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Intelligence for sustainable trade

Expanding the toolkit: Exploring European policy pathways to reduce agricultural deforestation and biodiversity loss

March 2026

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Trase is a partnership between the Stockholm Environment Institute and Global Canopy

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About Trase

Trase is a data-driven transparency initiative that revolutionises our understanding of the international trade and financing of agricultural commodities which drive tropical deforestation. Its unique supply chain mapping approach brings together disparate, publicly available data to connect consumer markets to deforestation and other impacts in producer countries. Trase's free online tools and actionable intelligence enable governments, companies, financial institutions and civil society organisations to take practical steps to address deforestation. Trase is a not-for-profit partnership founded in 2015 by the Stockholm Environment Institute and Global Canopy. www.trase.earth

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This report has been produced with the strategic inputs of the project's Steering Committee members and with the financial support of the Finnish Innovation Fund Sitra. The report reflects only the views of its authors and not the donors.

Citation

Croft, S., Vrijhoeven, R., Green, J., Simpson, J., Molotoks, A., Stokeld, E., Taherzadeh, O., & West, C. (2026). Expanding the toolkit: Exploring European policy pathways to reduce agricultural deforestation and biodiversity loss. Trase. https://doi.org/10.48650/4Y4G-R916

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Executive Summary

Context

The European Union's (EU) consumption of forest-risk agricultural commodities is a major driver of forest and biodiversity loss globally. While the EU Deforestation Regulation (EUDR) introduces mandatory obligations for companies to demonstrate due diligence in supply chains in order to 'de-risk' the EU from exposure to commodity-driven deforestation, its successful implementation faces significant political and logistical pressure. This report uses exploratory scenario analysis to model changes in the EU's environmental footprint. By examining the seven commodities covered by the EUDR (cattle, cocoa, coffee, oil palm, rubber, soy, and timber), the study calculates the potential reduction in global deforestation, associated emissions, and biodiversity impacts resulting from the implementation of EU policy measures. These measures include both the EUDR and a wider suite of policy levers that promote sustainable domestic consumption, sustainable domestic production, and sustainable supply chains via border adjustment costs. These policy levers are tested in combination to assess the potential for deeper reductions in the EU's footprint than might be achieved via supply-chain de-risking alone. Overall, the results demonstrate substantial potential to reduce the EU's footprint, with the largest reductions coming from a combination of policy measures.

Purpose and scope

This report establishes a baseline account of the EU27's deforestation footprint, associated deforestation emissions, and biodiversity impacts linked to the seven EUDR commodities. It then explores how these footprints change under different hypothetical levels of EUDR implementation ambition and under a set of non-EUDR policy levers designed to influence both demand and supply of deforestation-implicated materials. The scenarios are comparative rather than timebound forecasts, providing a "before versus after" assessment of the relative effects of different policy measures against the baseline.

Approach

The analysis employs a hybridised multi-regional input-output (MRIO) framework to explore the impact of future scenario space, in contrast with Trase's previous analysis which has explored historical supply chain impacts. The material footprint for the baseline (against which scenarios are compared) is derived from a model of the global economy for 2022 and is extended to environmental impacts by combining it with commodity-specific deforestation estimates (derived from the DeDuCE dataset) and a biodiversity metric (Forest-LIFE). Three footprints are calculated throughout: deforestation area (ha), associated deforestation emissions (tCO^2e), and biodiversity impacts measured as annualised species extinctions. Absolute footprint values should be interpreted as model outputs, with the primary emphasis on relative differences between scenarios.

Baseline footprint and hotspots

In the 2022 baseline, the EU27's estimated deforestation footprint according to the model implemented in this analysis is 162,240 ha across the seven focal commodities[1], with associated deforestation emissions of 59,417,088 tCO2e, and an associated biodiversity impact (Forest-LIFE score[2]) of 0.2946 annualised species extinctions[3]. This deforestation footprint represents an extent of annual deforestation five times the size of Malta, and is equivalent to over 200,000 full-sized football pitches. The associated carbon footprint is approximately equivalent to 60 million passenger return flights between London and New York. The footprint is dominated by cattle (about 48% of the total), while cocoa, oil palm and timber each contribute roughly 12-13%, followed by soy (around 6%), rubber (around 5.1%) and coffee (around 3.7%).

Footprints are unevenly distributed across Member States: Germany has the highest absolute footprint (around 23.4% of the EU total), and the five largest contributors (Germany, France, Italy, Spain and the Netherlands) account for around 70% of the total. At the same time, the footprint is also concentrated across points of origin, with the top 15 origin countries accounting for around 72% of the EU27 deforestation footprint. Brazil is the single largest origin (around 18.8% of the total), dominated by cattle and soy, while China is a major origin largely through timber and Indonesia through oil palm. Other commodities have more concentrated origin profiles, with Côte d'Ivoire dominating cocoa, Cambodia dominating rubber, and Peru dominating coffee.

Impact of the EUDR

The EUDR was adopted in 2023 and requires operators placing relevant commodities and products on, or exporting them from, the EU market to collect plot-level geolocation data and submit due diligence statements showing the products are deforestation-free (no deforestation or forest degradation after 31st December 2020) and produced in accordance with relevant laws in the country of production. Implementation has been pushed back and, following the latest postponements, it now applies from 30th December 2026 for large and medium operators and 30th June 2027 for small and micro operators (European Union, 2025a). These delays increase the near-term relevance of complementary policy levers that can reduce impacts even where EUDR implementation is phased, uneven, or weaker than initially anticipated.

The EUDR scenarios developed in this analysis comprise different hypothetical implementation scopes and enforcement strengths, applied across low, medium and high ambition settings which influence the degree to which EU supply chains are 'de-risked'. In practical terms, 'low' ambition reflects more limited scope and weaker enforcement and compliance, while 'high' ambition reflects an expansion to broader product scope and stronger enforcement and compliance (with 'medium' ambition in between). Following the implementation of these scenarios, deforestation footprint reductions are substantial and increase with ambition. From the baseline of 162,240 ha, the EU's deforestation footprint that is associated with the seven focal commodities falls to 127,096 ha under low ambition implementation (a 21.7% reduction), 109,668 ha

1. Note that the footprint calculations provided in this analysis use a combination of DeDuCE data (Singh et al., 2024) and the EXIOBASE MRIO model (Stadler et al., 2021), which is not identical to the version of the hybrid-MRIO-based 'Input Output Trade Analysis' (IOTA) framework used in other Trase datasets that summarise global deforestation and links to trade and consumption. A simpler modelling framework is used here, given the requirement to modify the MRIO framework to provide scenario-results. As such, the absolute footprint values provided here should be considered a coarser approximation of the EU's footprint than data for the EU footprint provided by Trase elsewhere, and it is the extent of footprint reductions modelled in this analysis that provide the key insights.

2. Forest-LIFE is a deforestation-focused biodiversity impact indicator expressed in annualised species extinctions. It should be interpreted as a comparative measure of biodiversity pressure across commodities and scenarios, rather than as a count of observed extinctions.

3. For comparison, this exceeds the annualised species extinctions associated with the production of all agricultural crops, timber and cattle grown or reared within 18 EU Member States (Austria, Belgium, Denmark, Croatia, Cyprus, Czechia, Estonia, Finland, Hungary, Ireland, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Slovakia, Slovenia, Sweden), as estimated by the LIFE score and provided via the Global Environmental Impacts of Consumption indicator (SEI and JNCC, 2025).

under medium ambition (32.4% reduction), and 51,582 ha under high ambition (68.2% reduction). In other words, the modelled deforestation footprint reduction ranges from around one fifth under low ambition to around two thirds under high ambition. Under low, medium and high ambition implementation, overall emissions fall to 44,191,481 tCO_2e (25.6% reduction), 36,974,116 tCO_2e (37.8% reduction) and 19,416,277 tCO_2e (67.3% reduction), respectively, with Forest-LIFE scores falling to 0.240 (18.5% reduction), 0.211 (28.4% reduction) and 0.104 (64.8% reduction).

Policy levers beyond the EUDR and combined outcomes

The non-EUDR mechanisms modelled in this report are a central part of the scenario set, designed to test how far demand-side, production-side and trade-related measures could reduce the EU's footprint, both on their own and in combination with the EUDR. The policy levers explored (Table a provides a summary) are not exhaustive options, but instead illustrate realistic and, as applied under low, medium and high scenario-space, increasingly ambitious options for reducing the EU's footprint. Across levers, ambition levels reflect differences in the assumed scale and uptake of the measures: low ambition represents modest innovation or adoption, medium represents wider uptake, and high ambition reflects more transformative policy, technological development and scale-up. Demand-side measures explored in the analysis include those that reduce consumption of high-impact commodities and materials, such as dietary shifts away from beef and measures to reduce food waste (including food waste linked to animal feed). Supply-side examples include shifts in production and material use that reduce pressure on deforestation-linked supply chains. The border adjustment mechanisms explored include levies applied to imports that attach a carbon-related cost, with more ambitious variants extending this logic to costs linked to biodiversity impacts.

Table a. Summary of policies explored in this analysis, the focal commodities targeted/influenced by these policy areas, and example measures (which influence one or more commodities) and their ambition levels. The commodity-specific sections of the report should be referred to for further detail, including the full scope of measures explored and their ambition levels.

Policy area	Policy Description	Commodities affected	Measures
Sustainable Domestic Consump-tion (SDC)	Food waste reductions	Soy, beef, coffee, oil palm	Voluntary behavioural change to reduce consumer food waste (low ambition) Coffee serving size reductions (low ambition) and increased uptake of 'no capsule' pod-based technologies (medium ambition) Food waste diversion to animal feed (high ambition) Recycling waste for biofuel (high ambition)

Table continues onto next page

Policy area	Policy Description	Commodities affected	Measures
Sustainable Domestic Consump-tion (SDC) (continued)	Other waste reduction	rubber, timber	Prefabrication in construction (varying ambition) Retreading and devulcanisation of tyres (medium ambition)
	Dietary shifts	Soy, beef, cocoa	Reductions in beef consumption to healthy, sustainable diets (varying ambition) Snack food reduction (varying ambition)
	Biomass-based energy	Soy, beef, cocoa	Diversion of primary timber away from biomass energy (varying ambition)
Sustainable Domestic Production (SDP)	Sustainable commodity production within the EU	Soy, timber, beef, rubber	Expansion of soy into ex-pasture (varying ambition) Closing soy yield-gaps (high ambition) Lab grown beef (varying ambition) Market-driven growth towards enhanced forest management (low ambition) Expansion of agroforestry over degraded land and pasture (high ambition) Domestic production of guayule as a rubber alternative (varying ambition)
	Alternative products	Coffee, cocoa	Promotion and R&D into cocoa and coffee alternatives (varying ambition)
Border Adjustment Mechanism (BAM)	Carbon and biodiversity border adjustment mechanisms	Timber, oil palm, soy, beef	Timber as a substitute for steel (low ambition) Carbon-adjustment costs (medium ambition) Biodiversity-adjustment costs (high ambition)

Figure a summarises the headline cross-commodity results reported here. In isolation, combined low ambition non-EUDR levers reduce the EU deforestation footprint associated with the seven focal commodities to 151,436 ha (a 6.7% reduction), while medium ambition non-EUDR scenarios reduce it to 119,891 ha (26.1% reduction). Under high ambition non-EUDR combinations, the footprint falls to 97,613 ha (39.8% reduction). The most transformative reductions arise when non-EUDR levers are combined with the EUDR (see Figure a). Implementing low ambition EUDR (which - at the time of writing - is considered the most 'realistic' of our scenarios given the challenges that the EUDR has faced to date) on top of high ambition non-EUDR levers reduces the EU's deforestation footprint associated with the seven focal commodities to 64,845 ha (a 60.0% reduction). Implementing high ambition EUDR on top of high ambition non-EUDR levers reduces the footprint further to 23,849 ha (an 85.3% reduction; versus 51,582 ha, 68.2% reduction under the high ambition EUDR scenario applied in isolation). These results indicate that, while the EUDR can deliver large reductions, the largest and most resilient reductions arise when de-risking is combined with measures that reshape demand, production and incentives across the EU market.

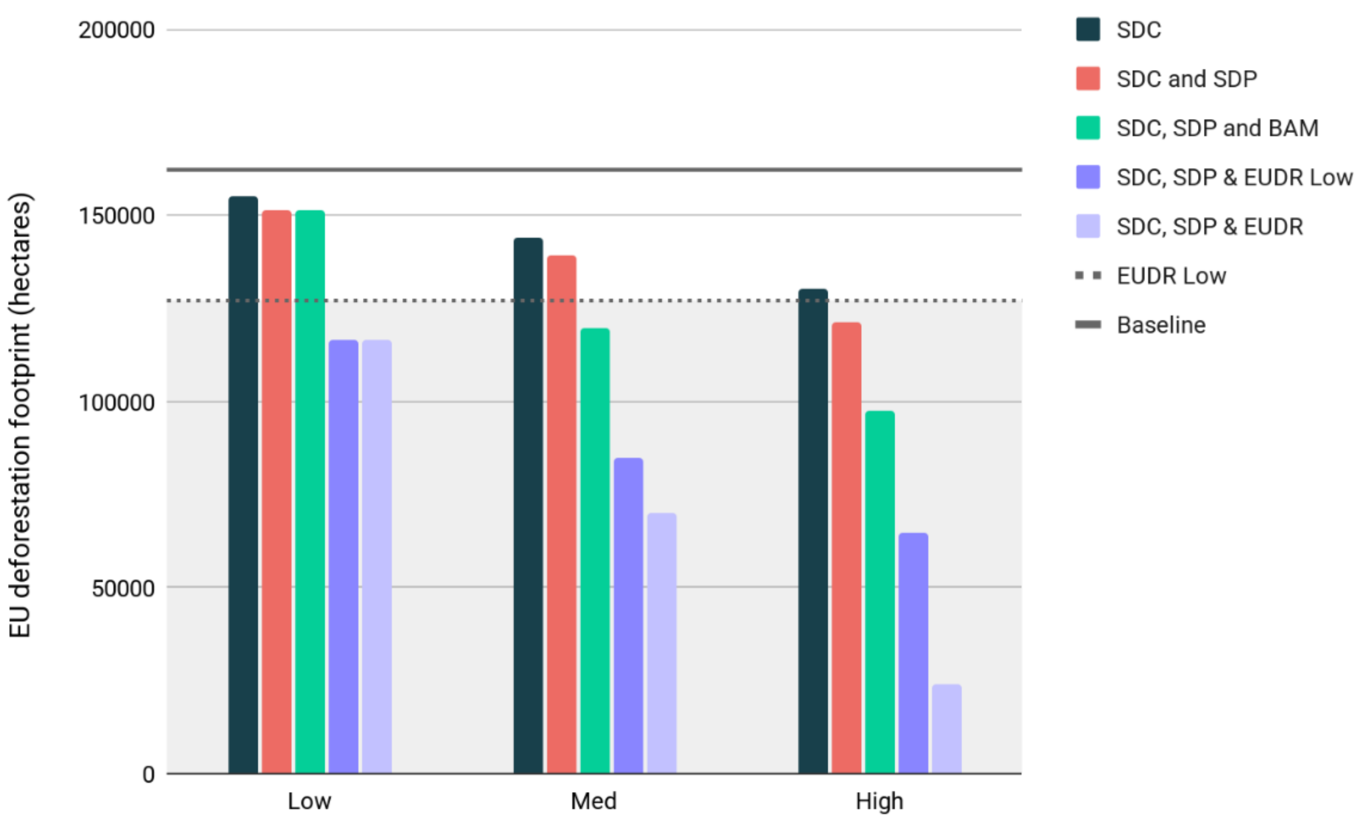

Figure a. The EU's deforestation footprint (across all in-scope commodities) for a combined set of policy levers covering the EUDR, sustainable consumption, sustainable production and border adjustment policies, as implemented in the scenario model. SDC = 'sustainable domestic consumption' levers which affect commodity demand; SDP = 'sustainable domestic production' measures that promote sustainable production of commodities/ products within Europe; BAM = 'border adjustment mechanisms'; EUDR = the EU Deforestation Regulation. The solid horizontal line shows the baseline footprint and the dashed horizontal line shows the total footprint under the EUDR low ambition scenario (across all commodities) when applied in isolation. For bars (with the exception of the bar including 'EUDR Low' where the EUDR is applied with low ambition), the level of ambition is stated on the x-axis, i.e. 'Med' = combinations of all levers with a medium level of policy ambition.

Differences across deforestation, emissions and biodiversity outcomes

While deforestation drives associated changes in emissions and biodiversity in this analysis, the results highlight important differences in how these footprints manifest. In the baseline, oil palm accounts for 12.6% of the deforestation footprint but 22.1% of emissions and 25.4% of biodiversity impacts. This underlines that relatively small deforestation reductions in biodiversity hotspots can have outsized effects on biodiversity footprints, and that targeting areas with the largest absolute decreases in deforestation does not necessarily align with regions where biodiversity is most vulnerable.

Implications and recommendations

Overall, these results demonstrate substantial potential for policy interventions to reduce the EU's footprint linked to the EUDR commodities. The EUDR can reduce the EU's exposure to deforestation through de-risking supply chains, but the scenario results indicate that the largest reductions arise via a combination of measures that reshape demand and production, and incentivise sustainable supply chains.

Four priority recommendations emerge from the analysis and associated discussion of the results (see the Discussion section of the main report). First, pursue effective implementation of the EUDR, including strengthening enforcement and compliance. Second, ramp up the non-EUDR measures explored in the scenarios (Table a), particularly those linked to circular economy approaches, including consumption shifts away from commodities that drive deforestation, improvements in sustainable product design and business model innovation, and reductions in demand through material efficiency and waste reduction. Third, build on the scenarios explored here by testing additional policy levers and exploring more targeted packages. This includes deepening analysis for Member States with large residual footprints, including interventions tailored to country-level consumption patterns (e.g. targeting the residual footprint linked to beef in Germany, France and Italy), sourcing profiles (e.g. targeting the outsized role of car manufacturing linked to rubber in Germany, or the residual cocoa footprints of the German and Dutch cocoa industries), and implementation constraints. Fourth, invest in knowledge transfer (in both directions) between consuming and producing regions to tackle deforestation, including building capacity, sharing best practices, and supporting implementation of zero-deforestation measures in producer-country landscapes where deforestation pressures are most acute.

Limitations and future work

This assessment is designed as a comparative baseline-versus-scenario exercise rather than a forecast. It translates exploratory policy interventions into modelled changes in consumption, sourcing and production patterns, but it does not capture all potential feedbacks, price effects, or interactions between policy levers. Future work could deepen the analysis through more targeted interventions, expand policy coverage within supply chains and across commodities, conduct sensitivity testing of key assumptions, and include complementary approaches that focus on reducing deforestation at source (including methods that consider the additional costs, resourcing requirements and implementation constraints that this would imply).

