase should consumption go up.

Image 3: A woman sorts dried tobacco leaves while a child sits nearby, Zimbabwe

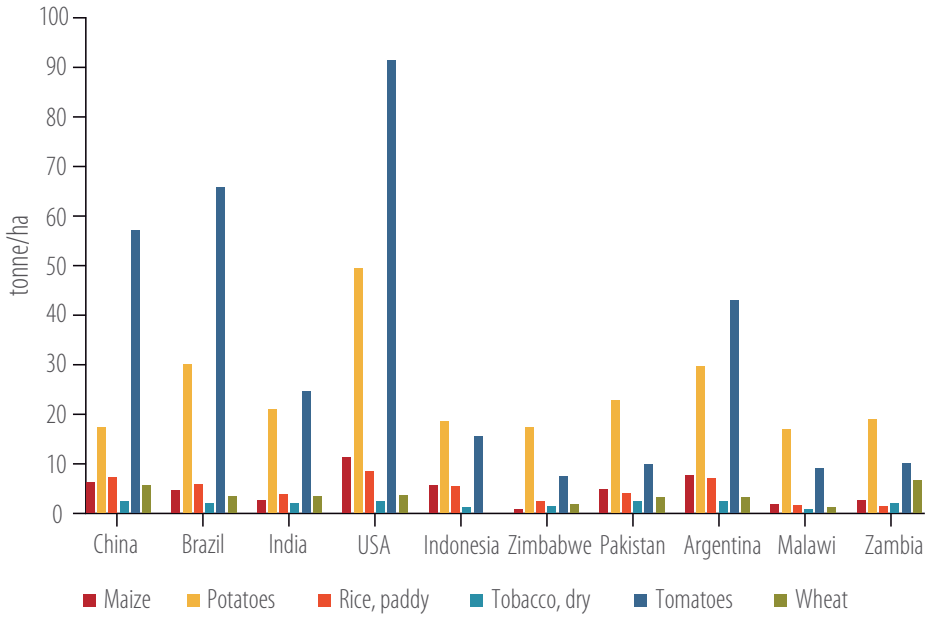
Source: Human Rights Watch, 2018. © 2015 Philimon Bulawayo/Reuters.

Image 4: Children working on a tobacco farm in Malawi

Source: Palitza, 2011

**Outgrower contracts are binding arrangements through which the buyer provides inputs, credit, and technical assistance to the producer, and commits to purchasing the crop upon harvesting (Campaign for Tobacco-Free Kids, 2001).*

Figure 5: Comparison of crop yields for 2016 in top 10 tobacco growing countries



Source: based on FAO reported yield for 2016 (FAO, 2018)

Case study C:

Alternative livelihoods in Indonesia

At nearly 200,000 tonnes of annual dry tobacco production, almost 210,000 ha of land devoted to the crop (FAO, 2017a) and with more than half a million farmers involved in tobacco cultivation (World Bank, 2017a), Indonesia is world's 5th largest tobacco grower. A study conducted by The World Bank (2017a) surveyed smallholder Indonesian farmers who recently switched from tobacco to growing more commonly-grown local crops and compared their incomes to those of farmers who continue to cultivate tobacco. The study found that former tobacco farmers:

- were on average doing better economically than current ones (with a total average household incomes of nearly US$ 3 800 compared to just over US$ 2 920 of current tobacco households
- spent far fewer hours in their fields and as a result, engaged in other economically productive activities
- tended to be less dependent on social assistance and health care benefits provided by the government

The "alternative" crops were all common, local crops, i.e. crops that grow well and which the farmers already know how to grow. For instance, former tobacco farmers in the region of Jember, were between US$ 440 and US$ 600 better off from selling corn and up to US$ 355 better off from selling chili compared to selling tobacco. Other substitute crops that showed to be more profitable in some or all regions include sweet potato, cassava, ground nut, green vegetables, and other mixed fruits and vegetables (Figure 6 and see Images 5 and 6).

For most farmers in Indonesia tobacco cultivation is not economically viable. They generally experience weighty economic losses, significantly underestimate the input costs, and engage in less diverse farming and fewer other economic activities. As a result, the majority are poor (72% compared to the 11% of the general population) with 60% suffering from food insecurity and many likely to display the symptoms of green tobacco sickness, and therefore more dependent on social assistance and health care benefits (World Bank, 2017a). Through a range of policies, governments can help facilitate the transition among farmers from tobacco to other crops and activities (see section 7).

Figure 6: Comparison of crop sales (USD) of selected alternative crops to tobacco, Indonesia

Source: adopted from the 6th edition of The Tobacco Atlas (Drope et al, 2018), based on The World Bank (2017a).

Image 5: A tobacco farm worker carries harvested tobacco leaves on her head, Indonesia.

Source: Human Rights Watch, 2016, © 2015 Marcus Bleasdale

Image 6: A young girl prepares tobacco leaves for curing, East Lombok in Indonesia

Source: Human Rights Watch, 2016, © 2015 Marcus Bleasdale

Climate Change

Each stage in the tobacco supply chain has a carbon footprint contributing to climate change either directly through the emission of greenhouse gases or by using materials that all have carbon footprints of their own. Thus, the production of one tonne of dry tobacco, i.e. enough to manufacture one million cigarette sticks, is associated with nearly 14 tonnes of CO_2 equivalent emissions (Net of the CO_2 uptake by tobacco crops as they grow). The sector's total annual contribution to climate change is nearly 84 Mt CO_2 eq,[vi] of which 20.8 Mt are attributed to cultivation, 44.7 Mt to curing,[vii] and 15.7 Mt to manufacturing (Figure 7 and see Appendix B). Tobacco's total annual carbon footprint is nearly as high as entire countries' GHG emissions such as Peru and Israel and more than twice that of Wales (based on the global and country GHG emissions reported by World Research Institute, 2015).