1. Background and introduction: The EU's role in agricultural-commodity linked forest and biodiversity loss

1.1. The state of the World's forests and biodiversity

Globally, forests are critical to planetary and human wellbeing, providing a vital resource in curtailing rising greenhouse gas emissions, offering a haven for biodiversity, and underpinning a wide variety of ecosystem services (Brockerhoff et al., 2017). Forest landscapes are estimated to absorb around 15.6 billion tonnes of carbon dioxide a year (Harris et al., 2021), have been estimated to support 80% of the world's terrestrial biodiversity, and provide livelihoods for an estimated 1.6 billion people worldwide (Gagen et al., 2023).

Yet forests - and other terrestrial landscapes of biodiversity importance such as woody habitats, native grasslands and wetlands - are in a state of chronic decline, with losses particularly prominent across Africa and South America (Salas, 2025). While forest loss has taken place over millennia, between 1990 and 2020 the world lost an estimated 178 million hectares (FAO and UNEP, 2020). Only 29% of forested area, estimated at 1.18 billion hectares, is classed as primary forest[4] (FAO, 2025) and according to the Planetary Boundaries framework, global reductions in forest area substantially exceed planetary limits (Richardson et al., 2023).

4. Primary forests are naturally regenerated forests of native tree species, where there are no clearly visible indications of human activities and ecological processes are not significantly disturbed.

Although rates of forest loss have declined recently, with net loss of forest area decreasing from 7.8 million hectares per year in the 1990s to 4.7 million hectares per year during 2010-2020, much of this loss has taken place in tropical regions where an estimated 60% of all vascular plants are found (FAO and UNEP, 2020). According to the latest assessment of the world's biodiversity - undertaken in the form of WWF's Living Planet Report - species continue to decline with little sign of abatement, with the average size of monitored populations shrinking by 73% over the past 50 years (WWF, 2024). At a regional level, the fastest declines have been seen in Latin America and the Caribbean, with average population sizes falling by 95% since 1970. These regions are also known to be facing among the highest rates of deforestation (Curtis et al., 2018; Hansen et al., 2013).

Key drivers of forest loss include fires, expansion of infrastructure, forest plantations, and agriculture (Curtis et al., 2018). While plantation forestry and fires are primary drivers in temperate and boreal regions, forest loss in these regions may be temporary. In the tropics, it is primarily agricultural production - including commodity crops and pastures - which is the dominant driver of forest loss, and leading to permanent reductions, i.e. deforestation. Globally, estimates of agricultural-linked deforestation across the tropics range from approximately 6.4 to 8.8 million hectares per year from 2011-2015 (Pendrill et al., 2022), although not all of this results in productive agricultural use due to factors such as land speculation.

1.2. High risk agricultural commodities

There is international recognition of these threats to forests and biodiversity. The Sustainable Development Goals include Goal 15 (Life on Land) to 'Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss'. Goal 12 (Responsible Consumption and Production) commits to the sustainable management and efficient use of natural resources, recognising the explicit link between consumption activities and environmental harms. The recently adopted Kunming-Montreal Global Biodiversity Framework commits (Target 16) to 'Enable sustainable consumption choices to reduce waste and overconsumption' (CBD, 2025).

In 2018, the European Commission published an initiative to 'step up' action on deforestation (European Commission, 2019) that was followed in 2021 by a proposal (and accompanying impact assessment) for a regulation on deforestation-free products (European Commission, 2025a, 2021a). These proposals - following negotiations to finalise their scope - were adopted as the EU's Deforestation Regulation (EUDR) in mid-2023 (European Union, 2023). The EUDR requires companies (those placing relevant commodities and products on, or exporting them from, the EU market) to provide geolocated information on product origin and accompanying due diligence statements which evidence that the product is not associated with illegal activity or deforestation after a December 2020 cut-off date. Originally, implementation of the EUDR was due on the 30th December 2024, but it has now been pushed back to 30th December 2026 (and to 30th June 2027 for small and micro operators), with a review also taking place by April 2026 seeking to assess the potential for further simplification (European Union, 2025a).

While different methods provide contrasting results when it comes to the absolute quantity of deforestation which is attributed to agricultural production and consumption (Pendrill et al., 2022; West et al., 2025), consensus emerges around the fact that a relatively small group of high-risk agricultural commodities are the dominant drivers, with permanent agriculture accounting for around 95% of total deforestation globally, according to estimates from Global Forest Watch (Global Forest Watch, 2025a). According to the DeDuCE dataset (Singh et al., 2024), between 2018 and 2022 pasture expansion for cattle production was the leading cause of agriculture-linked deforestation, accounting for 11.8 million hectares (40.6%) of the 29.1 million hectares across all agricultural commodity drivers. Other major global contributors include forest plantations used for timber (3.7m ha), oil palm (2.1m ha), rubber (1.4m ha), maize (1.3m ha), cassava (1.2m ha), soy (1.0m ha), rice (1.0m ha), cocoa (0.7m ha), and coffee (0.5m ha). Together, cattle, soy, oil palm, timber, rubber, coffee, and cocoa - the focal commodities regulated under the EUDR, which were selected on the basis of the EU's particular exposure to these commodities (European Union, 2021)[5] - accounted for 72% of the 5.1 million hectares of deforestation attributed to agricultural commodities in 2022. Hotspots of deforestation include Brazil for soy and beef, Indonesia for oil palm, and Côte d'Ivoire for cocoa. While some of this production is consumed domestically, a significant amount is also destined for international markets which act as a key driver for agricultural expansion (Meyfroidt et al., 2013). Global consumption activities linked to these materials continue to grow (UNEP, 2025), with production of all of the highest-deforestation risk commodities continuing to expand over time both to meet the demands of established high-income economies such as Europe and the US, but also growing economies such as those in China, South East Asia, Latin America and the Middle East. In sum, consumption - if it continues unabated via unsustainable production practices - will rapidly diminish remaining forests, and other natural habitats.

5. For example, whilst being associated with relatively high deforestation globally, cassava is not a key import into the EU.

1.3. Reducing the EU's consumption impacts

EU or Member State policy decisions linked to the EU's trade and consumption activities have the potential to substantially influence its exposure to deforestation (and associated emissions and biodiversity loss). While the EUDR regulates against European deforestation exposure, it needs to work via interplay with a large set of other EU policies, and it has been subject to intense political pressure that, along with implementation challenges, has resulted in its delay. The eventual implementation of the EUDR itself is also unlikely to be straightforward, with evidence from the EU Timber Regulation (which the EUDR replaces) suggesting that its relative success rests with the degree to which it is supported and - ultimately - enforced (Trinomics, 2021). Successful implementation will rely on companies being incentivised to take action - which in part relies on the resourcing of Competent Authorities as enforcers of the policy - and on the provision of adequate supply chain data and intelligence that will determine the degree to which due diligence can be carried out successfully. If implemented effectively, it can serve to reduce exposure of the EU's trade to deforestation activities, but this should not be taken for granted.

At the same time, European consumers are experiencing a cost of living crisis, with prices for food and other materials (having increased markedly via inflationary pressures during- and post-Covid, that significantly reduced consumer financial health (European Insurance and Occupational Pensions Authority, 2023) having again seen relatively recent rises. World cocoa prices increased to over $10,000 per tonne in 2025 compared to around $2,200 per tonne in early 2022 (Trading Economics, 2025a). Whilst not as dramatic, coffee prices recently rose to over $420 per tonne (compared to $220 per tonne in early 2022, and around $100 per tonne in early 2020) (Trading Economics, 2025b). And while down from their peak in early 2022 of $7,000 per tonne, palm oil prices remain much higher (at over $4,000 per tonne) than when they were trading at $2,000 per tonne in 2020 (Trading Economics, 2025c). High prices continue to put strain on the finances of European consumers, drawing into question whether more should, and could, be done to seek alternative products, shift consumption patterns, or reduce levels of consumption to levels which are financially, as well as environmentally, sustainable. Going forward, geopolitical uncertainties and the threat of future climate change raise the potential for price-pressures to get more - not less - pressing for consumers throughout Europe.

Ultimately, the EU's role in global deforestation is both a result of the deforestation intensity associated with the production of agricultural commodities, and the overall demand for these commodities by the EU market. The 'load' that the EU economy places on international production systems, and by extension the environment, needs attention in addition to the acute environmental concerns that arise at points of production. Within this context, many strategies and policies have the potential to influence and interact with the demand for the agricultural materials on which the EU economy depends, their sustainability credentials and, consequently, their environmental impact. Examples include those under the 'European Green Deal' which sets out a new growth model for Europe based on a clean and circular economy (European Commission, 2025b), with the associated Green Deal Industrial Plan (European Commission, 2023) seeking to scale up net-zero technologies and products. At the regional level, the EU's 2015 'Circular Economy Action Plan' (CEAP) mapped out 54 actions, and has been recognised as positioning the EU as a front runner in circular economy policy (Ellen MacArthur Foundation, 2022). A second action plan for the EU (European Commission, 2020a) was adopted in 2020 with 35 associated actions and the aim to make sustainable products 'the norm' in the EU and to empower consumers and buyers. It focuses on sectors where the potential for circularity is high which includes - amongst others - vehicles, construction and food. Building on these policies, the second von der Leyen Commission has seen the publication of a Clean Industrial Deal (European Commission, 2025c), where the circular economy is an important pillar, including through the yet-to-be-published Circular Economy Act.

At national scale, all but a handful of Member States have developed, or are in the process of developing, strategies and roadmaps related to the circular economy. As a follow-up to the 2016 Finnish circular economy roadmap, the 'Strategic programme to promote a circular economy' sets an absolute resource target for 2035, a target which includes renewable natural resources such as biomass (Ministry of the Environment, 2024). The Netherlands National Circular Economy Programme (Government of the Netherlands, 2023) lays out the need for product lifespan extension, reduction and substitution of raw materials, and promotion of recycling and re-use across key industries. Besides Finland and the Netherlands, Austria and Germany have also introduced absolute resource targets.

Beyond demand, there is also potential to explore whether Europe's own production systems can reduce net environmental impacts whilst increasing resilience and reducing dependencies of European supply chains that might be subject to higher risk. For example, more sustainable agricultural production systems in Europe can play their part in reducing the EU's footprint, particularly if products that were produced overseas with high impact can be substituted for products produced in Europe which fulfil the same requirements[6]. The EU's Farm to Fork Strategy (European Commission, 2020b), for example, seeks to accelerate the provision of food which has a neutral - or even positive - biodiversity impact whilst ensuring food is secure, nutritious and affordable. It also recognises that transition will not happen without a shift in consumer diets. The EU's biodiversity strategy for 2030 contains targets for agricultural land to transition to high-diversity and agro-ecological practices and to increase forest quantity and health (European Commission, 2025d, 2020c). The reformed EU Common Agricultural Policy also has clear environmental goals (European Commission, 2022a), including the provision of 'eco-schemes' for the adoption of sustainable practices, standards for maintaining biodiversity, protections for high nature-value farmland, and investments for technological and knowledge transfer. The implementation of a new Bioeconomy Strategy for the EU also sets out to boost innovation and support to companies to promote the circular and sustainable production and consumption of biomass resources, including strengthening the role of primary producers (European Commission, 2025e).

6. Notwithstanding the concurrent requirement overall to adjust consumer demand to also put this on a more sustainable footing. Transitions to sustainable production in Europe also need to consider producers overseas who may have established livelihoods based on access to EU markets.

In summary, whilst the EUDR is one policy lever available to Europe, a wider variety of policy-linked frameworks and strategies provide a broader and more holistic suite of activities that can influence the deforestation and biodiversity footprints of a future EU economy. It is from this framing that the analysis developed for this project departs; considering - and quantifying via an exploratory scenario exercise - the degree to which circular economy, sustainable production and other policy levers can serve to reduce the EU's deforestation and biodiversity footprint. We develop a series of viable policy leverage options that may - both in their own right and when combined with the EUDR - support these objectives. We combine these options to illustrate the breadth of existing policy space via which the EU might take relevant action to reduce the impacts associated with focal commodities of soy, cattle, oil palm, cocoa, coffee, timber and rubber. These policy levers include options which go some way beyond the existing discourse, or look toward emerging - but still viable - technological scale-up.

2. Baselining the EU's impact

2.1. General model structure and implementation

This study explores the potential impacts of a variety of demand-side policy changes that the EU could implement to reduce its global environmental footprint, specifically regarding deforestation (and associated carbon emissions) and biodiversity loss. The focus is on the EUDR's key commodities, which are central to the EU's environmental agenda and have a significant role in the EU's overall footprint.

Our investigation into potential policy leverage points is broad, drawing inspiration from recent initiatives to enhance the sustainability of the EU economy, such as the EUDR and circular and bioeconomy efforts. Our approach aims to 'stretch' current policy by advancing measures to drive sustainable product design and business model innovation, promote consumer behaviour changes, introduce progressive environmental legislation, invest in alternative technologies and product lines, and shift sourcing practices to reduce environmental harm.

At the same time, we focus on 'realistic' leverage points - opportunities for near-term implementation that build on existing activities with increased ambition - rather than requiring entirely new economic models or untested technologies. The results of this study should be seen as viable pathways for reducing the EU's environmental impact in the short term. The interventions we developed, parameterised, and modelled are not exhaustive but offer a range of options particularly relevant to reducing the impact of key commodities.

To capture the impact of policy interventions, we base our assessment on a modelling framework that uses an extended multi-regional input-output (MRIO) structure (see Annex A for further details). This allows us to target our interventions - in the form of 'levers' of change - on aspects of final consumption behaviour, on changes in the use of materials by industry, or changes in sourcing behaviors and associated production-impact intensities; all of which are amenable to modification within the model. An MRIO framework also allows us to explore both the 'direct' impacts on target supply chains and the 'indirect' effects that arise from global economic interconnections.

Our model outputs include estimates of the deforestation footprint, carbon emissions linked to deforestation, and biodiversity impact scores associated with the production of commodities in-scope of the EUDR, which are all attributable to the countries or regions of consumption. For deforestation, we used estimates derived from the DeDuCE dataset (Singh et al., 2024; Singh and Persson, 2024); a global dataset which estimates the deforestation connected to agricultural and timber-plantation production and associated land conversion. Deforestation emissions estimates are also available from this resource. For biodiversity, we employ the 'Land-cover change Impacts on Future Extinctions' (LIFE) metric (Eyres et al., 2025), which focuses on changes to the likelihood of species extinctions associated with land use change. Here, we have developed, and applied, a version of this score which estimates biodiversity impacts as a result of deforestation, which we term the 'Forest-LIFE' score.

2.2. Baselining the EU's deforestation, emissions and biodiversity footprint

In order to quantify estimates of the effect of policy change on the EU's deforestation and associated biodiversity-impact footprint, we first need a baseline to work from. This baseline represents the close-to-current estimate of the EU's (and its Member States') global impact associated with the consumption of commodities linked to deforestation. Our baseline estimate is derived from the deforestation (and associated emissions and biodiversity loss) associated with the agricultural production activities that are linked to the EU economy in 2022[7]. Deforestation estimates (derived from the DeDuCE dataset) are provided in terms of the average deforestation occurring over a preceding five year period before the year of commodity production (2022), amortised over this period[8]. The resultant account represents the 'current' footprint of the EU from which our scenarios can be compared. The scenarios themselves, that are compared to this baseline, are not projections over a timebound period. In other words, they represent a 'before versus after' account of the relative impact of different policy measures[9].

Our baseline uses a model of the global economy for 2022. According to this model, the EU27 has a total deforestation footprint across our seven focal commodities of 162,240 ha, associated deforestation emissions of 59,417,088 tCO2e, and a biodiversity (Forest-LIFE) impact of 0.2946 annualised species-extinctions.

The EU's deforestation footprint is dominated by cattle, which comprises ~48.0% of the total. Cocoa, oil palm and timber have comparative footprints at 12-13% of the total, followed by soy (~6.0%), rubber (~5.1%) and coffee (~3.7%). Germany has the highest absolute deforestation footprint of any of the EU Member States for all commodities, with ~23.4% of the EU total. France has the second highest footprint overall, but this is not always the case on a commodity-basis; for example, Italy has the second highest footprint for cattle, rubber, and coffee, the Netherlands for cocoa, and Spain for oil palm. These five countries account for ~70% of the total EU footprint. Five other countries (Bulgaria, Lithuania, Croatia, Malta and Cyprus) account for ~1% of the EU27's total footprint (Table 1). Belgium, Netherlands, Ireland and Luxembourg footprints are substantially higher than the EU average on a per-capita basis, with Luxembourg, Latvia and Belgium having high footprints on a per-GDP basis. This serves to illustrate that whilst some Member States dominate the EU's absolute footprint, other countries have an outsize footprint when considered on the basis of relative population or economic size. This has potential implications for the perceived 'fairness' of potential measures that could be introduced to reduce the footprint across the EU[10].

7. Baseline data is derived from a model using EXIOBASE v3.8.2 for the year 2022. To enable scenario modelling, this study employs a simplified framework (using DeDuCE and EXIOBASE) that is distinct from consumption-based modelling used previously by Trase. Consequently, absolute values are coarser approximations, and the analysis's primary value lies in the modelled trends and footprint reductions.

8. i.e. it is not the deforestation taking place in 2022, but rather an average of the deforestation taking place in the preceding 5 year period that can be reasonably linked to 2022 production. This is in recognition of the fact that the clearance of land historically can be used for production for many years.

9. This also means that the modelled scenarios do not account, for example, for exogenous changes in economic structure that might take place between the baseline and the eventual implementation of those policy levers in practice.

10. For example, if behavioural-change levers or regulatory measures are focused just towards those states with the highest absolute footprints then citizens and companies are likely to question whether they are being treated in a comparable way to actors in other EU Member States.

Table 1. The deforestation footprint of the EU27 Member States for each focal commodity, arranged in order of their total footprints. The main heat-map is derived from contributions of all commodities. Heatmaps per capita and per billion € are also individually derived.

Member State	Cattle	Cocoa	Oil Palm	Timber	Soy	Rubber	Coffee	Total	Ha per 10,000 people	Ha per billion € (GDP)
Germany	17,906	5,046	4,401	4,228	2,114	2,466	1,785	37,947	4.6	9.6
France	10,501	2,896	2,173	2,664	1,347	917	626	21,124	3.1	8.0
Italy	11,343	1,754	2,341	1,845	1,208	970	652	20,112	3.4	10.1
Spain	9,123	1,744	2,634	2,258	1,097	964	565	18,385	3.9	13.4
Netherlands	7,976	3,377	1,614	1,553	787	632	564	16,503	9.4	16.6
Belgium	3,963	2,038	1,819	999	643	616	597	10,676	9.2	18.9
Poland	1,807	791	1,284	827	436	426	233	5,805	1.6	8.8
Ireland	2,001	221	553	1,973	286	82	72	5,188	10.1	10.0
Sweden	2,473	335	501	582	179	123	152	4,345	4.2	7.9
Austria	1,421	229	300	290	191	87	54	2,572	2.9	5.7
Portugal	1,346	186	246	258	174	100	60	2,371	2.3	9.7
Finland	1,399	198	161	223	81	97	110	2,270	4.1	8.5
Czech Republic	1,269	161	238	225	123	129	62	2,208	2.1	7.7
Denmark	1,000	140	328	284	177	71	51	2,050	3.5	5.4
Luxembourg	680	370	413	98	103	113	102	1,880	29.1	24.5
Greece	813	133	377	199	234	70	50	1,876	1.8	9.0
Romania	510	137	151	196	134	98	46	1,272	0.7	4.5
Hungary	543	112	163	180	83	128	44	1,252	1.3	7.4
Slovakia	443	111	84	86	48	96	33	901	1.7	8.2
Latvia	113	29	241	378	21	25	10	818	4.4	22.7
Slovenia	292	64	71	55	70	31	17	601	2.9	10.6
Estonia	219	181	46	26	16	21	21	530	4.0	14.5
Bulgaria	228	74	67	49	34	46	20	516	0.8	6.0
Lithuania	199	65	71	39	26	16	12	428	1.5	6.3
Croatia	223	42	50	34	50	15	9	422	1.1	6.2
Malta	78	10	14	8	8	3	2	124	2.4	6.8
Cyprus	36	3	12	5	4	3	1	64	0.7	2.2
Total	77,905	20,447	20,353	19,565	9,673	8,347	5,950	162,240	3.6	10.1

Key deforestation hotspots (Table 2) from an EU27 perspective include Brazil which - as an origin for the EU's consumption footprint - accounts for ~18.8% of the total (and ~31.7% of the cattle and ~42.5% of the soy) footprint. China is the second largest footprint origin, principally associated with timber production where it accounts for 55.8% of the EU's total timber footprint. Indonesia is the third largest footprint origin, accounting for 5.6% of the EU total, primarily associated with oil palm production where it accounts for 42.7% of the EU's total oil palm footprint. Côte d'Ivoire is the origin of the largest component of the EU27 cocoa footprint (30.1%), Cambodia is the origin of the largest component of the rubber footprint (37.4%), and Peru is the origin of the largest component of the coffee footprint (28.7%). Collectively, the top 15 origin countries (Table 2) comprise 72.0% of the total EU27 deforestation footprint associated with the EUDR commodities.

Table 2. The EU27's deforestation footprint according to producer country (Top 15 origins, overall, shown plus 'other' aggregated countries). Heatmaps are generated on a per-commodity basis.

Country	Cattle	Cocoa	Oil Palm	Timber	Soy	Rubber	Coffee	Total
Brazil	24,671	79	17	1,176	4,113	76	424	30,555
China	52	-	0	10,910	-	2	-	10,964
Indonesia	8	-	8,688	85	191	118	19	9,110
Paraguay	6,747	-	2	27	538	-	0	7,314
Ghana	1,634	4,991	27	0	123	276	-	7,050
Malaysia	334	0	6,386	-	-	1	-	6,722
Bolivia	4,714	1	-	-	1,850	-	14	6,579
Côte d'Ivoire	-	6,156	120	-	0	281	-	6,556
Colombia	3,218	1,739	452	19	135	601	41	6,205
Viet Nam	713	52	-	948	4	2,174	1,375	5,266
Peru	1,108	923	1,297	3	4	-	1,709	5,045
Cambodia	159	-	559	344	291	3,124	0	4,476
Nigeria	3,312	248	254	-	357	1	-	4,172
Democratic Republic of the Congo	2,663	351	195	5	51	0	92	3,357
Argentina	2,622	-	-	105	706	-	-	3,434
Others	25,948	5,908	2,358	5,943	1,310	1,693	2,276	45,436
Total	**77,905**	**20,447**	**20,353**	**19,565**	**9,673**	**8,347**	**5,950**	**162,240**

Given that deforestation ultimately drives associated emissions, emissions footprints are - expectedly - closely correlated with the deforestation baseline (see Annex B). A notable exception is the role that timber plantations play (according to the underpinning DeDuCE dataset used, which provides net rather than gross emissions) in acting as a carbon sink, even if associated with deforestation. Rubber is also recorded as a carbon sink according to the DeDuCE data in some countries (e.g. Cambodia)[11]. There are some other notable differences, including the relatively more prominent role that oil palm plays to emissions compared to the area of total deforestation, contributing 22.1% to the overall emissions footprint (compared to 12.6% for deforestation) due to its particular association with deforestation occurring on peatland. Within the emissions baseline, Italy also moves to second and Spain to third in the EU-rankings, behind

11. The presence of negative emissions linked to deforestation reflects the fact that natural forest may be replaced with fast-growing tree plantations. Whilst in some cases in our analysis the aggregate effect of this is that a reduction in deforestation appears to result in higher emissions, it is important to note that this effect will be inconsistent across producing regions with some areas acting as sinks and others as sources and with real-world emissions highly dependent on the nature of landscape management which falls outside of the scope of what the DeDuCE dataset can account for.

Germany which remains as the highest-footprint Member State; with France falling from second to fourth position (due to its lower cattle footprint in comparison to Italy, and lower palm oil footprint in comparison to Italy and Spain).

Biodiversity impact measures indicate that oil palm has a relatively outsized biodiversity impact, in comparison to contributions to the EU's deforestation footprint (see Annex B). Oil palm contributes 25.4% of the biodiversity footprint, compared to 12.6% for deforestation. Coffee also has a more prominent contribution to the biodiversity footprint (10.4%) compared to its contribution to the deforestation footprint (3.7%). The order of the top nine EU countries is retained across deforestation and biodiversity footprints.

3. The impact of the EUDR

3.1. Modelling the EUDR's impact to the EU footprint

The European Union's Deforestation Regulation (EUDR) represents a significant intervention by the EU in its broader efforts to combat global deforestation. It was adopted in 2023, building on earlier initiatives but introducing mandatory obligations on the supply chain in recognition that prior, voluntary, arrangements had had limited success.

The EUDR has received broad support from polled members of the public (FERN, 2024a), NGOs (Together 4 Forests, 2024) and many businesses (Business & Human Rights Resource Centre, 2024) but has also experienced significant pushback, especially as the original implementation date of December 2024 approached, and subsequently. In the run up to the original implementation date, the lack of a finalised risk benchmarking system was used as justification for political interventions that - ratified by the European Commission - led to a delay in implementation to a date of the 31st December 2025, and then to the end of 2026. Since then, the risk benchmarking results have been published, but the EUDR remains under significant political pressure (Southey, 2025).

When it is implemented, the EUDR will legislate that companies that place relevant products on - or export them from - the EU market, must do so in accordance with certain criteria. This includes the provision of the geolocation of production (to allow for screening against recent deforestation). It also includes - for countries specified as having 'standard' or 'high' risk - provision of evidence that 'due diligence' has been conducted to ensure that production is not associated with any deforestation[12] activity taking place after a 31st December 2020 cut-off date, or illegality.

12. Or also forest degradation for timber products.

The EUDR is an interesting case in the context of the broader analysis conducted across the scenarios explored within this study as it represents a very 'direct' mechanism to reduce the deforestation exposure of imported commodities. It is designed to ensure that EU supply chains - specifically - are not associated with deforestation while not explicitly targeting a change in the dependencies that exist in the EU economy on in-scope commodities. In other words, the policy focuses on 'de-risking' supply chains without inherently restructuring them, although a degree of re-structuring of supply (e.g. to ensure materials reaching EU markets is segregated and traceable to plot level) is likely. Furthermore, the EU's own assessments, and - more latterly - more detailed assessments by Profundo (Rijk and Kuepper, 2024) - have suggested that the costs of implementation will have only marginal impact on the costs of products, meaning that demand-changes from an aggregated consumption viewpoint are unlikely.

To represent the impact of the EUDR within our scenario framework, we therefore model such 'de-risking', by modifying the deforestation impact per tonne of commodities linked to the EU. This modification is based on a defined set of parameters, which are informed by the commodity-specific deforestation risk of origins and the potential efficacy of enforcement processes. Enforcement will ultimately incentivise corporate compliance through the development of robust due diligence processes, which if successfully implemented, should demonstrably uncouple EU supply chains from deforestation. Our de-risking does not impose changes to supply chain structure at national scales. Instead it assumes that supply can be maintained from countries of existing production by sourcing deforestation-free materials[13].

13. This may imply shifting sourcing within a country to avoid deforestation, but this is not explicitly modelled and the potential for onward leakage effects or other dynamics are not explored in the scope of this study.

The question then emerges of how effective the policy might be - when implemented - against its ultimate objectives? Evidence from the review of the European Timber Regulation (EUTR) - that the EUDR supplants and extends - suggests that its success has been limited and that, overall, the level of enforcement has not been sufficient to incentivise compliance (Trinomics, 2021). While designed to be more robust, the EUDR is also currently at risk of being 'simplified', with a review to "evaluate the administrative burden and impact" of the Regulation and "indicate possible ways to address the identified issues" (European Union, 2025a), with fears that this could weaken its implementation. Overall, then, there is currently no guarantee of strong implementation, and - until eventual monitoring of the EUDR's impact suggests otherwise - it is realistic to suggest that its enforcement may suffer from shortcomings, especially early in implementation.

On the other hand, if successfully implemented and enforced, then the EUDR may offer a model for others to follow, with the potential to send clear market signals to countries who are key-exporters to the EU that sustainable production practices provide continued access to markets (Grabbe and Moffat, 2024). As such, the EUDR may incentivise broader action - beyond the EU's supply chain alone - towards deforestation-free production.

Here, we incorporate both outlooks; a less ambitious and more ambitious implementation scenario, in addition to a 'middle ground' case. As a directly-targeted policy measure focused on removing deforestation from EU supply chains, well-implemented EUDR could have a substantial impact on the EU's deforestation exposure. Efforts towards successful implementation - including improvements and extensions following periodic review of progress - remain an important tool in the EU's toolbox for reducing its deforestation footprint. On the other hand, the EUDR remains far from the only tool at the EU's disposal and - in a situation where the implementation of the EUDR remains under threat or is poorly enforced - considering how other options may take up the slack, and lead to more systemic change to the EU's consumption and its associated impacts, remains critical.

3.2. Implementation of EUDR scenarios

Under Article 16 Paragraph 3 of the EUDR regulations, Competent Authorities have to establish a 'risk-based' approach to carry out checks that - paying special attention to countries classified by the EU as high risk in their benchmarking exercise (European Commission, 2025f) - takes into account a variety of factors including the commodities and products involved, the complexity and length of supply chains and processing stages, whether plots of land are adjacent to forests, geolocation disclosure information, company risk assessments or assessments via the EU's information system (European Commission, 2025g). Additionally, checks "may be supported by other relevant sources such as monitoring data, risk profiles from international organisations, substantiated concerns submitted under Article 31, or the conclusions of Commission expert group meetings". Based on this, while far from exhaustive, determinants of EUDR implementation and enforcement success may therefore include:

The scope of products: The existing regulation covers a specific product list, classified by their Harmonised System (HS) codes and linked to soy, oil palm, cattle, timber, rubber, cocoa and coffee production systems. There are trade-offs at play linked to product scope: more highly processed products likely contain less material per unit of target-product sold, they have potentially more indirect supply chains, and they have a greater chance of being formulated alongside out-of-scope commodities. All such factors have the potential to complicate monitoring and enforcement. The product-scope therefore determines both the ease with which companies may demonstrate compliance and the ease with which Competent Authorities are able to undertake and act upon checks.

The resourcing available to Competent Authorities: Companies will be incentivised to undertake more extensive due diligence (with resultant decreases in the risk of non-compliance) if enforcement processes are robust. This includes aspects such as the number of checks taking place, the detail with which these checks take place, the manner in which any 'substantiated concerns' from third parties are responded to, and - ultimately - the application of penalties or sanctions. The Fitness Check for the EUTR unveiled varying approaches to enforcement (e.g. with some carrying out more checks than others), and varying reported-numbers of staff available in Competent Authorities. In October 2024, just a couple of months before the original EUDR implementation date, several Member States had not specified their Competent Authorities.

The volume of imported materials being handled by Member States: The primary sources of deforestation risk currently associated with the EU's economic activity originate from overseas. Across Europe, particular Member States (such as the Netherlands) act as major importing hubs for in-scope products. As such, these countries are likely to be a particular focus for attention by civil society. In addition, many of these countries have been actively involved in voluntary zero-deforestation commitments which pre-date the regulation such as the Amsterdam Declaration Partnership (Partnerships For Forests, 2021) and - by association - major companies and government bodies in these countries are likely to have already undertaken activities which cross-cut several commodities (e.g. linked to traceability in supply chains) that may benefit compliance and enforcement.

Risk benchmarking: Competent Authorities must undertake a greater volume of checks on products produced in countries deemed of higher risk by the Commission. Therefore, enforcement is weighted towards those areas with highest risk, leaving more opportunity for non-compliance in lower-risk areas. The EU's official 'risk benchmarking' has been eagerly awaited as it outlines which countries of origin should be treated as 'of higher risk', with companies only required to undertake simplified due diligence for their sourcing from low-risk areas (although still having to provide geolocations of sourcing origin). The eventual publication of the benchmarked list of countries (European Commission, 2025f) has led to some surprise, however, with only countries in breach of UN Security Council or EU Council sanctions designated as high risk, which is not necessarily a close reflection of key sources of deforestation linked to focal commodities. Countries such as China and Papua New Guinea, known to be producing deforestation-risk materials and with notable deforestation activities (Global Forest Watch, 2025b), have been classified as low risk. However, as above, Competent Authorities also have the ability to tailor checks and enforcement within their risk-based approaches based on sources of information that extend beyond the EU's benchmarking.

Spillover effects: Where Europe represents a relatively small market-share in countries of production, there will still be a plentiful market for material which may not be subject to deforestation-free regulation. In such cases, supply which is not linked to habitat destruction could be directed to Europe whilst production for other markets continues to result in deforestation (Global Canopy, 2024; Mongabay, 2025). Whilst Europe's share of global commodity markets is trending downwards, in cases where Europe continues to occupy a large market share of a country's production such bifurcation is arguably less likely. In such cases, access to the EU market is relatively more important to producers as a source of income (and access to other markets may be harder) (Grabbe and Moffat, 2024) and development-linked efforts by Europe on deforestation-free landscapes may be more likely in places where economic-ties are stronger.

The considerations above are used as the basis for our EUDR scenario parameterisation[14]. Here, we determine:

1. For each Member State, an overall enforcement strength which takes into account a) the share of total imports of EUDR commodities that the Member State is associated

14. In our scenario design we do not attempt to explicitly account for the prior existence of the EU's Timber Regulation which - for timber products - will be replaced by the EUDR. In essence, we assume that the current EU baseline already includes any effects of the EUTR, and that the addition of measures under the EUDR will act on top of this baseline. In reality, some enforcement resources previously devoted to EUTR will be incorporated into EUDR implementation.

15. If Member States handle more imports then their enforcement strength is weighted higher and vice versa.

with[15]; b) checks per value of imported timber and potential Competent Authority staffing levels, both as reported by the EUTR Fitness check; c) whether or not the Member State had a designated Competent Authority for the EUDR in October 2024.

2. A geographic consideration, where countries of production are classified - on a commodity-specific basis - as high, medium or low risk. Here, we use the producer country's share of 2018-2022 deforestation per commodity to determine risk. For example, Brazil is associated with 59% of global 2018-2022 soy deforestation and is therefore classified as high risk. Additionally, where a country is classified as 'low risk' in the EU's official benchmarking classification, we classify this country as low even if deforestation statistics suggest it should be classified as medium or high risk. This reflects the fact that - even if deforestation risk is deemed high - companies will not need to submit risk assessments for these countries.

3. The product scope, that determines the sectors in the model that are associated with deforestation-risk reductions (i.e. if those which are associated with more highly processed materials are in scope or not).

4. The potential for spillover effects from the policy which is determined by the EU's market share in places of production[16] and - when applied - has the effect of de-risking all production from that producer country.

Precise implementation then depends on the scenario's ambition level:

For **low ambition** implementation of the EUDR, we assume that the Member States with the worst enforcement strengths are only 20% effective at de-risking[17] supply chains, compared with up to 80% effective for those with higher enforcement strengths. Furthermore, in terms of geographic focus, those with lower enforcement strengths only influence (i.e. de-risk) supply chains associated with 'high risk' origins, whereas those with higher enforcement strengths influence deforestation risk in both high and medium risk origins. Under the low ambition scenario, de-risking of supply chains is also applied only to sectors associated with product scopes that are more directly associated with the focal commodity[18].

For the **medium ambition** implementation, we assume that all Member States have fully-operational enforcement (i.e. are 100% effective at de-risking supply chains) linked to both high and medium risk origins. De-risking of supply chains is still applied only to sectors associated with more direct use of focal commodities.

For the **high ambition** implementation, we assume that even low risk origins are subject to de-risking (at 100% as before), with additional sectors likely to be associated with the handling of derived or embedded commodity-linked materials also brought into the product scope[19]. Furthermore, for countries of origin with a large EU-market share, we assume a spillover effect with all global supply from that country being de-risked[20].

17. Here 'de-risking' means that deforestation associated with the specific supply-chain flow is scaled down from the baseline by the defined percentage.

18. For example, for soy in the low ambition scenario, de-risking of imports occurs for sector purchases covering "Cultivation of oil seeds", "Processing vegetable oils and fats", "Processing of Food products nec" but not "Cattle farming", "Poultry farming" and other downstream sectors that may be linked to soy.

19. For example, for soy, this includes "Cattle farming", "Poultry farming", and "Processing of meat cattle" and so on.

20. This means that any supply chains sourcing from this country will no longer be associated with deforestation in the model.

3.3. EUDR scenario results

From the baseline of 162,240 ha, implementation of the EUDR scenarios results in deforestation footprints of 127,096 ha, 109,668 ha and 51,582 ha under the low, medium and high ambition levels, respectively. These total footprints correspond to reductions of 21.7%, 32.4% and 68.2% from the baseline (Figure 1).

Overall, these results illustrate the potential for the EUDR to have a substantial impact on the EU's overall deforestation footprint. Our 'low ambition' scenario imagines only partial success at de-risking supply chains for high and medium risk origins, with enforcement for many Member States relatively modest. Strengthening enforcement without increasing the scope of countries or sectors results in a further 10.7% reduction from the low ambition scenario. An EUDR policy with broader sectoral scope which extends enforcement onto low risk origins and induces spillover effects (high ambition) is estimated to reduce the EU's deforestation risk by more than two-thirds.

Overall emissions results are 44,191,481 tonnes (25.6% reduction), 36,974,116 tonnes (37.8% reduction) and 19,416,277 tonnes (67.3% reduction) of the original 59,417,088 tonnes baseline, for low, medium and high ambition implementation, respectively. Overall Forest-LIFE scores are 0.240 (18.5% reduction), 0.211 (28.4% reduction), and 0.104 (64.8% reduction), respectively.

At commodity level, under the low ambition scenario, the cattle deforestation footprint is reduced the most in absolute terms, with a 18,805 ha decrease (24.1% reduction) with respect to the baseline. In relative terms, oil palm sees the largest reduction with a 28.5% decrease from the baseline (5,799 ha reduction). In the low ambition scenario, timber exhibits just a 1.5% reduction from the baseline (292 ha reduction)[21].