The carbon footprints established in this research project are higher than those stated by transnational tobacco companies in their sustainability reports. Thus, researchers at Imperial College found the CO_2 equivalent emissions at the manufacturing stage to be just over 2.6 tCO_2 eq per million cigarette sticks (or one tonne of dry tobacco).[viii] However, the 2015 emissions reported by British American Tobacco (BAT) and Philip Morris International (PMI) are 0.79 and 0.60 tCO_2 eq per million sticks respectively (BAT, 2017a; Philip Morris, 2017). Due to a lack of transparency on how these industry numbers were derived, it is not possible to say what drives this difference but it is likely to be down to the limited scope of the industry reports and the varying assessment methodologies.

vi The climate change and other environmental impacts linked to wildland and domestic fires caused by cigarette smoking as well as second-hand smoking were not included as they were beyond the scope of the study, but they are known to be substantial (Eriksen et al, 2015a).

vii Due to a lack of robust data on the deforestation caused by tobacco farming and the unsustainably sourced wood for tobacco curing, the impacts of smoking on climate change and ecosystems' health could not be fully captured.

viii There is inevitably a degree of uncertainty in the study findings down to the large scope and data availability, as well as the limitations associated with the LCA approach, which originate in the assumptions adopted and the choices made. Nevertheless because of the scale of both resource needs and environmental impacts, the significance of the results is clear. Furthermore, the sensitivity analyses demonstrated that it is unlikely that the findings represent a significant overestimate of the impacts, in fact, the known exclusion of some items because of an absence of data means that the true burden is likely to be even higher than reported.

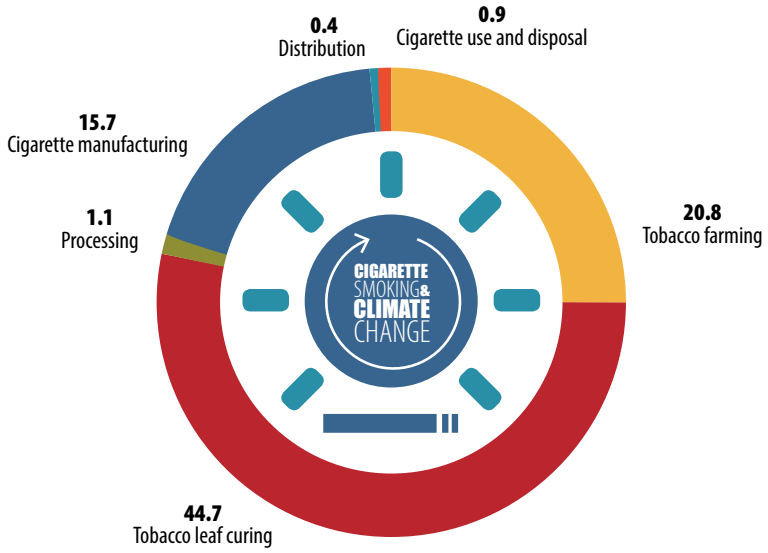
The many risks associated with climate change, including reduced crop yields, more frequent heat waves, droughts, floods, wildfires, population displacement and conflict etc., are already felt by communities around the world, particularly so among the most disadvantaged and vulnerable populations in low-lying coastal areas, including Small Island Developing States (SIDS) (IPCC, 2014a). The warming climate and the rising sea levels threaten these countries' infrastructure, ecosystem services, food security, economic stability and their very existence (IPCC, 2014a). Thus, climate change has been linked to increased coral bleaching in tropic small islands in Kiribati, Maldives, Seychelles, Papua New Guinea, and Barbados, and to the loss of mangroves, e.g. at Hungry Bay, Bermuda – all leading to declining fish abundance (Nurse, et al, 2014). In future, global warming is expected to exacerbate poverty in developing countries and create new poverty pockets in regions with increasing inequality, even in developed countries (IPCC, 2014b).

Reducing global cigarette production and consumption can be part of the solution to eliminating the sources of greenhouse gas emissions and achieving SDG 13, specifically through the lowering of the industry's direct and indirect GHG emissions, as well as the deforestation that is caused by tobacco farming and curing.

Ecosystem health

In addition to its contribution to climate change and resource depletion, the tobacco sector also has negative impacts on natural ecosystems, both–terrestrial and aquatic. Through the release of toxic substances such as pesticides or heavy metals into soil, air and water bodies, and their accumulation in the environment, tobacco puts live organisms at risk from chemical exposure, i.e. raising ecotoxicity levels (expressed using the reference unit of kg 1,4-dichlorobenzene (1,4-DB) equivalent). Similarly, the accumulation of nutrients in the environment as a result of such activities as fertiliser application on tobacco farms and the emissions linked to the burning of coal disturb the balance of natural nutrients in the environment. Through leachate or acid rain, the excess nutrients can cause, for example, explosions in algae and the associated oxygen depletion, i.e. eutrophication (expressed in kg of Nitrogen or Phosphorus equivalent (Chislock et al, 2013)), or terrestrial acidification (Pardo et al, 2011) (expressed in kg SO2 equivalent) with often devastating consequences for living organisms.

Figure 7: Annual contribution to climate change of the global cigarette smoking supply chain stages, in Mt CO^2 eq



Every one million cigarettes smoked (containing a tonne of dry tobacco) contribute over 6 kg 1,4-DB eq to terrestrial ecotoxicity levels, and about 80 kg 1,4-DB eq to each of freshwater and marine ecotoxicity levels. Additionally, the human toxicity potential associated with a tonne of tobacco is 3,250 kg 1,4-DB eq – that is excluding the direct health effects of first- and second-hand smoking, and occupational exposure. The terrestrial acidification associated with a tonne of tobacco is 76 kg SO2 eq, while freshwater and marine eutrophication amount to 2.7 kg P eq and 3.5 kg N eq respectively (Table 4, and see Appendix B).

The total annual impacts of tobacco on ecosystems include the contribution of 453,000 tonnes SO2 eq to terrestrial acidification, 16,000 tonnes P eq to freshwater eutrophication, and 21,000 tonnes N eq to marine eutrophication. Additionally, the sector's contributions to terrestrial, marine, and freshwater ecotoxicity levels amount to 36,000, 489,000, and 474,000 tonnes of 1,4-DB eq emissions respectively (Table 3).

Table 3: Annual impact on ecosystems' health of a tonne of produced and consumed tobacco, and total across the global tobacco supply chain

Impact category	Unit	Per tonne of tobacco	Total (millions)
Terrestrial acidification	kg SO_2 eq	76	453
Freshwater eutrophication	kg P eq	2.7	16
Marine eutrophication	kg N eq	3.5	21
Human toxicity	kg 1,4-DB eq	3250	19435
Terrestrial ecotoxicity	kg 1,4-DB eq	6.1	36
Freshwater ecotoxicity	kg 1,4-DB eq	82	489
Marine ecotoxicity	kg 1,4-DB eq	79	474

By putting pressure on natural ecosystems, tobacco poses a threat to the valuable ecosystem services that they provide and which are essential for societies' health, livelihoods and future development. Understanding the true cost of cigarette smoking to these ecosystem services is imperative to advancing policy action on factoring these environmental externalities into the taxes that tobacco companies pay with the aim of reducing these impacts and therefore contributing to the achievement of SDGs 14 and 15.

The main sources of tobacco's environmental impacts

Across the entire cigarette consumption supply chain, tobacco cultivation, curing, and manufacturing stand out as particularly resource-demanding and environmentally damaging. At the tobacco farming stage, irrigation and fertiliser use together drive more than 70% of the environmental damage across most impact categories, while at the tobacco curing stage, the direct burning of wood and coal accounts for more carbon emissions than all other stages combined, releasing at least 45 Mt CO_2 eq globally in a year, and that is excluding the deforestation impacts driven by the unsustainably sourced wood.

In cigarette manufacturing, the single most important driver of its substantial environmental impact is energy use, which accounts for at least 60% contribution across more than half of all impact categories. The choice of energy source plays an important role in mitigating tobacco's environmental footprint. For example, if coal dominates the energy mix, the carbon footprint of cigarette manufacturing may be higher by as much as 35%, while the damage to freshwater

and marine ecosystems can be at least 20% greater than the typical impacts estimated assuming a mix of energy sources across the world. Often, however, the comparison of the levels of environmental damage among alternative resource types is not clear-cut. For instance, although switching to natural gas as the main energy source may be less damaging than coal in terms of the carbon emissions and the damage to aquatic ecosystems, it may, at the same time, lead to higher levels of land transformation and fossil fuel depletion. Similarly, although the less intense farming practices are generally less environmentally damaging, their impact on agricultural land use and transformation can be far greater than in the case of more mechanised farms as a consequence of lower resulting yields (e.g. as is the case in Southern Africa).

In addition to the primary ingredient of cigarettes, the non-tobacco elements such as filters, cigarette paper, and packaging, that are an integral part of the final product, all carry a burden on the environment, especially when one considers the vast quantities used in the manufacturing of 6 trillion cigarettes annually. More than 1 Mt of filters and about 2.15 Mt of packaging are estimated to be used by the tobacco industry in a year (this excludes cardboard boxes for shipping). The activities and resources involved in the production of these items contribute about 10% to the carbon footprint of cigarette manufacturing, make up at least 80% of the latter's contribution to terrestrial ecotoxicity and agricultural land occupation, and account for at least 65% of the fossil fuel and water depletion. Furthermore, all the post-consumer waste that these items become and which has to be treated or, most importantly, ends up contaminating the environment, considerably aggravates tobacco's environmental footprint[ix] (see Figure B1 in Appendix B).

The environmental footprint of tobacco in perspective

Tobacco compared to other commodities

To help put the environmental footprint of tobacco into perspective, the impacts of a tonne of green tobacco can be compared to those of other crops, specifically the crops considered by WHO FCTC as potentially viable substitutes to tobacco in a number of developing countries (Keyser, 2015). It was found that the cultivation of a tonne of green tobacco has an approximately 2 to 3 times higher contribution to climate change than a tonne of tomatoes or potatoes but lower emissions than a tonne of wheat or rice. The average water depletion resulting from the cultivation of one tonne of tobacco is similar to that of rice but over 8 times higher than that of potatoes and 5 times higher than that of fresh tomatoes. The estimated freshwater eutrophication levels caused by the cultivation of a tonne of tobacco are lower than that of wheat but similar to the levels associated with potatoes and tomatoes. Table 4 presents a summary of the impacts per tonne of selected crop output.

ix Due to a lack of robust data on the post-consumer waste that end up contaminating the environment, the environmental impacts of tobacco waste could not be captured fully.

Table 4: Comparison of environmental impacts per tonne of output for selected crops

Impact category	Unit	Green tobacco	Potato	Rice	Tomato, fresh grade	Wheat grain
Climate Change	kg CO_2 eq	644	186	1842	266	806
Terrestrial acidification	kg SO_2 eq	3.7	1.8	7.3	2.6	8.0
Freshwater eutrophication	kg P eq	0.2	0.3	0.5	0.1	0.6
Marine eutrophication	kg N eq	0.3	2.2	11	2.3	5.4
Human toxicity	kg 1,4-DB eq	219	99	311	61	299
Terrestrial ecotoxicity	kg 1,4-DB eq	0.7	174	0.8	0.2	5.6
Freshwater ecotoxicity	kg 1,4-DB eq	5.7	12.6	8.4	1.9	6.0
Marine ecotoxicity	kg 1,4-DB eq	5.6	2.0	7.9	1.8	5.0
Agricultural land occupation	m^2a	1259	270	1546	357	3008
Urban land occupation	m^2a	40	4.1	104	14	14
Natural land transformation	m^2	1.7	0.0	0.1	0.0	0.1
Water depletion	m^3	670	81	663	126	246
Metal depletion	kg Fe eq	57	18	71	18	51
Fossil fuel depletion	kg oil eq	129	41	213	47	134
LCIA method used:						
Sources		Study results	(Ecoinvent, 2016e)	(Ecoinvent, 2016d)	(Ecoinvent, 2016b)	(Ecoinvent, 2016c)

The environmental footprint of a smoker

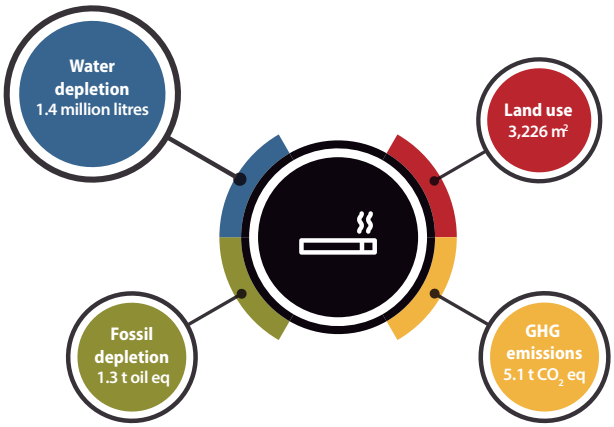
Even a single cigarette and one smoker carry an environmental burden that is noteworthy, particularly when all stages in the tobacco supply chain are taken into account. Thus, a typical cigarette was shown to have a water footprint of 3.7 litres, a fossil fuel cost of 3.5 grams oil eq, and a climate change impact of 14 grams of CO_2 eq emissions. Moreover, a person smoking a pack of cigarettes a day (herein referred to as a regular smoker), over a lifetime,[x] leaves a considerable environmental footprint (Figure 8):

- A total carbon footprint of 5.1t CO_2 eq emissions, which to offset, would require 132 tree seedlings planted and grown for 10 years (US EPA, 2017);
- A water footprint of 1,355 m3, which is equivalent to almost 62 years' water supply for any three people's basic needs[xi] (WHO, 2018b);
- Total fossil fuel depletion of 1.3 tonne oil eq, which is comparable to the electricity use of an average household in India for almost 15 years (World Energy Council, 2016).