21. Primarily explained by the classification of China as 'low risk' in the EUDR low ambition implementation, in line with the EU's official benchmarking.

Under the high ambition scenario, the cattle deforestation footprint is reduced by 52,777 ha (67.7% reduction) from the baseline, although the residual deforestation footprint still remains higher than for any other commodity's baseline footprint. Coffee now exhibits the largest relative reduction with a 94.1% decrease from the baseline (5,601 ha reduction). Timber continues to have the lowest relative reduction, with a 50.2% decrease from the baseline (9,814 ha reduction).

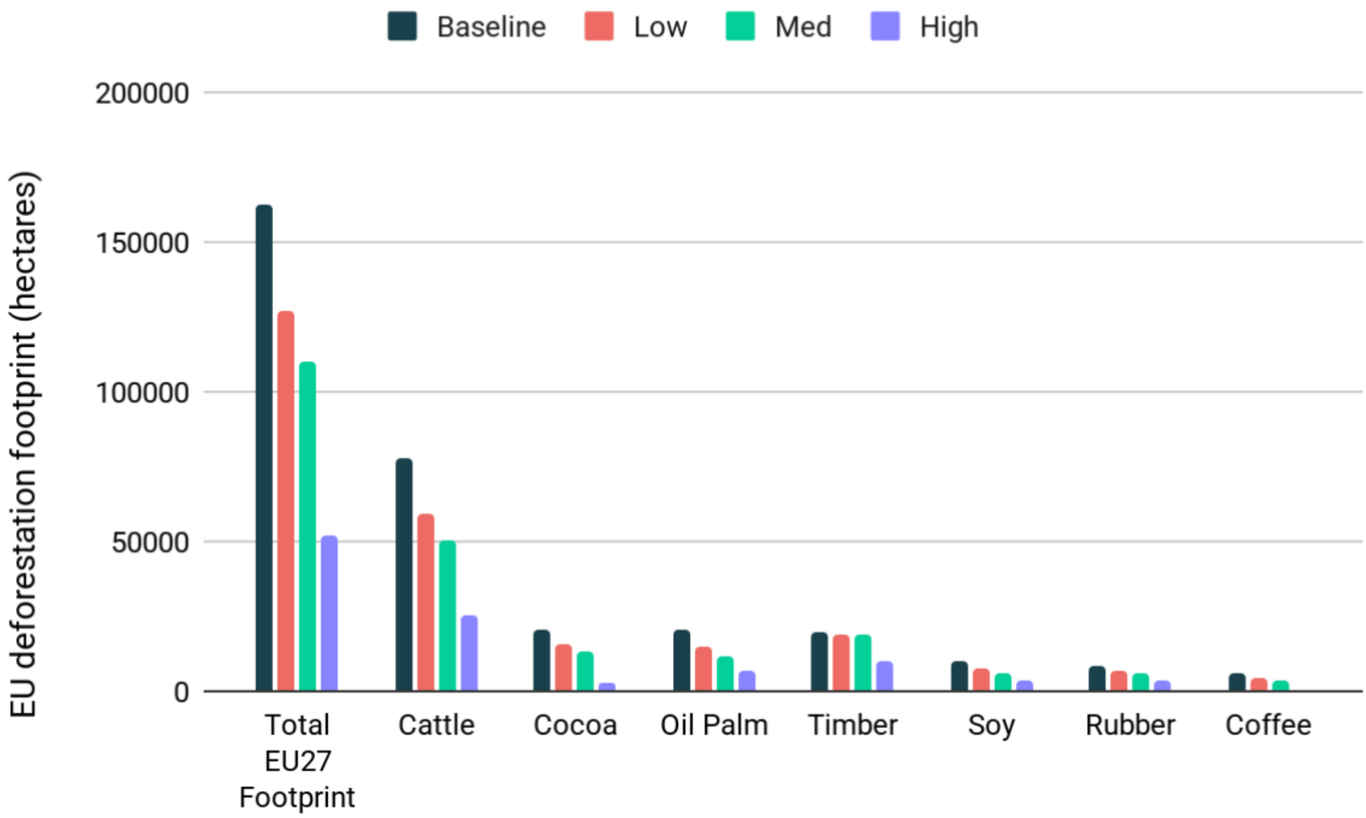

Figure 1. The EU's commodity deforestation footprints (plus footprint across all focal commodities) of the baseline and resulting from low, medium and high ambition implementation/enforcement strengths of the EUDR scenarios.

The contribution of each commodity to total deforestation, emissions and biodiversity footprint reductions in EUDR scenarios varies. For example, emissions reductions from oil palm make a relatively higher contribution (a 12.8% reduction from the baseline) to total reductions across commodities under the high ambition scenario (Figure 2) than relative deforestation reductions (8.3% reduction from the baseline). Oil palm's contribution to biodiversity footprint reductions is higher still (17.1% reduction from the baseline). Coffee also has an outsized impact on biodiversity reductions, contributing 9.49% to the EU's total footprint reductions from the baseline under the high ambition scenario, compared to a 3.45% contribution to deforestation footprint reductions from the baseline.

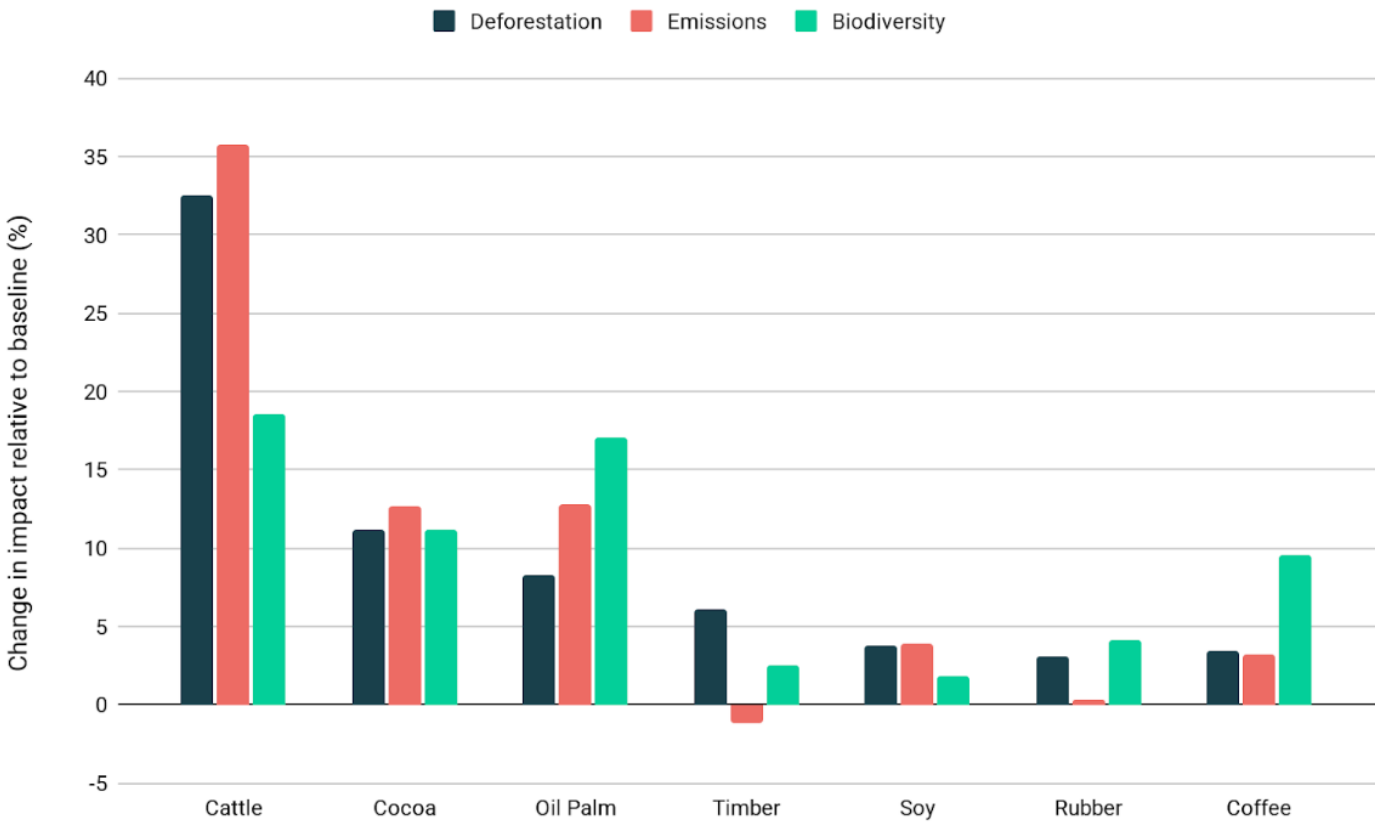

Figure 2. Change of impact across focal commodities relative to baseline deforestation, emissions and biodiversity (Forest-LIFE) footprints. Data is shown for the high ambition EUDR implementation.

At country level, exploring the implications of EUDR policy on the deforestation footprints originating from the countries representing the top 15 of the EU baseline (Figure 3), we observe that the country of origin with the largest baseline footprint, Brazil, sees a reduction of 35.1% from its original value under the low ambition scenario and 65.9% under the high ambition scenario. For Brazil, larger gains are seen for cattle (68.8% reduction from the baseline, with high ambition) than for soy (50.3% reduction, high ambition) or timber (48.2% reduction, high ambition). For the high ambition scenario, the China component of the footprint (dominated by timber) sees the lowest reduction at 37.5%, with the largest percentage reduction of EU-linked deforestation from Côte d'Ivoire (dominated by cocoa) which has a reduction of 99.0% of the baseline. Under low and medium scenarios, the impact of countries being classified as low risk (as modelled) under the EU's risk benchmark is clear, i.e. China, Ghana and Viet Nam exhibit no footprint decreases.

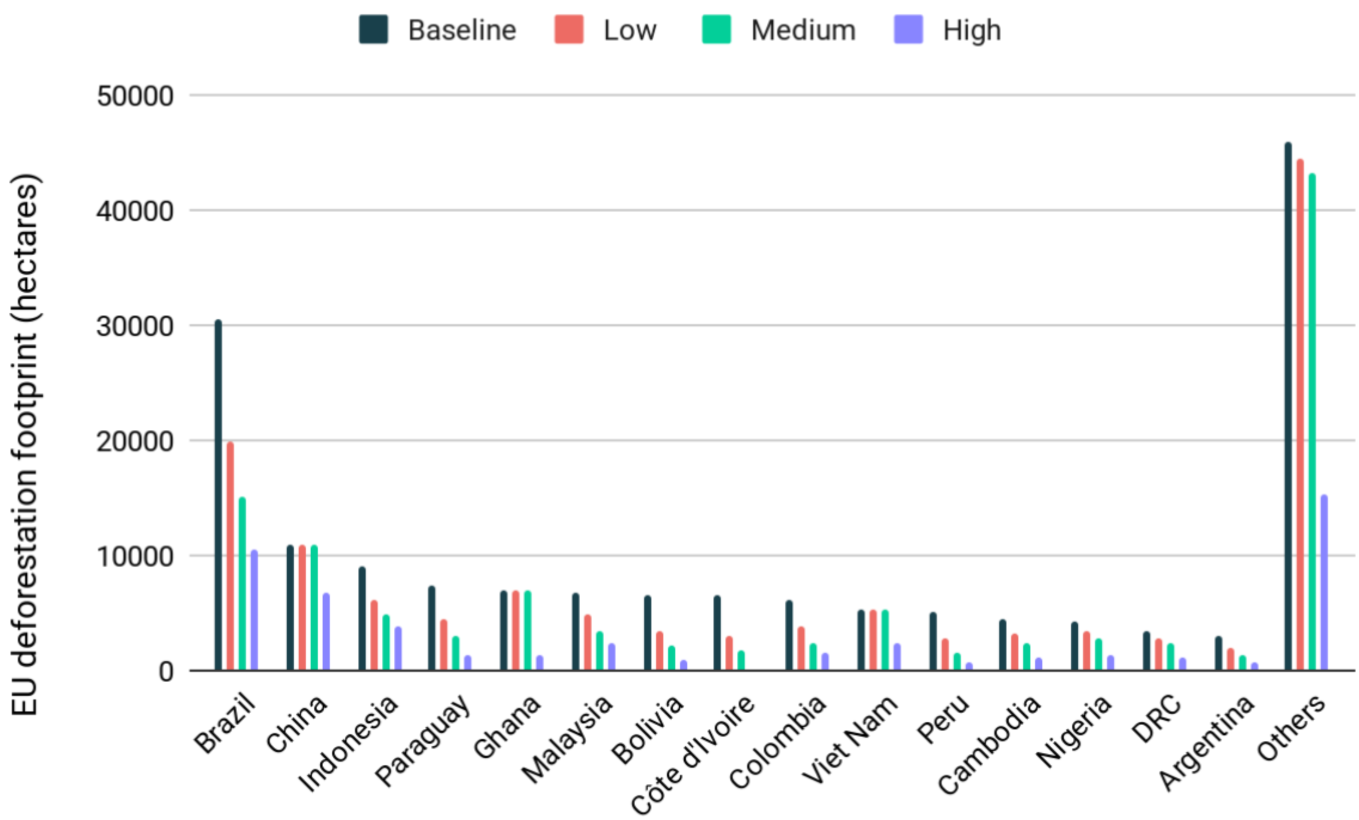

Figure 3. The EU's commodity deforestation footprints (for the baseline and under low, medium and high ambition implementation of the EUDR) in the countries of origin with the top 15 highest baseline footprints (plus 'other' category).

4. Consumption-transition scenarios

4.1. Policy levers to influence EU demand and sourcing of deforestation-risk commodities

The EUDR is an important policy mechanism for reducing the EU's exposure to commodity-linked deforestation-risk via its supply chains. The 'low ambition' scenario offers an approximation for what implementation in the short term might achieve - with our exploration of partial enforcement still resulting in meaningful reductions in deforestation exposure. That said, more ambitious implementations - with greater scope of coverage and additional enforcement placing higher incentives for companies to de-risk their supply - result in more transformational change. However, given the pressure the EUDR has been under to just reach the implementation stage, efforts that approximate these medium and high scenarios appear unlikely to be realised at present.

Due diligence regulation to reduce exposure of the EU's supply chain to deforestation (by sourcing from areas where deforestation is not occurring) is also not the only policy lever that the EU has available to reduce its deforestation footprint. Indeed, the EU's footprint is a product of the intensity of deforestation per tonne consumed (something that is directly modified in our EUDR implementation, above, by changing the intensities of production) but equally by the tonnes of materials that are consumed.

We turn now to levers which address the EU's demand for deforestation-risk commodities, i.e. those which seek to impact the consumption and international sourcing patterns of the EU as linked to deforestation-risk commodities. The levers that we explore are broad, inspired by efforts to shift towards a circular, low-carbon, economy with sustainable domestic production within the EU complementing efforts towards reduced material consumption overall and towards imports that impose a lower environmental burden. Our approach is to identify measures to 'stretch' current policy by promoting sustainable product design and business model innovation, consumer behaviour changes, introducing progressive environmental legislation, investing in alternative technologies and product lines, and shifting sourcing practices to reduce environmental harm. At the same time, we focus on leverage points that are realistic: opportunities for near-term implementation that build on existing activities with increased ambition, rather than requiring entirely new economic models or untested technologies. The results of this study should be seen as viable pathways for reducing the EU's environmental impact in the short term, and in addition to the EUDR.

The interventions that we parameterise and implement here are not exhaustive; there are other levers that can be pulled and other sectors that can be influenced, either with similar interventions with wider scope, or with other policy options. Our intent is to provide illustrative and exploratory options which result in specific changes to important sectors or commodity-supply chains that utilise forest-risk materials and are amenable to policy mechanisms that can be used to modify this use or consumption.

We consider three broad areas:

Sustainable domestic consumption (SDC) measures that seek to shift consumption practices and habits. These include measures to divert end-of-life material to new uses and thereby reduce waste and the requirement for new raw materials and seek efficiency improvement in product lifecycles through design and business model innovation, and those which seek to facilitate more sustainable consumer habits to reduce consumption.

Sustainable domestic production (SDP) interventions that introduce alternative EU-based production lines or adjust the structure of the production system to meet the EU's consumption demands with more sustainable products.

Border adjustment mechanisms (BAM) that apply taxation on environmentally damaging imports - as measured by either their carbon or biodiversity footprint - to improve the sustainability of trade and consumption.

Each policy intervention developed for this study has been assigned to one of these three areas. The interventions themselves were identified via review of literature, European or Member State strategies, and existing policies. Individual policy levers are assigned to one or more 'ambition' levels, with some also having alternative implementation strengths at different levels of ambition if - for example - uptake is envisaged to be more pronounced under high ambition scenario space. For some policy levers linked to the SDC area and one SDP lever, each Member State may also be subject to an implementation 'scaling factor' (that we base on the Sustainability Governance Indicator (SGI) 'Environmental Policies' scores (Bertelsmann Stiftung, 2024) that indicate how well government environmental policies address sustainability issues[22]), and variation in implementation across Member States may also exist for other levers based on specific factors described for each focal commodity, below. Levers within policy areas are combined and these policy areas are themselves combined to provide scenario results for a set of low, medium, and high ambition interventions, overall.

Below, we describe, for each focal commodity in turn, the levers that apply to adjust demand and supply for the commodity, the impact of these levers individually, and when combined across policy areas (SDC, SDP and BAM; note that, below, our levers are marked with these initials to cluster them into different policy areas) in overall scenarios. Scenarios are also explored with or without the addition of the EUDR[23]. Outputs are provided in terms of changes to the EU's deforestation, deforestation emissions and biodiversity footprint from the baseline. More detail on each of the policy areas, including further supporting evidence and justification for any assumptions adopted, is provided in Annex C - Background Documents for Policy Areas.

22. Uptake of policy may vary across Member States even if there is some regulatory intervention at European Commission level due to the economic, political or cultural context of those states.

23. In addition to combined low, medium and high ambition implementations of the EUDR with other levers, we also run out combined results which combined non-EUDR levers of different ambition with the low ambition EUDR scenario; this provides insight into what additional reductions other levers might induce alongside our model for immediate-term EUDR implementation.

4.2. Soybean consumption

4.2.1. Lever description and implementation

Several policy levers influence the consumption of soybean in our scenarios. Linked to the SDC space, we target food waste as a pertinent issue affecting soy consumption with dietary shifts away from meat also having an indirect effect on the use of soy vis-a-vis direct human food use and - in particular, given its dominant use for animal feed - for meat production. We also explore the impacts of increased domestic production of soy within the EU as an alternative to extra-EU imports. Finally, we explore the implications of an extension to the EU's carbon border adjustment mechanism to incorporate soy. Table 3 provides a summary of the levers employed.

Table 3. Summary of policy levers impacting the soy footprint, the application of these levers across 'ambition' levels, and whether or not Member State-specific scaling occurs.