Additionally, comparing the annual environmental footprint of a regular smoker (7.3 kg tobacco per year) to the global average red meat (14.4 kg meat per capita per year (OECD, 2017)) and sugar (24.3 kg sugar per capita per year (OECD, 2015)) consumption demonstrates that the resource depletion and pollution levels caused by cigarette use can be several times greater than those driven by other popular consumer commodities.

x A lifetime of smoking is assumed to be 50 years of smoking.
xi A person's basic water needs include hygiene and food hygiene needs (WHO, 2018b).

Figure 8: Environmental impacts of a lifetime of smoking, i.e. a person smoking a pack of 20 cigarettes every day for 50 years



For instance, in one year a smoker contributes almost 5 times more to water depletion and nearly 2 and 10 times more to fossil fuel depletion than an average consumer of red meat and sugar respectively, and 4 times more to climate change than a sugar consumer (Table 5). Smoking is, therefore, not only a problem for the lives of the smokers and the people around them, but for entire communities and the planet – it is truly a global problem.

Table 5: Comparison of environmental impacts associated with smoking a pack of 20 cigarettes every day and a world average annual per capita consumption of red meat and sugar

Impact category	Unit	Cigarettes, smoker of 1 pack/day	Red meat, average consumer	Sugar, average consumer
Climate Change	kg CO_2 eq	100	196	27
Terrestrial acidification	kg SO_2 eq	0.55	1.3	0.20
Freshwater eutrophication	kg P eq	0.02	0.03	0.00
Marine eutrophication	kg N eq	0.02	1.05	0.08
Human toxicity	kg 1,4-DB eq	23	21	0.09
Terrestrial ecotoxicity	kg 1,4-DB eq	0.04	1.3	0.83
Freshwater ecotoxicity	kg 1,4-DB eq	0.56	0.89	0.21
Marine ecotoxicity	kg 1,4-DB eq	0.55	0.64	0.12
Agricultural land occupation	m^2a	64	179	26
Urban land occupation	m^2a	2.45	2.5	0.35
Natural land transformation	m^2	0.08	0.41	0.33
Water depletion	m^3	27	4.3	4.1
Metal depletion	kg Fe eq	3.97	4.3	0.86
Fossil fuel depletion	kg oil eq	25	13	2.6
Sources:		Zafeiridou, Hopkinson & Voulvoulis, 2018	Ecoinvent, 2016c; OECD, 2017a	Ecoinvent, 2016g; OECD, 2015

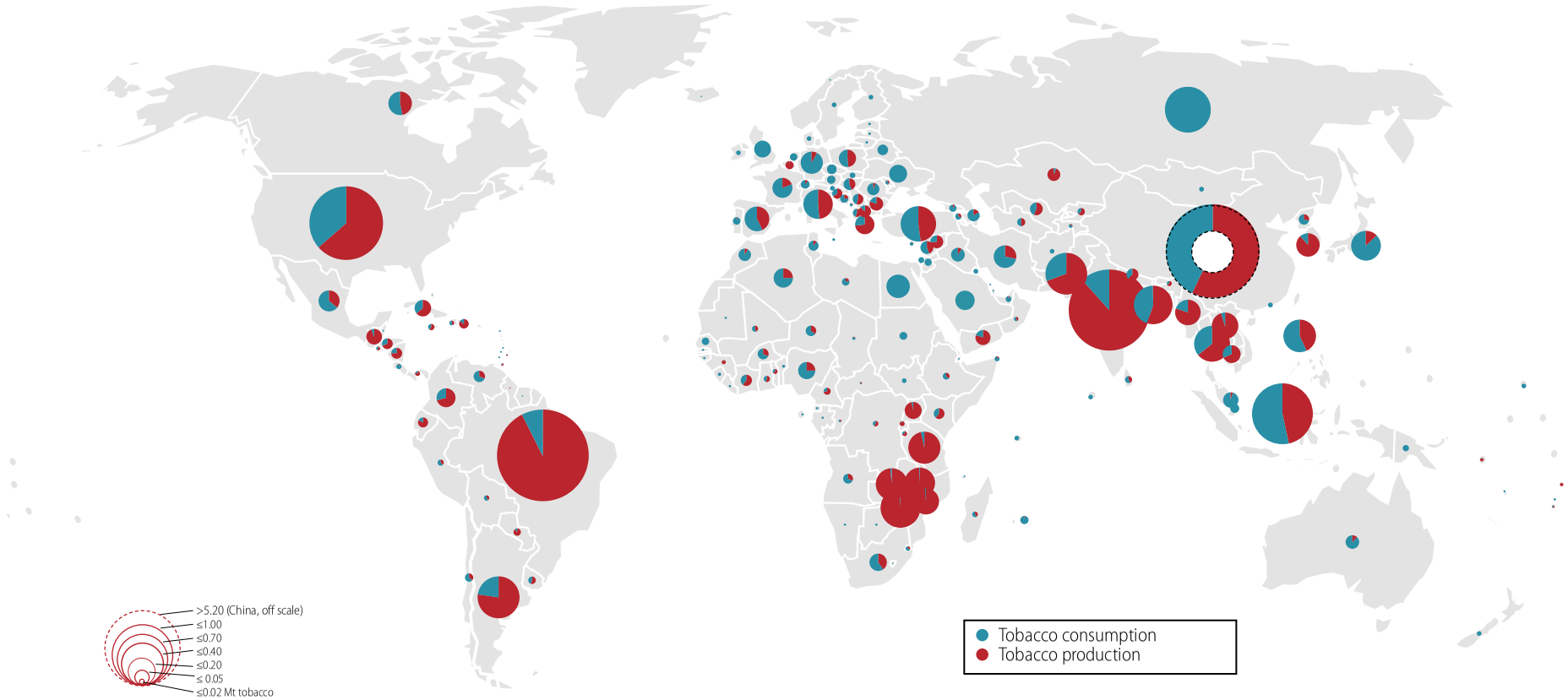
The growing environmental injustice

Today, almost 90% of all tobacco production is concentrated in the developing world and of the top ten tobacco producing countries, nine are developing and four are low-income food-deficit countries (LIFDCs), including India, Zimbabwe, Pakistan, and Malawi. In many of the low-income countries growing tobacco, and particularly so in the food-deficit countries in Africa and Asia, the vast majority of all tobacco produced is destined for exports, with less than 20% consumed locally (Figure 9, based on data in FAO, 2017a; Euromonitor International, 2014; The World Bank, 2018a and 2018b).

As a result, the extra stress that the tobacco sector puts on ecosystems and natural resources is now mainly borne by the less developed regions, often threatening livelihoods in most vulnerable communities (as demonstrated in the case studies and examples in section 4). And that is on top of the burdens of green tobacco sickness, child labour and other human rights issues (Human Rights Watch, 2018). Meanwhile, profits from the sale of tobacco products are largely returned to tobacco corporations without benefit to the developing world (Chaloupka & Warner, 2000; Warner, 2000).

Without coordinated government action, tobacco consumption will continue to grow, deepening the environmental crisis in the producing countries. Intergovernmental organisations such as, for example, the WHO FCTC, UNDP, and FAO can play a key role in putting an end to this growing injustice by facilitating international cooperation that would address all key sources of environmental damage across the entire tobacco supply chain.

Figure 9: Annual tonnage of tobacco production and consumption per country in year 2014



Based on: data from FAO, 2017a; Euromonitor International, 2014; The World Bank, 2018a and 2018b

Note: circles represent the sum of total annual tobacco production and consumption in a country, their size differs by aggregate tonnage and the colours represent production (orange) and consumption (black). For example, Brazil produces over 860,000 tonnes of tobacco and consumes about 70,000 tonnes, while Russia has zero production but consumes approximately 270,000 tonnes of tobacco in a form of cigarettes.

Policy opportunities for impact mitigation

Scenarios for the future

As the industry has already delivered some improvements in efficiency in parts of the supply chain, benefits from further improvements are unlikely in light of the increasing levels of global production and consumption. For instance, PMI claim to have reduced their CO_2 equivalent emissions and water withdrawal per million sticks by 24% between 2010 and 2015 (Philip Morris, 2016a) and BAT report a 47% reduction in their carbon footprint from the 2000 baseline and an almost 30% reduction in water use between 2007 and 2016 (BAT, 2017a). However, aggressive tobacco marketing in low- and middle-income countries means that globally, the number of smokers and total tobacco consumption are growing every year, and so therefore will the environmental impact.

No efficiency improvements can possibly approach the benefit that cuts in absolute production and consumption would deliver across the board. For example, as was mentioned earlier in the report, a drop in cigarette consumption to the 1970-level of 3.26 trillion sticks per year (American Cancer Society, 2015) would almost half tobacco's global footprint across all impact categories, while potential improvements in performance efficiency may only lead to incremental reductions across selected impact categories. On the other hand, should cigarette consumption be allowed to grow to the predicted 9 trillion sticks annually by 2025 (Pass et al, 2012), the annual agricultural land use for global tobacco can be expected to reach 7.9 million hectares, water depletion would exceed 34 billion m3, and the annual fossil fuel depletion would rise to 5 Mt oil eq.

The 55% rise in cigarette consumption would also result in a commensurate rise in pollution levels with the annual CO_2 eq emissions reaching almost 130 Mt (assuming no changes in current production processes). In times when over 800 million people are undernourished (FAO, 2017b), when water scarcity is already at the source of regional and international conflict (Pacific Institute, 2017), and colossal efforts are required to stop climate change, such a scenario is unacceptable.

Policy considerations and challenges

Tobacco depletes the planet of water, fossil fuel and metal resources and competes for land with commodities essential for people's livelihoods and food security around the world, it pollutes aquatic and terrestrial ecosystems through the emission of toxic substances and excess nutrients, and emits 84 million tonnes of greenhouse gases into the atmosphere, contributing to climate change. All these environmental impacts, on top of the many health, social and economic issues associated with smoking, make tobacco incompatible with the global sustainable development agenda and its control an indispensable part of the solution to achieving the Global Goals. And since no efficiency gains in the tobacco supply chain can compare to the far-reaching benefits that the cuts in cigarette production and consumption can deliver across a number of Global Goals, the ultimate objective for all tobacco control policies should be to eliminate tobacco use altogether.

The SDGs pose a challenge to manufacturing businesses such as the tobacco industry because Global Goals imply increased responsibility for the full length of their supply chains. Most importantly though, sustainable development requires that we rethink not only how products are made but also what products are made (Business and Sustainable Development Commission, 2017a), therefore challenging the very existence of such industries as tobacco. As a result, the latter resort to corporate social responsibility (CSR) activities with the main aim of distracting attention away from what their products essentially represent, to positioning themselves as

positive contributors to society through, for example, reforestation and education programmes, and as responsible producers through their sustainability reports claiming reductions of their carbon and water footprints (e.g. Japan Tobacco International, 2012; BAT, 2017b; Universal Corporation, 2017b). Naturally, most tobacco control policy strategies will have a positive effect on mitigating tobacco's environmental footprint too. Nevertheless, specific measures addressing the environmental impacts of smoking need to be integrated into those control policies, completing them and strengthening the overall fight to end the global tobacco epidemic. There are a number of challenges, however, that need to be considered in designing effective policy strategies, and these include:

- The lack of robust data on and awareness of tobacco's true environmental cost among smokers, general public, and even policy-makers;
- The differences in national regulations being exploited by tobacco companies to avoid reporting or paying for the damage caused by their activities;
- Dependence on tobacco as a cash crop in a number of lower income countries;
- Strong tobacco lobby and the growing uptake of smoking.

Addressing these challenges would instigate a number of policies that can help reduce tobacco's environmental footprint and contribute to the achievement of SDGs 12, 13, 14 and 15.

Practical steps for delivering SDGs 12, 13, 14, 15

To be most effective in addressing the resource depletion, the harm to ecosystems and the contribution to climate change that tobacco causes, policies must consider all key stakeholders, including the tobacco farmers, the tobacco processing and cigarette manufacturing corporations, and the consumers. More specifically, policy measures can be taken to ensure the responsible parties are made accountable for the environmental externalities they cause, to improve the current knowledge base on tobacco's environmental impacts locally and globally; raise awareness of the issue among smokers, civil society, and policy makers, and leverage private-public partnerships and intergovernmental agreements.