Area	Description	Lever and scenario level	Member State specificity
SDC	Reductions in food waste	- Consumer food waste reductions to decrease soy consumption (same reduction applied in low, med, high scenarios) - Indirect impacts of beef-linked consumer food waste reductions (same reduction applied in low, med, high scenarios) - Food waste diversion to animal feed (high only)	Yes - using Sustainable Governance Indices
	Dietary shifts	- Reductions in beef consumption affecting soy in animal feed plus substitutions for direct human consumption (variable change applied to low, med, high)	Yes - using Sustainable Governance Indices
SDC	Domestic production of sustainable soy	- Production of sustainable soy over pasture in Europe (pasture availability in line with dietary shifts) (variable change applied to low, med, high) - Closure of yield-gaps for existing Member State-producers of soy (high only)	Yes - based on potential availability of pasture per Member State. Yes - based on existing Member State-specific yield gaps
	Lab grown beef	- Uptake of lab grown protein alternatives produced sustainably in Europe has impact of soy-feed requirements (variable reduction across low, medium, high scenarios)	Yes - using Sustainable Governance Indices
BAM	Border adjustment price applied to soy	- Carbon pricing (medium scenario) - Combined carbon and biodiversity pricing (high scenario)	No - sourcing changes applied in equivalent manner across all Member States (but some higher-production emissions/biodiversity-impact states are implicated from a producer-perspective if impacts of soy production are above EU-averages)

4.2.1.1. Sustainable domestic consumption

For food waste (SDC) we explore two specific levers for reducing consumption of soy. Firstly, we explore the opportunity to reduce food waste associated with human consumption via policy-driven consumer-level behaviour change, assuming that reductions in total food waste of circa 20% are viable based on studies on consumer waste reductions. This reduction in waste then applies to the proportion of soybean use which is avoidably wasted, estimated at 12.3%, and equating therefore to a demand reduction potential of 2.5% (20% of 12.3%). We also assume that some (25%) of this prior-waste is simply redistributed into the food system rather than resulting in an absolute demand-reduction[24], arriving at a final demand-reduction of 1.8% (75% of 2.5%). This lever is applied in low ambition scenarios upwards[25]. In addition, we apply the food waste lever so that it also impacts beef consumption (see 'Beef/cattle consumption' for additional information), with impacts of a reduction in beef consumption of 1% modelled in low ambition scenarios (and upwards) which then has a small indirect modelled impact on soy via its use in animal feed.

24. This accounts for the fact that some redistributed waste may fill nutritional gaps in society, or may be associated with resultant over-consumption by some cohorts.

25. i.e. the lever is applied in the low ambition scenario and retained alongside other more ambitious levers in medium and high ambition scenarios.

The second food waste linked lever applying to soy explores the role that food waste more generally could play in feeding animals. Considering the EU's 2022 food waste estimates by supply chain segment, we apply varying collection-rate and waste-to-feed conversion factors accounting for the fact that collection and conversion in the supply chain is more difficult at the consumer- compared to the producer-end. Accounting also for the fact that some food waste is already used for feed products, we arrive at the estimated potential - via further incentivisation - for an additional 5.6 megatonnes of animal feed to be produced from the EU's estimated 59.2 megatonnes of food that would otherwise go to waste, which equates to a substitution of around 3.7% of the compound feed used by EU livestock farmers. This lever is applied in high ambition scenarios only.

Dietary shifts (SDC) within our scenario focus on reductions in beef consumption. Whilst often overlooked as a circular-economy policy measure, reduction in beef and other meat consumption constitute part of a portfolio of circular strategies, including those linked to resource-efficiency gains (e.g. through lowering wastage associated with feed material and energy inputs, lowering metabolic energy losses, and avoiding wastage on-farm). A combination of mechanisms are explored to reduce meat consumption, with voluntary eco-labelling and public-procurement policy focused on increased procurement of vegetarian meals (low ambition scenarios upwards), food designed with alternative proteins, mandatory labelling (medium ambition upwards) and an environmental tax on beef (high ambition) constituting progressively more ambitious levers. These levers result in a maximum reduction in beef consumption of 33.9% (see 'Beef/cattle consumption' for additional details on this set of levers). Due to soy's role as a feed in beef supply chains, we provide results of these levers as part of the wider soy scenarios. In addition, we take into account the fact that beef-consumption changes will result in substitution to other forms of food, either alternative meats or towards plant-based meat alternatives. Considering the caloric content of foods and alternative dietary options linked to EAT-Lancet dietary gaps, we estimate that direct soy consumption in human diets may increase by 55.4%, 58.1%, or 67.2% under low-to-high ambition scenarios in response to changes to beef consumption.

As mentioned above, across the SDC-linked policy levers (and for the SDP-linked lab grown beef lever described below), we envisage that in some cases policy implementation (i.e. uptake and/or enforcement) will vary by Member State. For simplicity, we apply the same scaling factor for uptake across multiple levers, based on Sustainability Governance Indicator (SGI) 'Environmental Policies' scores (Bertelsmann Stiftung, 2024) which has the effect of weakening the reductions in soy demand described above for some countries.

4.2.1.2. Sustainable domestic production

Sustainable domestic production of soy (SDP) explores the potential for the EU to produce more soy which is not associated with additional forest or biodiversity loss. Taking the reductions in beef demand from the dietary shift (SDC) levers (which differ across low, medium and high ambition scenarios as described above) we assume commensurate reductions in requirements for pasture and - on a Member State level - then determine how much agricultural land might become available. Existing shares of soy-specific growing area versus total agricultural land area within Member States is used to estimate how soy-specific production might increase[26]. In low and medium scenarios, this equates to 7.4% and 11.1% increases in EU soy production. For high ambition scenarios, this lever is further combined with efforts to close soy yield gaps. Data from the Global Yield Gap Atlas (University of Nebraska Lincoln and Wageningen University, 2025) is used to determine yields of rainfed and irrigated soy per Member State in recent decades which is compared to an 'exploitable yield gap' estimate to determine the potential for growth in production with no additional land-occupation. Existing soy production statistics per Member State are then scaled to provide estimates of total exploitable soy production. Thus, under a high ambition scenario, the combination of pasture-to-soy conversion and yield-gap measures results in a potential for 69% growth in soy production across current EU producers. Note that, across all levers, we assume that gains are reserved for current-producers of soy only (i.e. there is no expansion of soy production into other currently-non-producing Member States).

The soy footprint is also influenced by levers which promote uptake of lab grown beef (SDP). Note that, in our scenarios, this lever acts in addition to the uptake of more traditional alternative proteins (such as legumes) that are modelled in the dietary shifts (SDC) policy lever described above. Using estimates of market growth in alternative proteins (see 'Beef/cattle consumption' for additional details) under different policy regimes, and potential shares of lab grown vs other alternative proteins within this segment, we assume lab grown beef market capture of 4.2%, 5.7% and 7.3% under low-medium-high scenarios, leading to a reduction in traditional beef demand. With the further assumption that feedstocks used in lab-derived meat are either from non-soy or sustainable European-derived soy[27], this is modelled as a reduced dependency on deforestation-risk soy as a feed for the beef industry.

4.2.1.3. Border adjustment mechanism

For the border adjustment mechanism (BAM) levers, under medium and high ambition scenario space we include soy as a product covered by regulation that attaches a levy on goods imported into the EU. Currently, soy is not considered in scope of the EU's CBAM regulation (European Commission, 2024) so the impact of price increases on soy as explored here are illustrative of a potential expansion in product scope. In our

26. i.e. we assume that land can also become available for other purposes, which also allows for the fact that some ex-pasture would not be suitable for soy production.

27. Soy is considered a potential feedstock for lab grown meat, e.g. see Sinke et al., 2023.

medium ambition scenario we assume a carbon price is applied to soy of €70 per tonne of emissions in line with 2024/25 EU ETS carbon prices (Statista, 2025a). With CO^2-equivalence of 2.6 tonnes per tonne of soy produced (Parajuli et al., 2022), this equates to a cost of €182 per tonne imported (which is comparable to the costs per tonne of steel covered by existing CBAM regulations) (PricewaterhouseCoopers, 2024). With bulk commodity prices of soy at around €400 per tonne, this represents a 45.5% increase in price which is considerable. However, in comparison to other commodities such as beef, oilseed (which includes soy) demand elasticities are modest and - with the additional constraint that a large proportion of EU soy demand is currently imported - we assume that a resultant reduction of soy from areas of high-carbon intensity of 25% is reasonable. Sources with high carbon intensity are determined based on global deforestation emissions for soy per hectare, which allows classification of countries of origin into high and low risk regions in terms of their emissions associated with deforestation as compared to the EU average[28].

Under our high ambition scenario space, we introduce a further levy, this time linked to costs associated with biodiversity loss, rather than carbon emissions. We consider the biodiversity loss associated with soy in comparison to other commodities (with biodiversity loss as measured by the LIFE score) (Ball et al., 2025) to determine an illustrative 'biodiversity border adjustment' price of €100 per tonne for soy[29]. When applied in addition to the carbon price above, this then results in a 70.5% total increase in price which we assume translates to a total reduction of demand of 35% from areas of high biodiversity risk (with biodiversity risk derived from the LIFE score for soy).

4.2.2. Results

4.2.2.1. Individual levers

Taken individually[30], the policy levers described above have a relatively marginal impact on soy deforestation footprints under low ambition implementation scenarios (Figure 4), with the largest changes observed under the dietary shifts lever. Here, soy footprints actually rise marginally in our model implementation as a transition from beef to other meat products and alternative proteins induces a slight increase in demand for soy overall (the soy footprint increases by 199 ha under the dietary shifts lever low ambition scenario). It is important to note - however - that any such rises for soy are more than offset by associated decreases in the deforestation footprint linked to beef which is the primary target of the dietary shifts lever (and see Section 4.3, below). Therefore, overall deforestation footprint reductions are observed. The impacts of applying a border adjustment mechanism to soy are relatively marked, with a soy deforestation footprint reduction of 674 ha (7.0% of the baseline) under the medium ambition scenario that imposes a carbon price and 2,116 ha (21.9% of the baseline) under the high ambition scenario that imposes an additional biodiversity price. The border adjustment decrease of 2,116 ha under the high ambition implementation is comparable in size to the low ambition implementation of the EUDR (2,255 ha).

28. I.e. If a country of origin has deforestation emissions associated with soy which are higher than the EU average then demand reductions from this country are applied. Given that EU production in some Member States can be above-average intensity levels, this means that demand may also fall from high-intensity countries within the EU. We deem this reasonable, as whilst BAM is an import-focused instrument, it is reasonable to assume domestic taxation may also apply so that the policy is compatible with the non-discrimination requirements of the World Trade Organisation.

29. i.e. biodiversity levies are somewhat lower per tonne than carbon levies, which we deem realistic given that - in this scenario - these are applied on top of carbon prices.

30. i.e. extracting results from model runs when levers are applied in isolation.

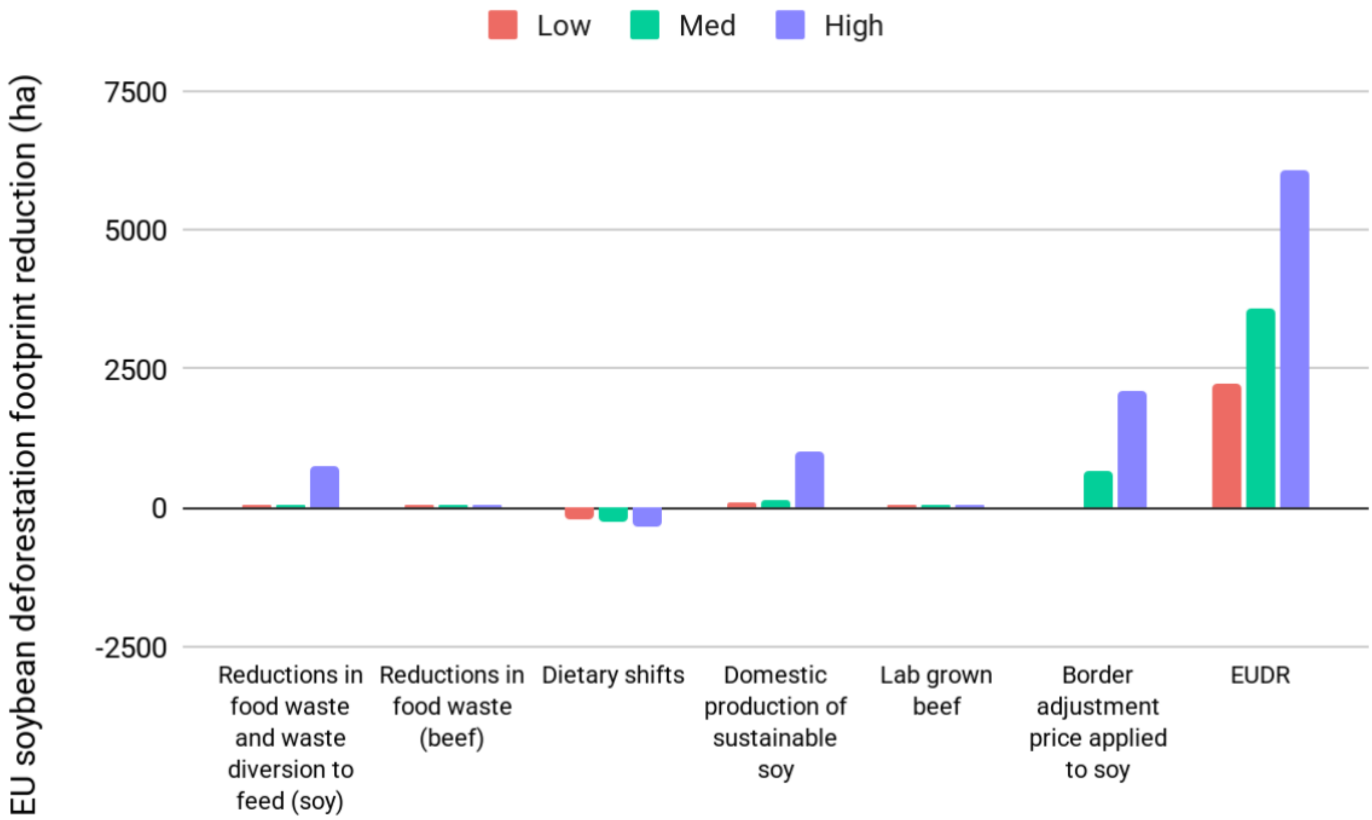

Figure 4. Changes (under low, medium and high ambition implementation) to the EU's commodity soy-deforestation footprints for individual levers as-implemented in the scenario model. Positive values are reductions to footprint.

4.2.2.2. Combined levers

Figure 5 shows results of scenarios when levers are applied in combination. Here, SDC-linked levers are implemented in combination first (for low-, medium- and high-scenario space), then SDP-linked levers are combined with these levers (i.e. low ambition SDP levers are applied with low ambition SDC levers and so on), then BAM-levers are applied. When all non-EUDR levers are applied, the reductions in deforestation footprint from the baseline are 31 ha (0.32% reduction from the baseline), 709 ha (7.33%) and 3,133 ha (32.4%) for low, medium and high ambition combinations, respectively. Thus, only under high ambition scenarios do combined non-EUDR levers exceed the deforestation footprint reductions of the low ambition EUDR implementation applied in isolation.

When the low ambition EUDR lever is applied in combination with high ambition non-EUDR levers, the deforestation footprint falls to 4,803 ha, a 50.3% reduction from the baseline, i.e. low ambition EUDR implemented on top of non-EUDR levers induces an additional 27.0% reduction (2,614 ha) in footprint (from the baseline) compared to the application of low ambition EUDR on its own[31]). If a high ambition EUDR scenario is applied in combination with all other levers, the deforestation footprint falls to 2,464 ha (a 74.5% reduction from the baseline), i.e. high ambition non-EUDR levers induce

31. A lower percentage reduction from the baseline when EUDR is applied on top of other levers is expected, given that reductions in footprint from some origins will have already been realised via the application of other levers.

a further 11.7% reduction (1,129 ha) compared to the application of the high ambition EUDR on its own.

To summarise, low ambition implementations of non-EUDR policy levers have marginal impact on the footprint, with medium ambition (carbon-price) implementation of BAM having some impact and high ambition CE, SDP and BAM measures having a more pronounced impact that - combined - can exceed the deforestation footprint reductions estimated under a low ambition, isolated, implementation of the EUDR. Further, non-marginal, footprint reductions are gained when the more ambitious soy levers are used in combination with the EUDR[32].

32. i.e. the addition of non-EUDR levers can realise additional reductions in footprint, substantially beyond those achieved with EUDR alone.

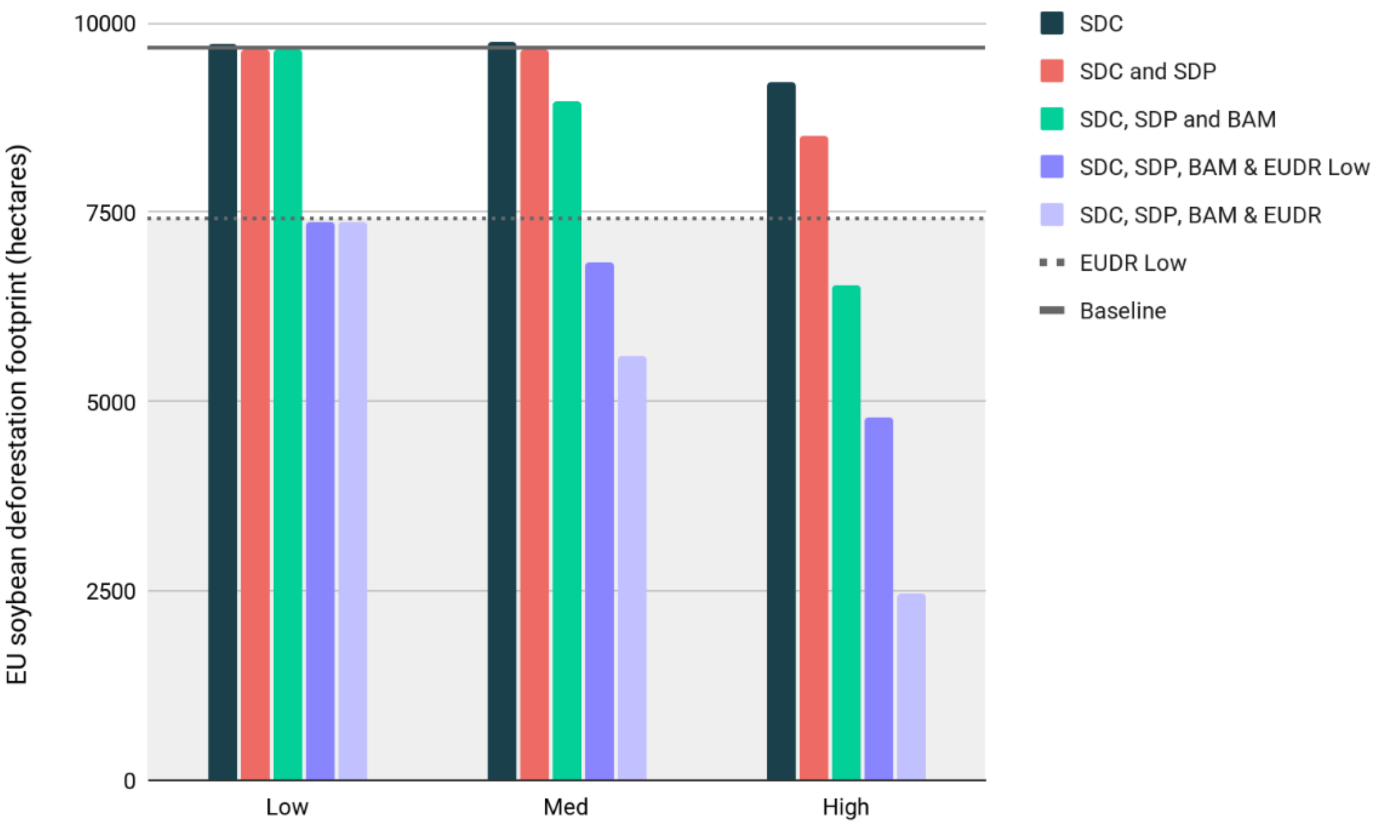

Figure 5. The EU's soy deforestation footprints for combined levers as implemented in the scenario model. The solid horizontal line shows the baseline footprint and the dashed horizontal line shows the soy footprint under the EUDR low ambition scenario when applied in isolation. For bars (with the exception of the bar including 'EUDR Low' where the EUDR is applied with low ambition), the level of ambition is stated on the x-axis, i.e. 'Med' = combinations of all levers with medium ambition.