The policies proposed here are based on a combination of recommendations identified in a number of consultancy reports on achieving the SDGs (PwC, 2017; Business and Sustainable Development Commission, 2017a and 2017b; The World Bank, 2017b; SDSN Secretariat, 2015; DEFRA, 2006) and are aligned with the policies recommendations presented in the latest WHO overview of tobacco's environmental impacts (2017).

a. Strengthening the global evidence base

The lack of robust data on the environmental impacts of the tobacco sector makes it challenging for policy makers to manage the issue effectively. It is therefore imperative that governments mandate systematic and extensive reporting from the tobacco industry on the environmental impacts of their operations across the entire supply chain, from all stakeholders. A standardised reporting framework should be in place to facilitate the accuracy and transparency of the information disclosed, requesting data against a comprehensive list of KPIs such as:

- Emissions to air (such as greenhouse gases, toxic gases linked to acid rain and eutrophication, metal emissions, etc.);
- Emissions to water (metal, nutrient and organic);
- Emissions to land, including agrochemical and metal emissions, as well as waste;
- Resource use, including water, land, metals, energy, forestry, etc.

b. Encouraging sustainable investment

Governments can encourage the shift of investment away from tobacco and to sustainable alternatives by providing supportive regulatory frameworks and the right business environment conditions, including:

- Improving pension and insurance regulations to encourage divestment from tobacco;
- Improving regulations to enable bond issuance and investment for long-term, sustainable finance for switching from tobacco sector;
- Strengthening certification and Environmental, Social and Governance (ESG) standards for green bonds and climate bonds to prioritise investments that genuinely contribute to achieving the SDGs.

c. Pricing of environmental externalities

To hold the industry accountable and encourage the move to more sustainable alternatives, the environmental externalities of tobacco must be reflected in tobacco taxing, including:

- Carbon pricing to address climate change
- Cost of damage to ecosystems estimated through Ecosystem Services Valuation;
- Impose fines for unauthorised deforestation and pollution.

The adoption of such national-level pricing policies is likely to prompt tobacco corporations to move operations to countries with more lenient price policies. Global cooperation with potential supranational/ global policy on pricing of environmental externalities would be key in overcoming this issue. WHO FCTC can play a key role in facilitating such international cooperation.

d. Tobacco waste and Extended Producer Responsibility

Extended Producer Responsibility regulations would make tobacco producers accountable for the post-consumer cigarette waste, obliging them to take responsibility for the prevention and mitigation of tobacco product waste. Part of the solution to keeping tobacco waste out of the environment could be:

- Elimination of single-use filters
- Elimination of unnecessary packaging
- "Polluter pays" levies on tobacco industry profits to fund environmental restoration programmess, tobacco control and awareness raising.

e. Assist tobacco farmers in switching to alternative crops or activities

To encourage and help tobacco farmers switch to alternative crops or activities policies should support them in their transition, especially those with low skills and/ or tied by their outgrower contracts with the tobacco industry. Substantial work has already been carried out in this area by the WHO FCTC Conference of the Parties, as set out in COP decision FCTC/COP6(11) Economically sustainable alternatives to tobacco growing (in relation to Articles 17 and 18 of the WHO FCTC).

f. Minimising environmental damage on farms

To incentivise the adoption of more sustainable agricultural practices, it is important to provide farmers with the necessary knowledge and skills, and assist them with access to tools that will help them improve their productivity:

- Build awareness of the value and the indispensable role that ecosystem services and biodiversity play in the livelihoods of local communities;
- Involve farming communities in monitoring the health of their local ecosystems;
- Provide/ encourage education on more sustainable practices on farms, including:
  - new technologies for micro-irrigation techniques
  - better weather monitoring
  - microbial fertilisers
  - precision agriculture & nutrition
  - integrated waste management to avoid incorrect disposal of leftover pesticides
- Facilitate knowledge sharing among farmers and communities through outreach programmes (e.g. as in the case of Barry Callebaut chocolate manufacturer that adopted a "cascade approach" starting with training cooperative managers, then qualified farmers sharing knowledge with farmer academies, then model farms and field schools (Barry Callebaut Group, 2017).

g. Empowering the public and changing consumer behaviours

The most effective way of reducing the supply of tobacco products would be to reduce the demand for them. Demand-side measures aimed at raising awareness among public of the devastating environmental impacts of smoking and ultimately changing consumer behaviours play a crucial part in tobacco control strategies. These measures could include:

- Empower civil society by making tobacco industry environmental performance publicly available;
- Raise awareness of how tobacco production harms the planet, harms the most vulnerable including children and impedes sustainable development through targeted communication campaigns (according to
  a report by PwC, 78% of citizens, when made aware of the SDGs, say they would change their buying behaviour because of the Global Goals (PwC, 2015));
- Raise awareness and change behaviours through support of voluntary work, e.g. beach clean ups with the Ocean Conservancy;
- Introduce fines for improper disposal of tobacco products.

h. Fostering cooperation through partnerships

Cooperation between public, private and academic partners, as well as the involvement of environmental activists, will be essential for a speedy transition from tobacco and to achieving the Global Goals. Partnerships, implemented in line with Parties' obligations under Article 5.3 of the FCTC, can encourage the innovation needed to monitor and protect the health of the ecosystems affected by tobacco. For example, a partnership of over forty organisations, including UNEP, WRI, Google, Amazon, NASA, University of Maryland among others, has resulted in the development of new forest monitoring system that enables faster, more effective forest conservation and sustainable forest management by combining a novel near-real-time deforestation alert system, satellite data and systems, crowdsourcing, and mobile technology (World Research Institute, 2014). Equally, the inclusion of tobacco control in the international agendas on environmental protection, including climate change and biological diversity, is important.

Conclusion

The resource needs and the environmental impacts of cigarette smoking, from cradle to grave, add significant pressures to the planet's increasingly scarce resources and fragile ecosystems. Tobacco reduces our quality of life as it competes for resources with commodities valuable to the world societies' livelihoods and development. Its environmental footprint, together with its negative health, social and economic implications, makes tobacco incompatible with the global sustainable development agenda, including SDGs 12, 13, 14, and 15.

From tobacco cultivation and curing, to cigarette manufacturing, distribution, consumption and discarding, every stage in the global tobacco supply chain involves considerable resource inputs such as water, land, energy and material resources, as well all as outputs in the form of wastes and emissions. Globally, in a year, cigarette smoking causes over 22.2 billion m3 in water depletion, almost 21 Mt oil equivalent and 3.3 Mt Fe equivalent in fossil fuel and metal depletion, respectively, and requires a total of almost 5.3 million ha of agricultural and urban land. The sector's annual climate change impact at 84 Mt CO_2 eq is comparable to entire countries' emissions and 0.2% of the global total, while its contribution to ecosystem ecotoxicity levels reaches up to 490,000 tonne 1,4-DB eq. Tobacco also causes significant deforestation with at least 6,500 ha of forest land cleared annually to make way for tobacco farming, and over 8Mt of wood required for tobacco curing. Tobacco cultivation, curing, and manufacturing stand out as particularly resource-demanding and environmentally damaging stages in the supply chain. Tobacco production is often more environmentally damaging than that of more essential commodities such as potatoes, tomatoes, and wheat. Given that incorrectly disposed post-consumer waste, unsustainably sourced wood, wildland and domestic fires as well as a number of the supply chain inputs were not included in the assessment, the impacts reported here are likely to be a significant underestimate of tobacco's true cost to planetary health.