4.2.2.3. Impacts at origins

Exploring how countries of origin contribute to footprint reductions under the high ambition implementation of non-EUDR levers (SDC, SDP and BAM) combined with the low ambition EUDR lever reveals that reductions from Brazil and Bolivia dominate the total experienced reduction (Figure 6). Whilst deforestation reductions are most significant from Brazil (driving a 20.1% change in impact relative to the EU27 baseline), Bolivia has high contribution relative to its share of the original deforestation footprint (16.6% of total change in impact relative to the baseline whilst being associated with just 19.1% of the original deforestation footprint, compared to Brazil's 42.5%[33]). Emissions reduction-contributions from Brazil are low relative to its deforestation contribution, with emissions reductions from Cambodia and Indonesia having an outsized effect. Bolivia's contribution to biodiversity footprint reduction is also somewhat high relative to deforestation, with Colombia and Mexico also having an outsized biodiversity contribution relative to the contribution to deforestation reduction[34].

33. This result infers that Bolivian soy is associated with supply chains into European Member States which are more substantially affected by the combination of policy levers implemented.

34. Emissions- or biodiversity-loss intensities per hectare of deforestation, which vary by country of origin, explain these differences.

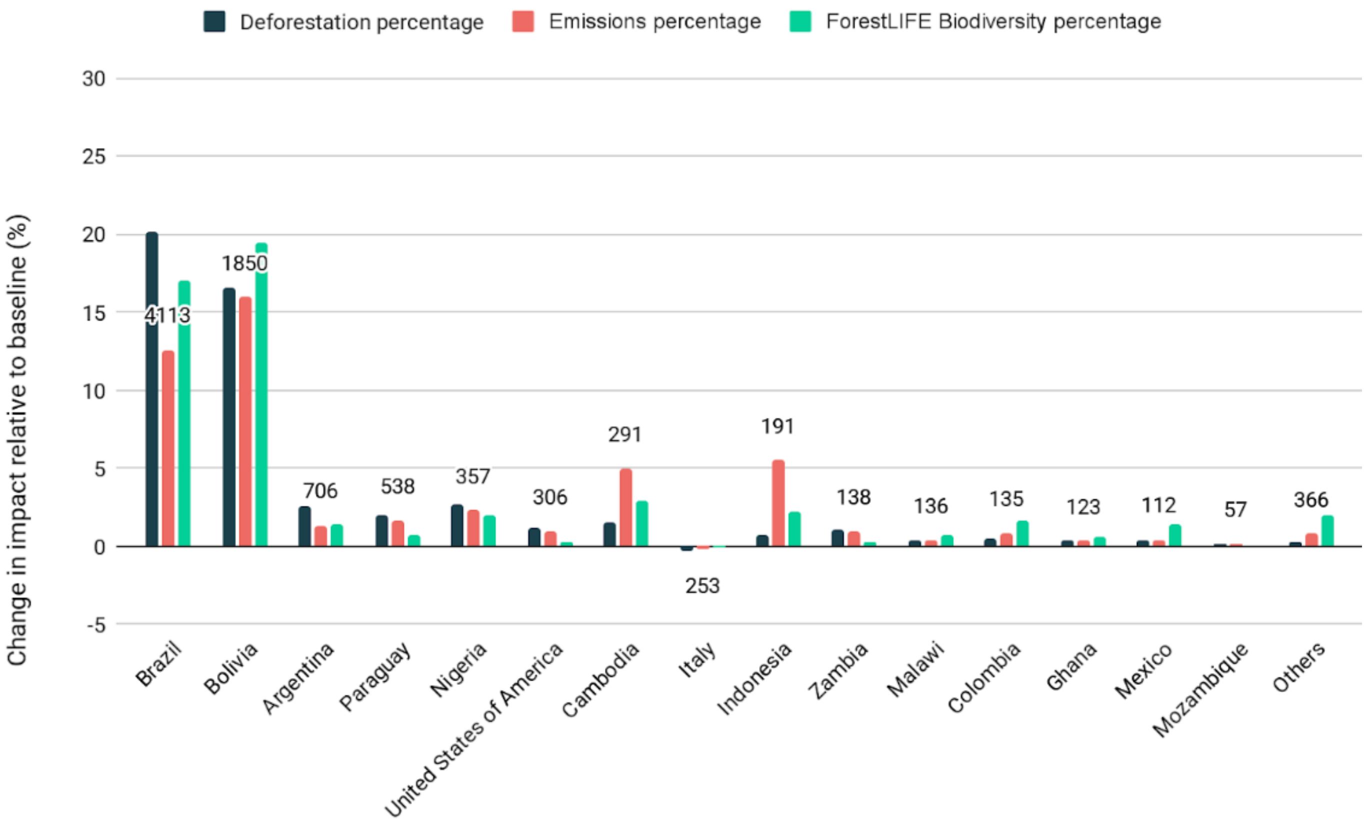

Figure 6. Change of impact in points of origin of the EU's soy footprint relative to the baseline. Data is shown for high ambition non-EUDR levers combined with low ambition EUDR. Contributions to overall deforestation, emissions and biodiversity (Forest-LIFE) changes are provided. Labels show the original soy deforestation footprint (ha) associated with each country.

4.3. Beef/cattle consumption

4.3.1. Lever description and implementation

For beef consumption, levers within the circular economy scenario space are closely connected to those for soy, with the implications of dietary shifts and food waste levers on demand for beef and associated cattle-linked footprints being explored. With dietary shift levers incorporating a transition from beef to other proteins (a mix of other meat products or plant-based proteins - including soy - in differing proportions depending on policy ambition levels), we also explore the impacts of the uptake of lab-based meat, produced domestically within the EU, as an alternative to traditional production methods. Finally, we explore the implications of an extension of the EU's carbon border adjustment mechanism to beef. Table 4 provides a summary of the levers employed.

Table 4. Summary of policy levers impacting the beef footprint, the application of these levers across 'ambition' levels, and whether or not Member State-specific scaling occurs.

Area	Description	Lever and scenario level	Member State specificity
SDC	Reductions in food waste	- Consumer food waste reductions to decrease beef consumption (same reduction applied in low, med, high scenarios)	Yes - using Sustainable Governance Indices
	Dietary shifts	- Reductions in beef consumption with shifts to alternative protein (variable change applied to low, med, high)	Yes - using Sustainable Governance Indices
SDP	Lab grown beef	- Uptake of lab grown protein alternatives produced sustainably in Europe (variable reduction across low, medium, high scenarios)	Yes - using Sustainable Governance Indices
BAM	Border adjustment price applied to beef	- Carbon pricing (medium scenario) - Combined carbon and biodiversity pricing (high scenario)	No - sourcing changes applied in equivalent manner across all Member States (but some higher-production emissions/biodiversity-impact states are implicated from a producer-perspective if impacts of beef production are above EU-averages)

4.3.1.1. Sustainable domestic consumption

For food waste (SDC), a previous study (Garcia-Herrero et al., 2018) has suggested that 11% of all meat purchased by EU consumers is wasted, of which 58% is avoidable waste. We assume a reduction of this avoidable waste of circa 20% is viable (adopting the same assumptions as for soy, above, in terms of the uptake of behavioural-change to reduce food waste via policy-driven information campaigns) and that 75% of this reduced waste actually leads to demand-reduction (with the rest redistributed or over-consumed). In sum, these assumptions equate to total beef demand-reduction of approximately 1%, with this lever applying in low ambition scenarios upwards.

The dietary shifts (SDC) lever (introduced above for soy) envisages a combination - depending on ambition level - of voluntary and mandatory labelling, promotion of food designed with alternative proteins, procurement changes and environmental taxes. In low ambition space, a combination of a voluntary eco-label for meat products (7.9% reduction) and public procurement of vegetarian meals (2.9% reduction) equate to a total 10.8% reduction in beef demand. In medium ambition scenarios, eco-labelling is strengthened to become mandatory, equating to a 13.1% reduction in demand so that total meat reductions under medium ambition scenarios equate to 16.0%. In high ambition scenarios, these policies are combined with a tax on beef which results in a further 17.9% reduction, for a total reduction of 33.9%. These reductions are associated with dietary shifts towards alternative meat or plant-based proteins which impact on soy consumption (see above).

For both of these SDC-area levers (and for the SDP-linked lab grown beef lever described below) policy implementation (i.e. uptake and/or enforcement) also varies by Member State, and we apply the SGI-derived scores to scale country implementation which has the effect of weakening the reductions in beef demand described above for some countries.

4.3.1.2. Sustainable domestic production

Uptake of lab grown beef (SDP) is explored alongside the shift to more traditional alternative proteins explored in the dietary shifts (SDC) lever. Here, we explore the potential for uptake of lab grown beef against a backdrop of limited pre-existing consumer acceptance. A prior study (Morach et al., 2021) suggests that the global alternative protein market may grow within ten years (i.e. by 2035) by 11%, 16% or 22% under low, medium or higher ambition scenarios, with low ambition reflecting minimal additional intervention (i.e. just reflecting ongoing growth in environmental awareness) but more ambitious scenarios requiring accelerated technology development, regulatory change around lab grown alternatives, taxes and public information campaigns. These growth rates are adjusted to account for the fact that 'alternative beef products' will make up only a portion (6.9%) of projected changes, and for the assumption that lab grown alternatives will make up 29.8% of the alternative proteins market overall (both estimates derived from Witte et al., 2021). Ultimately, these assumptions result in lab grown beef market-capture estimates of 4.2%, 5.7% and 7.3% under low, medium and high scenarios, respectively, which we model as equal reductions in traditional beef demand.

4.3.1.3. Border adjustment mechanism

For the border adjustment mechanism (BAM) levers, under medium and high ambition scenario space we include beef as a product covered by an extension to the existing regulation. As for soy, we explore a medium ambition scenario on the basis of a carbon price of €70 per tonne of GHGs emitted. With an average of 129.72 tonnes for carbon equivalent emissions arising per tonne of beef[35], however, this results in a potential BAM price of €9,080 per tonne of beef. Given this very high price, we also consider the imposition in Denmark of a carbon tax on beef (Carbon Brief, 2024; Carlsson, 2024) which - at 120 DKK (€16.09) per tonne of carbon equivalent emissions - results in a somewhat more modest price of €2,087 per tonne of beef. This price is much higher

35. Based on 49.89 kg of greenhouse gas emissions per 100 g of beef protein, Poore and Nemecek, 2018; and 26g of protein per 100g of beef, USDA, 2019.

than for the other commodities explored in this study linked to the BAM policy area and, considering also that beef trades at around €4800 per tonne, this would result in a potential 43.5% increase in beef import prices. With demand elasticity for beef relatively high, and only around 5% of total EU beef consumption imported providing ample opportunity for potential switches to domestic supply (either for traditional sources or alternative proteins), we consider that the impact of such a sharp price uplift would have a marked impact on imports, and therefore model a 95% reduction in beef demand from areas of high-carbon intensity[36]. Under the high ambition scenario, the effects of an additional price linked to biodiversity impacts is explored. For beef, global average impacts of associated land use change on biodiversity are estimated with the LIFE score to be more than two orders of magnitude larger, per tonne, than soy and oil palm[37]. However, we deem a price of €500 (five times that of soy) per tonne to be a reasonable additional cost, which would result in a total increase in baseline beef import prices of 53.9% (compared to 43.5% for carbon alone). This relatively modest additional cost is imposed as a further 2% reduction in demand from high-risk countries[38], with overall reductions thus at 97%.

4.3.2. Results

4.3.2.1. Individual levers

When applied individually, the food waste policy lever applied for beef under the low ambition implementation has a marginal impact on the EU deforestation footprint, but application of policy to promote reduction in beef consumption via dietary shifts, and the introduction of lab grown beef, has a more pronounced impact (Figure 7). The dietary shifts lever applied in isolation results in a 5,800 ha deforestation reduction under the low ambition scenario, and up to a 18,375 ha reduction in the high ambition scenario (26.5% of the original beef baseline of 77,905 ha). The impacts of the border adjustment mechanism are even more pronounced, with a 21,402 ha (27.5% of the baseline) reduction under the medium ambition scenario and 29,718 ha (38.1% of the baseline) reduction under the high ambition scenario, with the former exceeding deforestation reductions associated with a low ambition scenario implementation of the EUDR and the latter exceeding the deforestation reductions modelled in the medium ambition EUDR implementation.

36. See description of soy (above) for how high-risk countries from emissions and biodiversity perspectives are determined. As for soy, reductions in demand may take place from EU countries which have above-average beef-linked emissions or biodiversity impacts.

37. Resulting from a combination of extensive clearance of land for pasture in biodiversity hotspots, and the relatively lower material-efficiency of beef production per unit land compared to crops.

38. We consider the very small further increase to be reasonable in light of the fact that imports have already been markedly reduced in the medium ambition scenarios. However, this high ambition scenario, whilst only having a relatively small impact on further demand reductions from high-risk countries, also brings additional country origins into the scope of the modelling based on their relative biodiversity risk linked to beef.

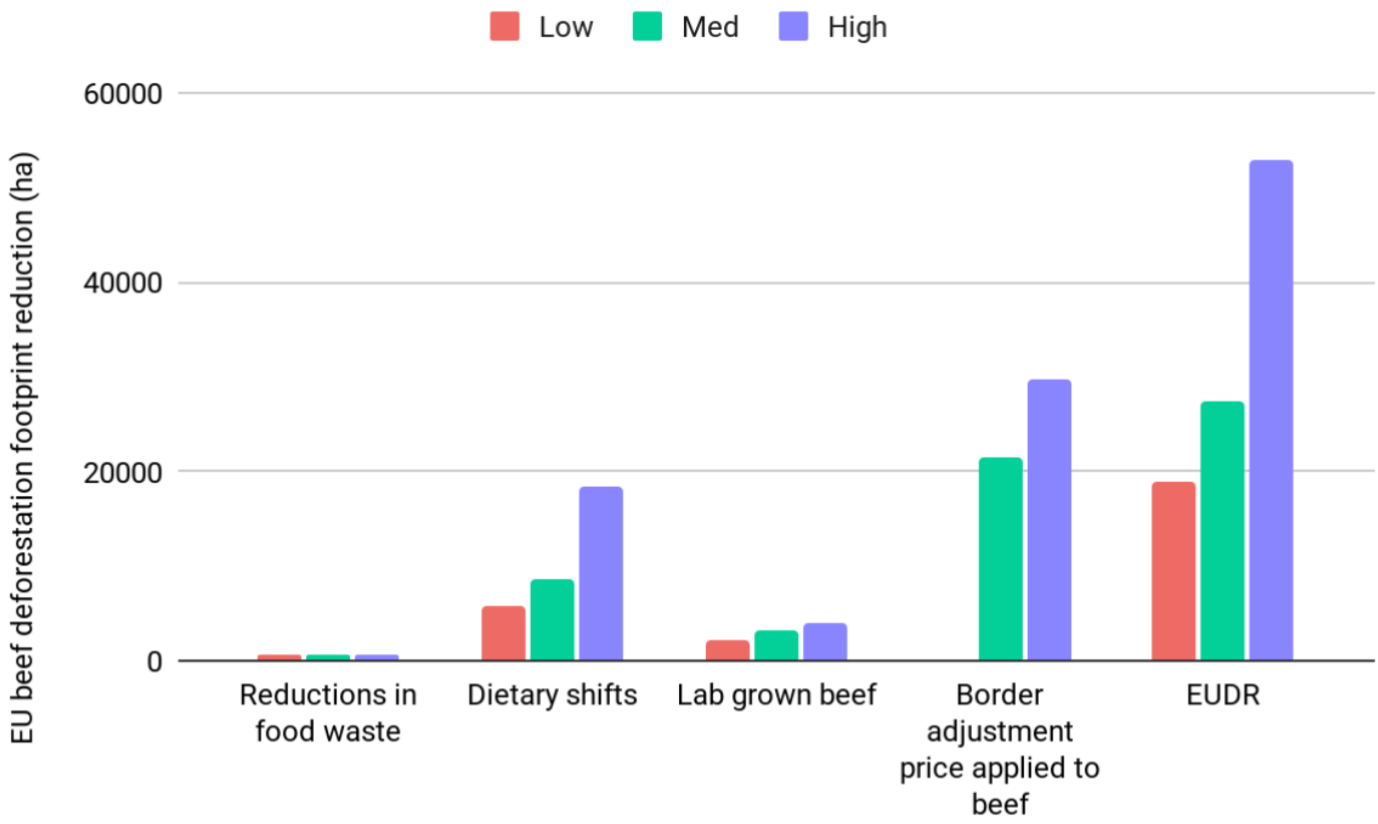

Figure 7. Changes (under low, medium and high ambition implementation) to the EU's commodity beef-deforestation footprints for individual levers as-implemented in the scenario model. Positive values are reductions to footprint.

4.3.2.2. Combined levers

Figure 8 shows results when levers are applied in combination. When all non-EUDR levers are applied, the reductions in deforestation footprint from the baseline are 8,595 ha (11.0% reduction), 30,241 ha (38.8%) and 43,786 ha (56.2%) for low, medium and high ambition combinations, respectively. Thus, under both medium and high ambition scenarios, combined non-EUDR levers exceed the deforestation footprint reductions of the low ambition EUDR implementation when applied in isolation.

Applying the low ambition EUDR lever in combination with high ambition non-EUDR levers results in the beef footprint falling to 18,125 ha, a 76.7% reduction from the baseline. In other words, applying the low ambition EUDR lever on top of high ambition non-EUDR levers induces an additional 52.6% reduction (40,975 ha) in footprint compared to the application of low ambition EUDR on its own. If a high ambition EUDR scenario is applied in combination with high ambition non-EUDR levers, the beef deforestation footprint falls to 6,317 ha (a 91.9% reduction from the baseline, i.e. high ambition non-EUDR implemented on top of high ambition EUDR induces a further 24.2% reduction (18,812 ha) compared to the baseline.

To summarise, even under low ambition implementations, non-EUDR-linked policy levers explored in this analysis can have a substantial impact on the footprint. The implementation of medium ambition non-EUDR levers in combination outweighs the reductions estimated from a low ambition EUDR scenario, and high ambition non-EUDR levers reduce the beef-deforestation footprint markedly below that of the low ambition EUDR implementation. When EUDR is applied in combination with non-EUDR levers, the beef deforestation footprint overall can be substantially reduced.

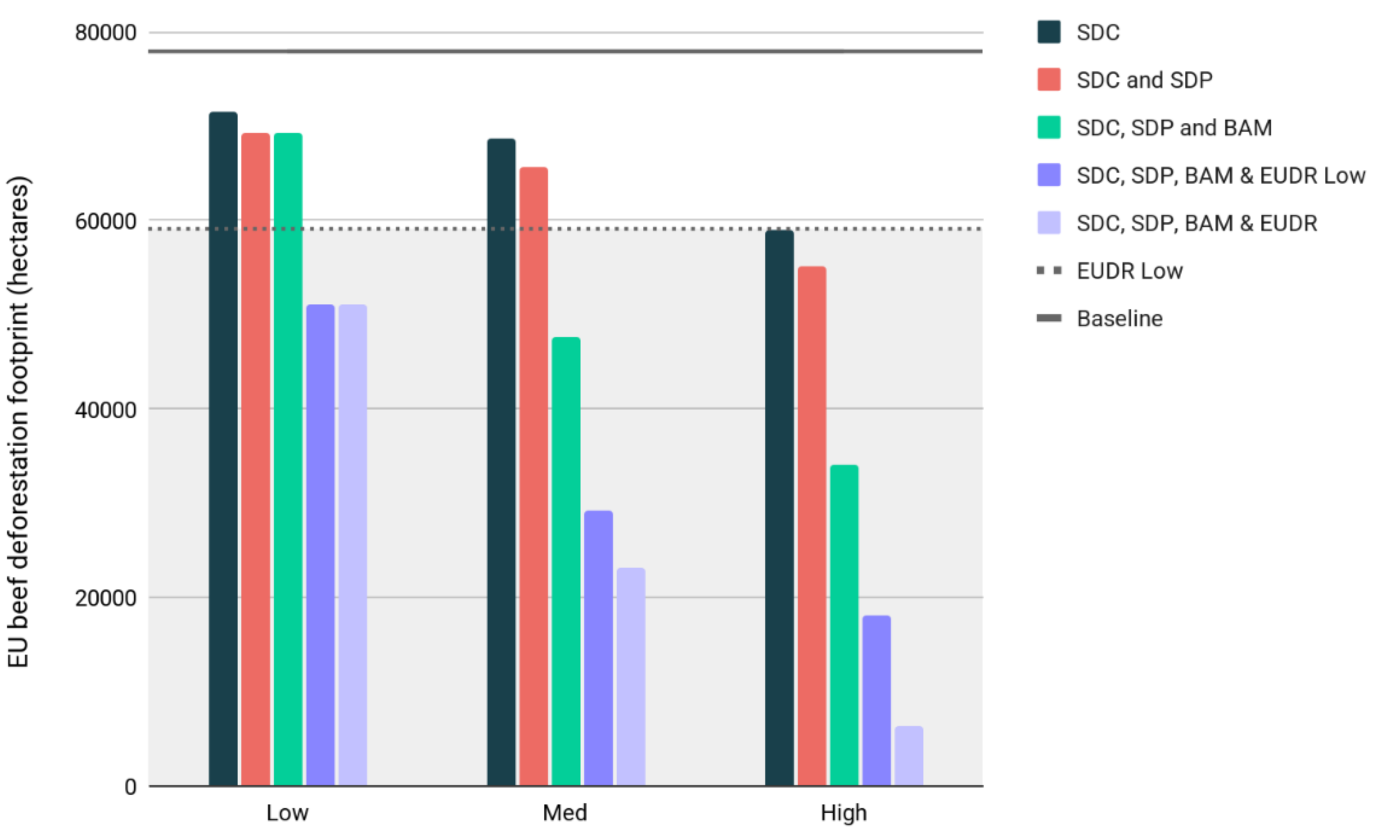

Figure 8. The EU's beef deforestation footprints for combined levers as implemented in the scenario model. The solid horizontal line shows the baseline footprint and the dashed horizontal line shows the beef footprint under the EUDR low ambition scenario when applied in isolation. For bars (with the exception of the bar including 'EUDR Low' where the EUDR is applied with low ambition), the level of ambition is stated on the x-axis, i.e. 'Med' = combinations of all levers with medium ambition

4.3.2.3. Impacts at origins

Exploring how countries of origin contribute to footprint reductions under the high ambition implementation of non-EUDR levers (SDC, SDP and BAM) combined with the low ambition EUDR lever reveals that reductions from Brazil dominate the total experienced reduction (Figure 9). Overall, deforestation footprint reductions originating from Brazil make up 25.3% of the change in impact relative to the baseline. Emission reduction contributions from Brazil are more pronounced still, contributing 34.1% of change from the baseline. However, the contribution of sourcing from Brazil to biodiversity impact reductions is more modest at 14.8% with relatively greater contributions arising from Colombia and - notably - Madagascar when compared with their respective contributions to the deforestation footprint reduction. Biodiversity impact reductions in Madagascar amount to 8.8% of the baseline, despite only contributing a 0.91% change from the baseline for deforestation.

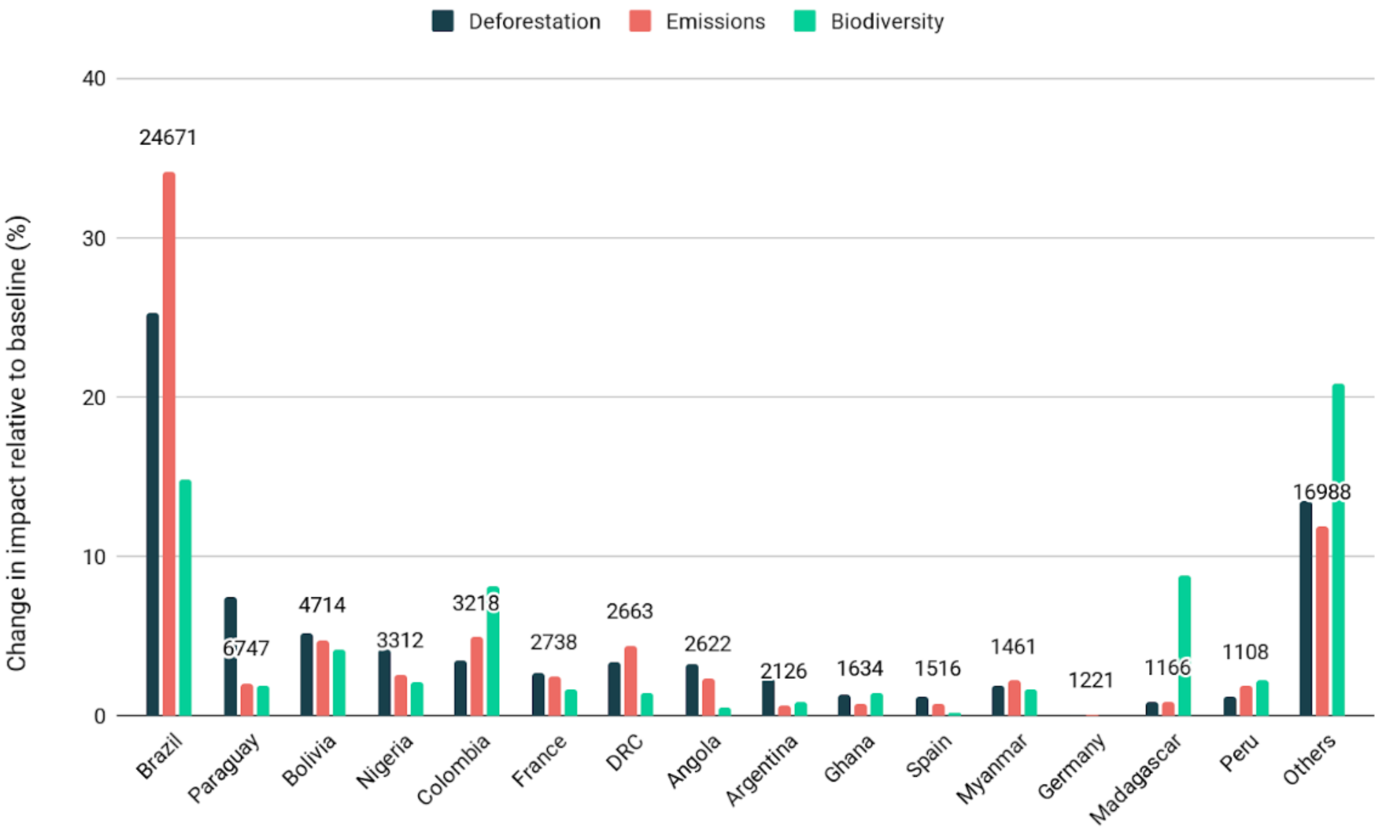

Figure 9. Change of impact in points of origin of the EU's cattle footprint relative to the baseline. Data is shown for high ambition non-EUDR levers combined with low ambition EUDR. Contributions to overall deforestation, emissions and biodiversity (Forest-LIFE) changes are provided. Labels show the original cattle deforestation footprint (ha) associated with each country.

4.4. Cocoa consumption

4.4.1. Lever description and implementation

For exploring cocoa-linked impacts, within the sustainable domestic consumption space, we target reductions in snack food consumption as part of transition to healthier diets as a key policy area. Linked to sustainable domestic production, we also explore the potential for cocoa-alternatives to be introduced into the EU market. Cocoa is not modelled within the border adjustment policy area because - as a high-value but lower-volume product that has no directly analogous production within the EU and therefore does not align with CBAM's 'levelling' objectives - we do not consider cocoa to be likely for inclusion in realistic future BAM developments. Table 5 provides a summary of the levers employed.

Table 5. Summary of policy levers impacting the cocoa footprint, the application of these levers across 'ambition' levels, and whether or not Member State-specific scaling occurs.

Area	Description	Lever and scenario level	Member State specificity
SDC	Reductions in snack food towards healthy diets	- Dietary campaigns aimed at reducing consumption of unhealthy foods; mandatory portion sizes; taxation on unhealthy food, (Increased reduction in cocoa consumption under low, med, high scenarios based on a 'backcasting' from Eat Lancet healthy diet recommendations)	Yes - using Sustainable Governance Indices
SDP	Development of alternatives to cocoa that can be produced within Europe	- Information campaigns and research and development in use of alternatives such as carob for niche markets (e.g. for consumers with health or sustainability concerns). (Same reduction applied in low, medium and high ambition scenarios) - Market-based investment in technologies and product-alternatives combined with policy-based incentives for uptake promotes substitution targeted at 'bulk' cocoa use (e.g. as an ingredient). Further regulatory intervention (e.g. mandatory targets for product formulation) required for higher uptake. (Modest reduction of cocoa applied in medium scenario, with higher reduction applied in high ambition scenario).	No - applied equally across Member States

4.4.1.1. Sustainable domestic consumption

For our reductions in snack food (SDC) lever we assume a reasonable estimate that 80% of cocoa demand in the EU is associated with chocolate or other snack products that might be implicated in health-linked policy. Approximately 90% of cocoa is traded as 'bulk cocoa' meaning that it is not associated with particular premium standards (e.g. on taste or sustainability) and we deem the remaining 10% to be out of scope of health-related policy measures (i.e. those buying premium chocolate continue to do so in similar quantities). Our cocoa scenarios are then based on objectives of reducing sugar consumption to EAT-Lancet levels (30g per person per day) from current EU levels (62.7g per person per day); a 52.2% reduction. A European's average annual intake of chocolate (5kg) is associated with 9.3% of their total sugar intake (5.8g of the approximately 62.7g of sugar intake by an average EU citizen), so this is 19.4% of the intake of the EAT-Lancet recommended total amount. Whilst theoretically possible that chocolate consumption could remain part of a healthy average diet if other sugar-containing products are reduced, we deem it likely that some reduction in chocolate intake would be achieved alongside other foodstuffs, albeit at a potentially lower rate. In the absence of information on the degree to which consumers would substitute other sugar-containing products, we assume that chocolate is half-as-likely to be substituted. Therefore, to achieve an EAT-Lancet diet, we assume existing levels of non-premium chocolate consumption fall by 26.1% (half of 52.2%). Using the assumptions above about the portion of the cocoa market that this impacts equates to a cocoa demand reduction of 18.8% (26.1% x 90% x 80%). This reduction is achieved in our 'high ambition' scenario which we envisage requiring a mix of dietary campaigns (including additional labelling), mandatory portion sizes and taxation on unhealthy food.

For our low ambition scenario we envisage a situation where only labelling measures are utilised and assume a modest reduction of 10% of the size of the high ambition scenario (i.e. a 1.88% reduction). For our medium ambition scenario in the absence of available data on sales per pack size (that might inform the degree to which sales of larger packs might influence overall demand) we make the assumption that pack-size-regulation, combined with labelling, accounts for a reduction in cocoa consumption of 4.7%[39]. For this lever, we envisage that the inclusion of behavioural change measures and potential controversy linked to taxation will mean that policy implementation may vary by Member State, and we apply the SGI-derived scores to scale country implementation which has the effect of weakening the reductions in cocoa demand described above for some countries.

39. This is relatively modest, mindful of the fact that even with levers to reduce portion sizes - overall - chocolate availability would remain similar and that whilst there may be some financial cost to consumers (i.e. smaller pack sizes cannot be offered with the same 'value for money') this could be avoided via utilisation of 'promotional purchasing' and is likely to be far less influential in dietary behavioural change than the taxation levers envisaged under our high ambition scenario.

4.4.1.2. Sustainable domestic production

For our cocoa alternatives (SDP) lever we observe the existing availability of more traditionally-produced alternatives to cocoa (such as carob) alongside a growing market in non-traditional formulations using more complex product lines (e.g. those using seed fermentation (ChoViva, 2025), waste products from other industries (Bitter, 2022) or locally-produced crop alternatives (Southey, 2024). Growth in the market for cocoa alternatives is expected with, for example, the cocoa butter alternatives market expecting a 6.91% annual growth rate between 2023 and 2032, and the carob powder market projected to grow by 3.8% per annum by 2030. Yet existing markets are very small in comparison with traditional cocoa products and we assume that market growth may be most likely as a substitute for where cocoa is used as an ingredient rather than as the main product of consumption - and within products focused on health or sustainability benefits. Given that carob currently has usage rates of less than 0.1% of the EU's use of cocoa, we envisage projected growth under a low ambition scenario could achieve a maximum reduction in cocoa demand of 0.5% which - even in this scenario - may require further investment in research and development and information campaigns to increase awareness of these product alternatives.

In medium and high ambition scenarios we consider the potential for further uptake as a substitute for bulk chocolate. For the medium ambition level we assume that alternative products may occupy up to 2.5% of the bulk cocoa market and 10% under high ambition levels. The increase in the medium scenario is selected on the basis of relatively minor use alongside 'true' cocoa in product formulation may not be noticed by consumers and could be met with relatively little resistance from manufacturers (but may still require regulation in the form of mandatory use or subsidy). At higher uptake rates (which might lead to consumer resistance) further policy intervention might be required (e.g. stipulating minimum percentages as an ingredient in lower-value cocoa-linked food items). Multiplying the market-penetration values by the share of bulk cocoa in the EU market (90%), and adding the additional market penetration from low ambition scenarios, results in reductions of 2.81% and 9.74% under medium and high scenarios. We assume within this lever that market penetration is equally distributed across Europe.

4.4.2. Results

4.4.2.1. Individual levers

When applied individually, the introduction of measures seeking to reduce snack food consumption, with a resultant reduction in cocoa use, result in reductions in the cocoa deforestation footprint of 1.20% (246 ha) under the low ambition implementation, 3.00% (612 ha) under the medium implementation and 12.0% (2,452 ha) under the high ambition implementation (Figure 10). The introduction of sustainable domestically-produced alternatives to cocoa has a more marginal influence on the baseline cocoa deforestation footprint with reductions of 0.19% (39 ha), 1.05% (215 ha) and 3.62% (740 ha) under low, medium and high ambition implementations, respectively. In comparison, the low ambition implementation of the EUDR results in a reduction of 23.3% (4,763 ha) from the baseline.

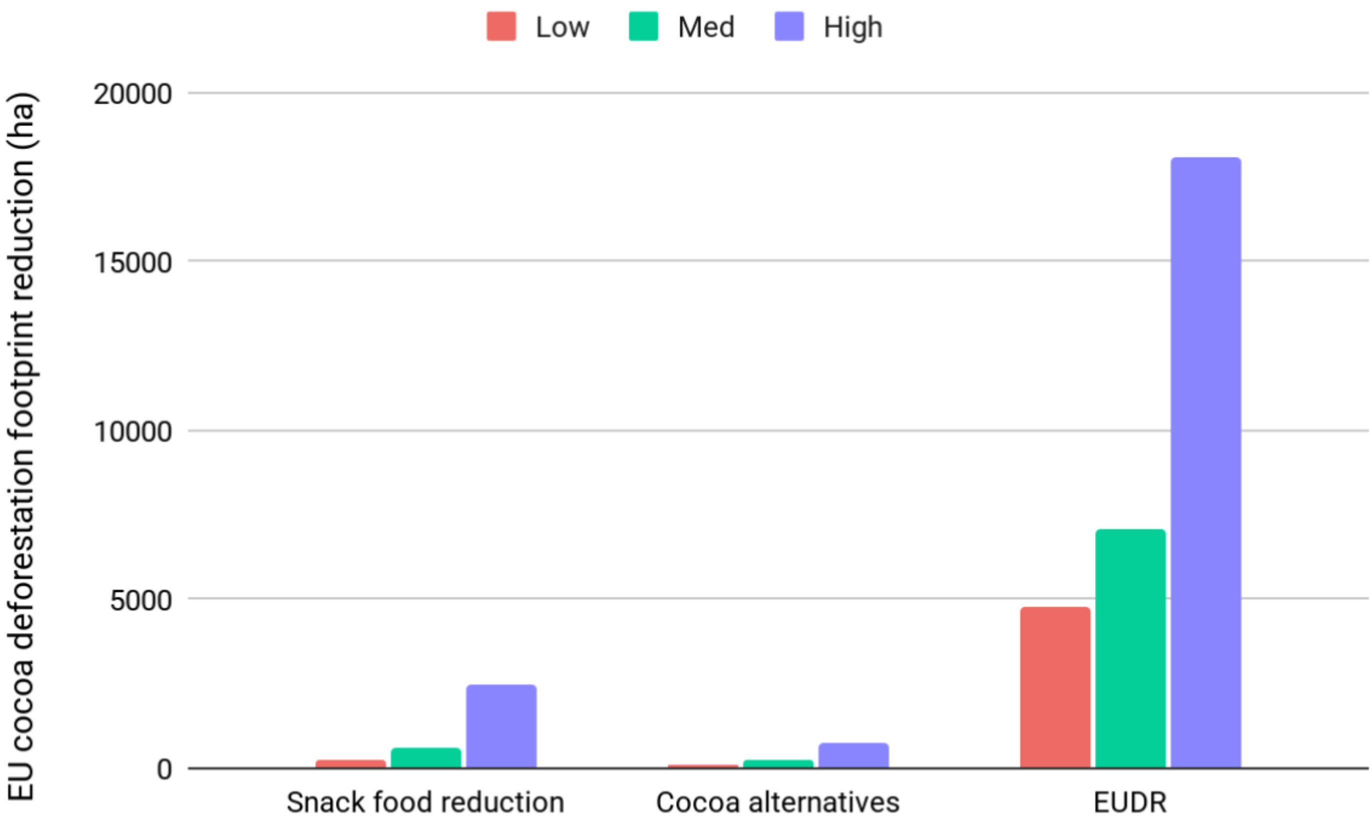

Figure 10. Changes (under low, medium and high ambition implementation) to the EU's commodity cocoa-deforestation footprints for individual levers as-implemented in the scenario model. Positive values are reductions to footprint.