As a result of the shift of tobacco production from richer to lower income countries its environmental impacts are now mostly borne by developing regions. By depleting these countries' valuable resources, polluting, and damaging their ecosystems, tobacco puts their livelihoods and development at risk.

Failure to address tobacco's impacts on the planet's ecosystems and resources will delay the world's transition to a sustainable path. Policy measures aimed at mitigating the environmental damage caused by tobacco should be therefore an integral part of tobacco control policies and of the overall solution to achieving the SDGs. These would require that governments create mechanisms and the right conditions that will hold the tobacco industry accountable for the environmental externalities they cause, facilitate the transition of tobacco farmers to alternative crops or activities, improve the current knowledge base on tobacco's environmental impacts globally and regionally, raise awareness of the issue among smokers, civil society, and policy makers, and leverage private-public partnerships (in compliance with Article 5.3) and intergovernmental agreements.

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Appendix A

Table A1: Life cycle assessment (LCA) study scope and system boundaries of global cigarette production and consumption

Study features	Description
Processes included	Tobacco cultivation, curing, primary processing, cigarette manufacturing, distribution, use and disposal, plus transportation and waste management activities at every process stage
Representative product	Cigarette sticks including manufactured and roll your own sticks containing 1g and 0.75g of tobacco and accounting for 98.35% and 1.65% production respectively*
Functional unit	A tonne of produced and consumed tobacco, equivalent to 1 million cigarette sticks*
Scope	Global cigarette production and consumption in one year
Base year	2014
Mass flows allocated to tobacco	100%
Types of resource flows included in the analysis	Key direct and indirect inputs and outputs
Types of resource flows excluded from the analysis	Office supplies, cleaning products, chemicals and additives used in production and manufacturing processes, smoking accessories
Issues excluded from impact analysis	Smoking-related fires, second-hand smoke, unsustainably sourced wood in curing, post-consumer waste that end up in the environment
Impact categories considered	Climate change, terrestrial acidification, freshwater eutrophication, marine eutrophication, human toxicity (excluding the health impacts of direct and second-hand smoking, as well as occupational exposure), terrestrial ecotoxicity, freshwater ecotoxicity, marine ecotoxicity, agricultural land occupation, urban land occupation, natural land transformation, water depletion, metal depletion, and fossil fuel depletion

*The assumption that the average tobacco weight of 1g in a typical manufactured cigarette (based on the PMI reported tobacco weight (Gallus et al., 2014) was tested in the sensitivity analysis by substituting it with 0.75g

Table A2: Summary annual mass flows in the global tobacco supply chain

INPUTS		Unit	Inputs per tonne of output tobacco	Total output tobacco at each stage (Mt)	Total Inputs (millions)	Inputs per tonne of tobacco produced for consumption
WATER						
Stages	- Cultivation	tonne	678	32.4	21978.1	3675.3
	- Processing	tonne	7.59	5.98	45.4	7.6
	- Manufacturing	tonne	2.47	5.98	14.8	2.5
Total		**tonne**			**22038.2**	**3685.3**
ENERGY						
Stages	- Cultivation	MJ	8.59	32.4	278.3	46.5
	- Processing	MJ	277	5.98	1655.5	276.8
	- Manufacturing	MJ	10076	5.98	60253.6	10075.8
Total		**MJ**			**62187.4**	**10399.2**
MATERIAL RESOURCES						
Stages	- Cultivation	tonne	0.03	32.4	1.07	0.2
	- Curing	tonne	3.25	6.48	21.1	3.5
	- Processing	tonne	0.19	5.98	1.11	0.2
	- Manufacturing	tonne	0.63	5.98	3.78	0.6
	- Distribution	tonne	0.02	5.98	0.15	0.0
Total		**tonne**			**27.2**	**4.5**
TRANSPORT						
Stages	- Cultivation	tkm	12.5	32.4	405	67.7
	- Curing	tkm	100	6.48	648	108.4
	- Processing	tkm	2900	5.98	17342.0	2900.0
	- Distribution	tkm	1019	5.98	6093.6	1019.0
Total		**tkm**			**24488.6**	**4095.1**
LAND						
Stages	- Cultivation	m^2	1235	32.4	40000.2	6689.0
	- Curing	m^2	0.13	6.48	0.84	0.1
	- Processing	m^2	12.31	5.98	73.6	12.3
	- Manufacturing	m^2	0.53	5.98	3.15	0.5
Total		**m^2**			**40077.7**	**6702.0**

WASTE and EMISSIONS		Unit	Waste and emissions per tonne of output tobacco	Total output tobacco at each stage (Mt)	Total waste and emissions (millions)	Waste and emissions per tonne of produced and consumed tobacco
SOLID WASTE						
Stages	- Cultivation	tonne	0.6	32.4	19.4	3.3
	- Processing	tonne	0.08	5.98	0.5	0.1
	- Manufacturing	tonne	0.2	5.98	1.2	0.2
	- Use & Final Disposal*	tonne	0.7	5.78	4.1	0.6
Total		**tonne**			**25**	**4.2**
WASTE WATER & WATER LOSS						
Stages	- Cultivation (losses from irrigation)	tonne	674	32.4	21844.5	3652.9
	- Curing (loses from evaporation)	tonne	4.0	6.48	25.9	4.3
	- Processing (waste water)	tonne	7.61	5.98	45.5	7.6
	- Manufacturing (waste water)	tonne	1.50	5.98	9.0	1.5
Total		**tonne**			**21925**	**3666.4**
EMISSIONS TO AIR						
Stages	- Cultivation	t CO_2 eq	0.64	32.4	20.9	3.5
	- Curing	t CO_2 eq	6.89	6.48	44.6	7.5
	- Processing	t CO_2 eq	0.18	5.98	1.1	0.2
	- Manufacturing	t CO_2 eq	2.63	5.98	15.7	2.6
	- Distribution	t CO_2 eq	0.07	5.98	0.4	0.1
	- Use & Final Disposal*	t CO_2 eq	0.15	5.78	0.9	0.2
Total		**t CO_2 eq**			**84**	**14.0**

** Note: amounts for the Use & Final Disposal stage refer to consumed tobacco as opposed to produced tobacco in the preceding stages*
Source: Zafeiridou, Hopkinson & Voulvoulis, 2018.

Appendix B

Table B1: Environmental impacts per tonne of produced and consumed tobacco

Impact category	Unit	Farming	Curing	Processing	Cigarette Manufacturing	Distribution	Cigarette Use & Disposal	TOTAL
Climate Change	kg CO_2 eq	3486.5	7470.6	179.3	2628.7	64.6	145.4	13975.2
Terrestrial acidification	kg SO_2 eq	19.9	40.1	1.8	13.1	0.4	0.5	75.8
Freshwater eutrophication	kg P eq	1.1	0.1	0.1	1.4	0.0	0.1	2.7
Marine eutrophication	kg N eq	1.9	0.6	0.1	0.7	0.0	0.2	3.5
Human toxicity	kg 1,4-DB eq	1188.4	813.5	98.7	1051.2	8.7	89.4	3249.9
Terrestrial ecotoxicity	kg 1,4-DB eq	4.0	0.2	0.0	0.8	0.0	1.0	6.1
Freshwater ecotoxicity	kg 1,4-DB eq	30.9	7.3	2.4	36.2	0.3	4.8	81.8
Marine ecotoxicity	kg 1,4-DB eq	30.2	8.8	2.7	33.2	0.3	4.0	79.3
Agricultural land occupation	m^2a	6821.2	1368.3	47.1	534.4	57.9	-335.9	8493.0
Urban land occupation	m^2a	215.9	79.6	16.0	23.8	2.1	-2.3	335.0
Natural land transformation	m^2	9.4	0.7	0.1	0.5	0.0	0.0	10.8
Water depletion	m^3	3631.3	21.6	2.4	57.2	1.0	-0.6	3712.9
Metal depletion	kg Fe eq	307.7	77.8	55.8	102.7	2.3	2.7	548.9
Fossil fuel depletion	kg oil eq	696.2	2014.9	50.8	674.2	21.2	23.2	3480.5

Source: Zafeiridou, Hopkinson & Voulvoulis, 2018.

Table B2: Total annual environmental impacts of the global tobacco supply chain

Impact category	Unit	Farming	Curing	Processing	Cigarette Manufacturing	Distribution	Use & Disposal (Millions)	TOTAL
		Million						
Climate Change	kg CO_2 eq	20849	44674	1073	15720	386	870	83572
Terrestrial acidification	kg SO2 eq	119	240	11	78	2.4	2.9	453
Freshwater eutrophication	kg P eq	6.8	0.6	0.3	8.3	0.03	0.3	16
Marine eutrophication	kg N eq	11	3.7	0.4	4.3	0.2	1.0	21
Human toxicity	kg 1,4-DB eq	7107	4865	590	6286	52	534	19435
Terrestrial ecotoxicity	kg 1,4-DB eq	24	1.5	0.2	4.5	0.1	6	36
Freshwater ecotoxicity	kg 1,4-DB eq	185	43	14	216	1.7	29	489
Marine ecotoxicity	kg 1,4-DB eq	181	53	16	199	2.1	24	474
Agricultural land occupation	m^2a	40791	8182	282	3196	346	-2009	50788
Urban land occupation	m^2a	1291	476	96	142	12	-14	2004
Natural land transformation	m^2	56	4.4	0.8	2.7	0.2	-0.1	64
Water depletion	m^3	21715	129	15	342	5.8	-3.5	22203
Metal depletion	kg Fe eq	1840	465	334	614	14	16	3282
Fossil fuel depletion	kg oil eq	4163	12049	304	4032	127	139	20813

Source: Zafeiridou, Hopkinson & Voulvoulis, 2018.

Figure B1: Environmental impacts contribution of the global tobacco supply chain stages across the full life cycle of cigarette production and consumption

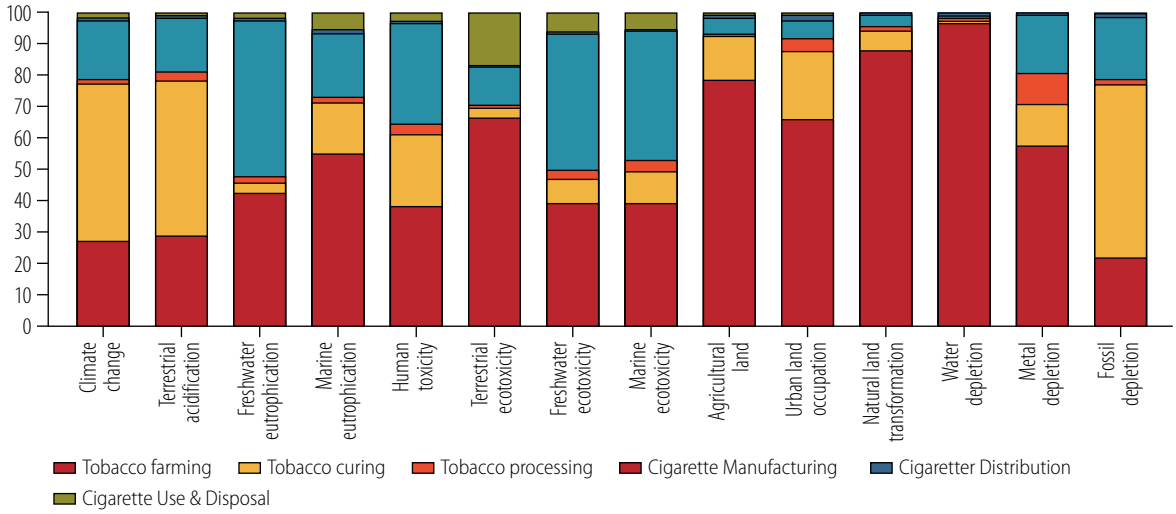

Table B3: Upper and lower percent variance established in the sensitivity analysis compared to the total 3 impact assessment results

Impact category	Unit	Study results (millions)	% Variance
Climate change	kg CO_2eq	83572	± 8
Terrestrial acidification	kg SO_2eq	453	±7
Freshwater eutrophication	kg P eq	16	±12
Marine eutrophication	kg N eq	21	±10
Human toxicity	kg 1,4-DB eq	19435	±7
Terrestrial ecotoxicity	kg 1,4-DB eq	36	±19
Freshwater ecotoxicity	kg 1,4-DB eq	489	±9
Marine ecotoxicity	kg 1,4-DB eq	474	±9
Agricultural land occupation	m^2a	50788	± 6
Urban land occupation	m^2a	2004	±4
Natural land transformation	m^2	64	±6
Water depletion	m^3	22203	±8
Metal depletion	kg Fe eq	3282	±4
Fossil fuel depletion	kg oil eq	20813	±9

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