4.4.2.2. Combined levers

Figure 11 shows the results of scenarios with combined levers. When all non-EUDR levers are applied, the reductions in deforestation footprint compared to the baseline are 284 ha (1.39% reduction), 821 ha (4.01%) and 3,104 ha (15.2%) for low, medium and high ambition scenarios. These are therefore below the deforestation footprint reductions achieved when the low ambition implementation of the EUDR is applied in isolation.

Combining the low ambition EUDR lever with high ambition non-EUDR levers results in the cocoa footprint falling to 12,088 ha, a reduction of 40.9% from the baseline. In other words, the addition of non-EUDR levers induces an additional 17.6% reduction (3,596 ha) in the footprint from the baseline compared to the application of low ambition EUDR in isolation. When high ambition EUDR implementation is applied alongside high ambition non-EUDR levers the cocoa deforestation footprint falls to 2,021 ha (a 90.1% reduction from the baseline), i.e. the addition of non-EUDR levers results in an additional 1.78% reduction in footprint compared with the isolated implementation of the high ambition EUDR.

In summary, the non-EUDR levers applied here for cocoa have a relatively small impact on the footprint unless applied under high ambition scenarios, and footprint reductions without the EUDR are more modest than the application of the EUDR under a low ambition scenario. When high ambition SDC and SDP levers are applied in combination with the low ambition EUDR, substantive further footprint reductions are obtained.

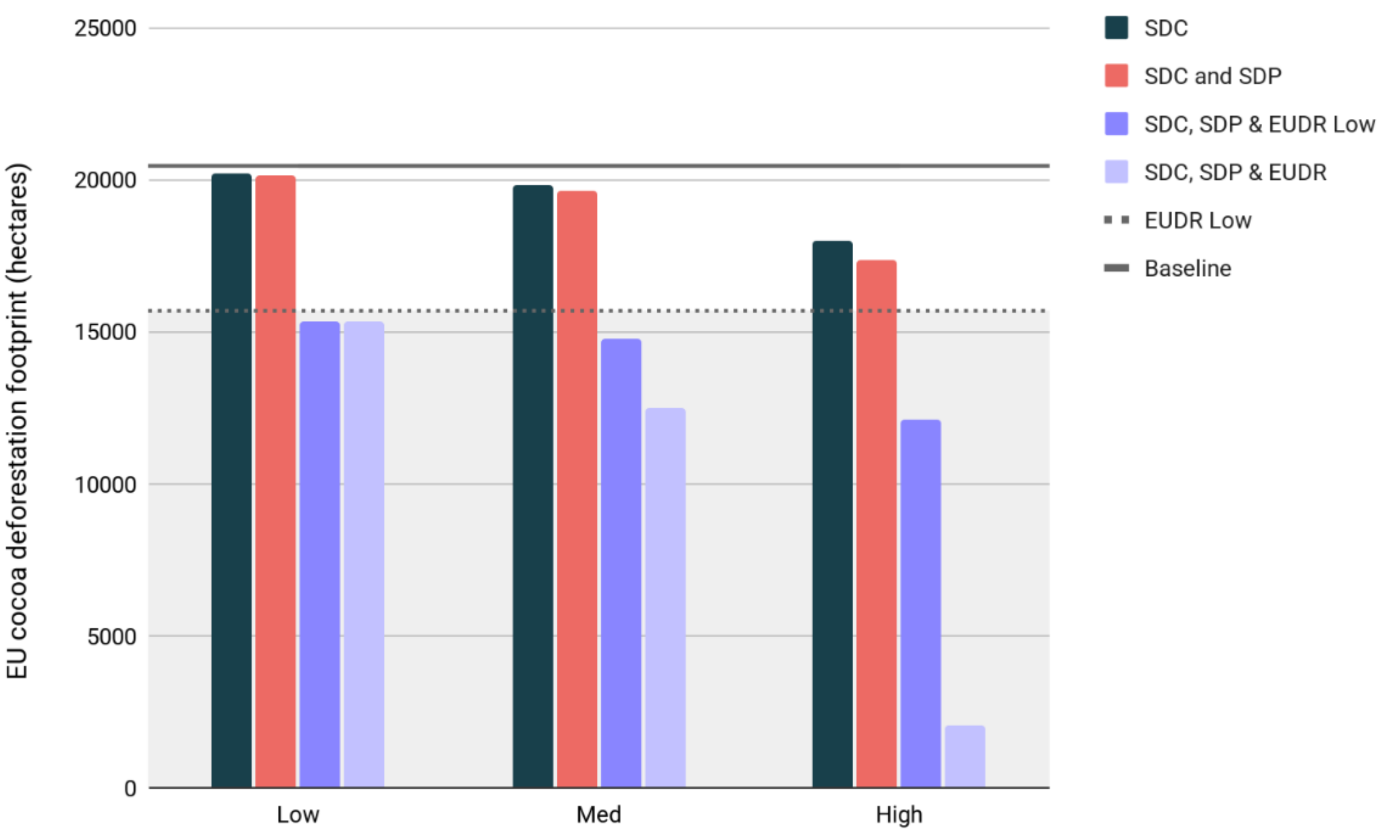

Figure 11. The EU's cocoa deforestation footprints for combined levers as implemented in the scenario model. The solid horizontal line shows the baseline footprint and the dashed horizontal line shows the cocoa footprint under the EUDR low ambition scenario when applied in isolation. For bars (with the exception of the bar including 'EUDR Low' where the EUDR is applied with low ambition), the level of ambition is stated on the x-axis, i.e. 'Med' = combinations of all levers with medium ambition.

4.4.2.3. Impacts at origins

Exploring the combination of high ambition implementation of non-EUDR levers (SDC and SDP) combined with the low ambition EUDR lever reveals that footprint reductions in Côte d'Ivoire dominate, contributing a 24.3% change from the EU27 baseline (Figure 12). Emission and biodiversity reduction contributions from Côte d'Ivoire, however, are somewhat lower at 12.5% and 16.7%, respectively. Colombia, which contributes a 4.28% reduction to deforestation from the baseline, has greater contributions to biodiversity impact changes (7.16%). Ecuador is also notable from a biodiversity perspective, contributing to a biodiversity impact reduction of 1.66% of the baseline, despite contributions to deforestation of 0.40%.

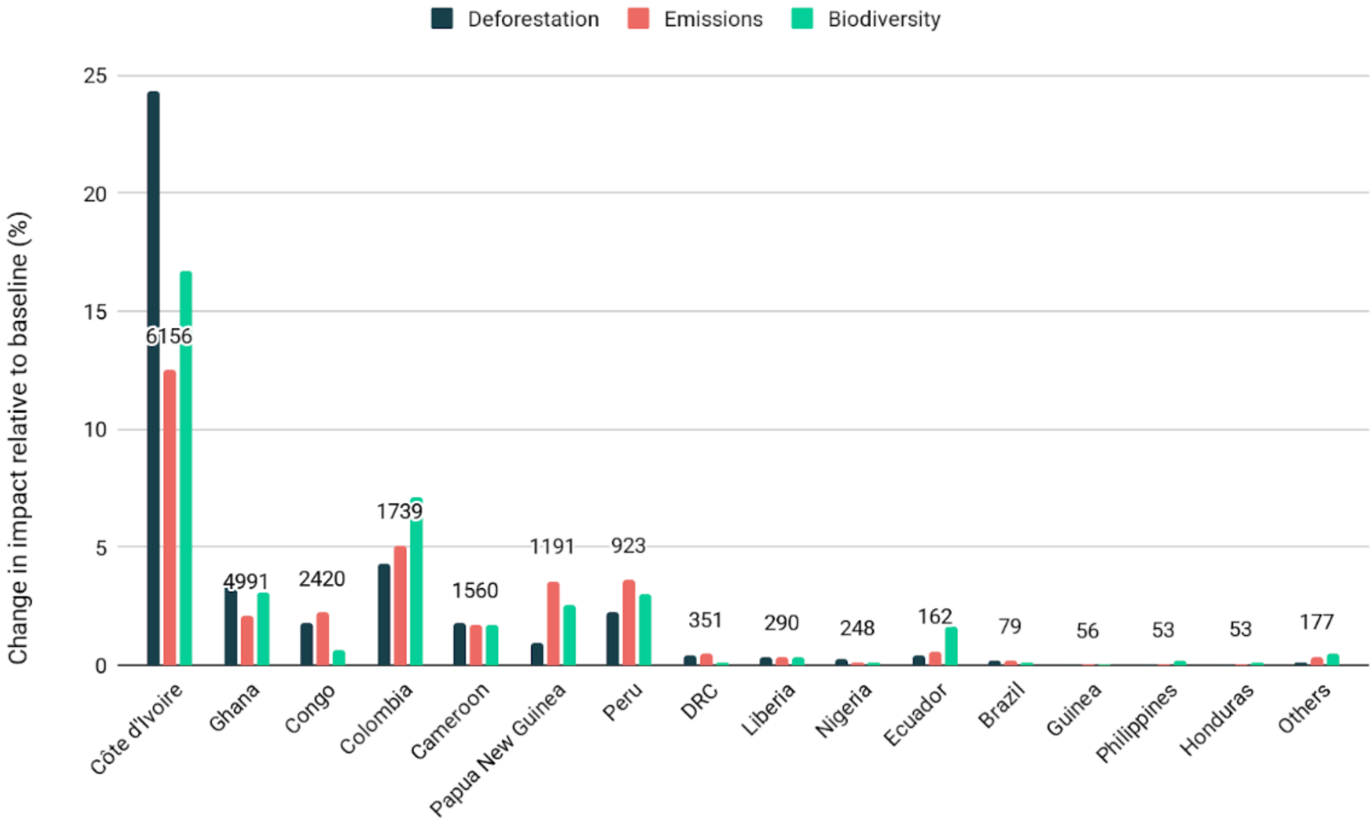

Figure 12. Change of impact in points of origin of the EU's cocoa footprint relative to the baseline. Data is shown for high ambition non-EUDR levers combined with low ambition EUDR. Contributions to overall deforestation, emissions and biodiversity (Forest-LIFE) changes are provided. Labels show the original cocoa deforestation footprint (ha) associated with each country.

4.5. Coffee consumption

4.5.1. Lever description and implementation

For exploring impacts linked to coffee, within the sustainable domestic consumption space we target reductions in coffee waste and smaller serving sizes as levers to reduce consumption. For the sustainable domestic production area, similar to cocoa above, we explore the potential for the introduction of coffee-alternatives into the EU market. Also as for cocoa (and for the same reasons), coffee is not modelled within the border adjustment policy area. Table 6 provides a summary of the levers employed.

Table 6. Summary of policy levers impacting the coffee footprint, the application of these levers across 'ambition' levels, and whether or not Member State-specific scaling occurs.

Area	Description	Lever and scenario level	Member State specificity
SDC	Reduction in coffee waste and smaller serving sizes	- Consumer-focused on waste in coffee-service environments; financial resourcing for training to avoid waste (Applies to low ambition scenarios upwards). - Consumer focused campaigns on reduced serving sizes (low ambition scenarios and upwards) and introduction of 'no capsule' pod-based brewing technologies (medium ambition)	Yes - using calculations on Member State-specific share of coffee consumption in different settings and differences in brewing technologies
SDP	Development of alternatives to coffee that can be produced within Europe	- Information campaigns and research and development in use of caffeine-alternatives (from various sources). (Same reduction applied in low, medium and high ambition scenarios) - Market-based investment in technologies and product-alternatives combined with policy-based incentives for uptake promotes substitution targeted at 'instant' coffee use. Further regulatory intervention (e.g. mandatory targets for product formulation) required for higher uptake. (Modest reduction of coffee applied in medium scenario, with higher reduction applied in high ambition scenario).	No - applied equally across Member States

4.5.1.1. Sustainable domestic consumption

For our reductions associated with coffee waste and serving size (SDC) levers, for coffee waste reduction potentials we focus on service environments where opportunities to train staff on waste reduction, opportunities to influence the use of technologies, and opportunities for more efficient demand-scheduling offer feasible mechanisms. Based on European statistics, we assume that 19.4% of coffee consumption takes place outside the home but adjust this value up or down for each Member State based on the share of coffee purchases in retail versus market environments. Coffee drunk in service outlets (e.g. cafes and restaurants, as opposed to office-environments) varies but in the absence of Member State-specific data we assume that 50% of out-of-home coffee is associated with service outlets. We were unable to obtain estimates of coffee beans/grounds that are wasted before brewing, so make the assumption of a 4% volume of avoidable waste via reasonable means[40]. Thus, for Austrian consumption (which we estimate has 12.8% out-of-home consumption) we assume that total coffee consumption reductions of 0.26% (12.8% x 50% x 4%) are possible via implementation of waste reduction measures. We implement this lever in the low ambition scenario (and upwards), deeming the

40. Estimates of general pre-consumer food loss in restaurants range from 4-10%, so this is at the lower end of that range (FoodPrint, 2024).

informational campaigns and basic training mechanisms underpinning this lever to be in the business interests to reduce overall waste (and therefore costs).

For serving size change, we assume that this lever focuses on home and office environments where the consumer is in more control of coffee methods and dosage size. We assume consumers who would have previously drunk single or double espresso continue to do so (i.e. there is no change in preferences) but that consumers are encouraged to reduce dosages size in espresso machines or by switching technologies to 'no capsule' based brewing methods[41]. Under a low ambition scenario, no technology switch is modelled, but we assume a reduction in dose-size by 12.5% (equivalent to switching from 8g to 7g (single espresso) and 16g to 14g (double espresso). Based on statistics, we assume 17% of coffee in home and office environments is instant (i.e. 83% is not) and that each Member State has a varying amount of coffee consumed in home/office environments compared to service outlets (see above). For example, Austria, which has 93.6% home/office consumption and 82% traditional coffee (vs 18% pod-coffee use) by volume, has a total reduction potential of 93.6% x 82% x 83% x 12.5% = 8.0%. In medium ambition scenarios, on top of this change we also assume a switch from traditional to 'no capsule' pod-based brewing, assuming a concurrent serving size reduction of 28.6% (7g to 5g for a single shot). Using existing shares of pod-brewing as a baseline, we assume an additional 20% of the home and office market uptakes pod-based brewing.

41. No-capsule pods do not contain e.g. plastic or foil wrappers which induce other environmental impacts.

Across both the waste and serving size levers, in addition to the reductions applied above we also consider that a small proportion of coffee consumed in the EU will not be for consumption as a hot beverage. In the absence of information on the percentage of coffee used as an ingredient in other products, we assume that 95% is consumed as a beverage and is therefore in scope of the levers described above. Note also that for coffee, we have no 'high ambition' scenario for sustainable domestic consumption, deeming that the mechanisms described above are achievable with 'medium' ambition levels.

4.5.1.2. Sustainable domestic production

For our coffee alternatives (SDP) lever we observe the existing availability of several alternatives in the market, including caffeine-free alternatives such as Caffe d'orzo (made from barley), and 'Swedish coffee' (a legume-based beverage), alongside a growing market products with synthetic caffeine addition such as products which contain a blend of non-coffee ingredients (Northern Wonder, 2025). Technologies for 'alternative' coffee production therefore exist (or are under development) and can make use of domestically-produced materials. However, while projected to have an 8.7% annual growth rate (to reach 2.66 billion US dollars by 2030), the current market share of alternatives is only 0.6% of the total coffee market so even with this growth alternatives would only represent the equivalent of 1.2% of the coffee market. We assume though that - under a low ambition scenario with further market-based investment - a reduction in coffee consumption of 0.6% is possible, and would likely focus on 'niche' areas where consumers take up these alternatives for health or sustainability reasons).

For more ambitious scenarios, we deem instant coffee (which occupies around 17% of the EU market) to represent a segment which could be a target for expansion of alternatives. However, one cannot translate this directly to an equivalent material reduction as instant coffee is the product of processing meaning that a greater share of green coffee is required than percentage-shares in the market might suggest. For every kilogram of instant coffee approximate 2.43 kg of green coffee is required, and we therefore estimate[42] that a 17% market share of instant coffee in the EU would equate to a 28.4% green coffee share. In comparison to cocoa, we envisage that policy intervention (supported, in a similar manner to cocoa, with potential regulation in the form of mandatory use or subsidy) may have the potential for somewhat higher penetration given the fact that instant coffee (even in comparison with 'bulk' cocoa used in chocolate) is a less premium product and may therefore face lower consumer-resistance on the basis of taste. In our medium ambition scenario we therefore assume that a 10% instant-coffee substitution rate is possible, resulting in a 2.84% total coffee reduction (applied on top of the 0.6% market penetration described above). In the high ambition scenario we assume a 40% substitution rate is possible, resulting in an 11.36% total reduction (11.96% when combined with the 0.6% market penetration described above). We assume within this lever that market penetration is equally distributed across Europe.

42. Using statistics based on the UK, which has a 41% market share of instant coffee which requires an estimated 92.34 kilotonnes of green coffee, which is 68.5% of total green coffee demand.

4.5.2. Results

4.5.2.1. Individual levers

When levers are run in isolation, the introduction of measures seeking to reduce coffee waste result in reductions in the deforestation footprint of 7.6% (452 ha) under the low ambition implementation and 11.6% (690 ha) under the medium (and high) implementation scenario (Figure 13). The introduction of sustainable domestically-produced alternatives to coffee has a relatively marginal impact, with reductions of 4.35% (259 ha) compared to the baseline in the high ambition implementation compared to just a 0.22% (13 ha) reduction under low ambition scenarios. In contrast, the low ambition implementation of the EUDR results in a reduction of 26.5% (1,577 ha) from the baseline.

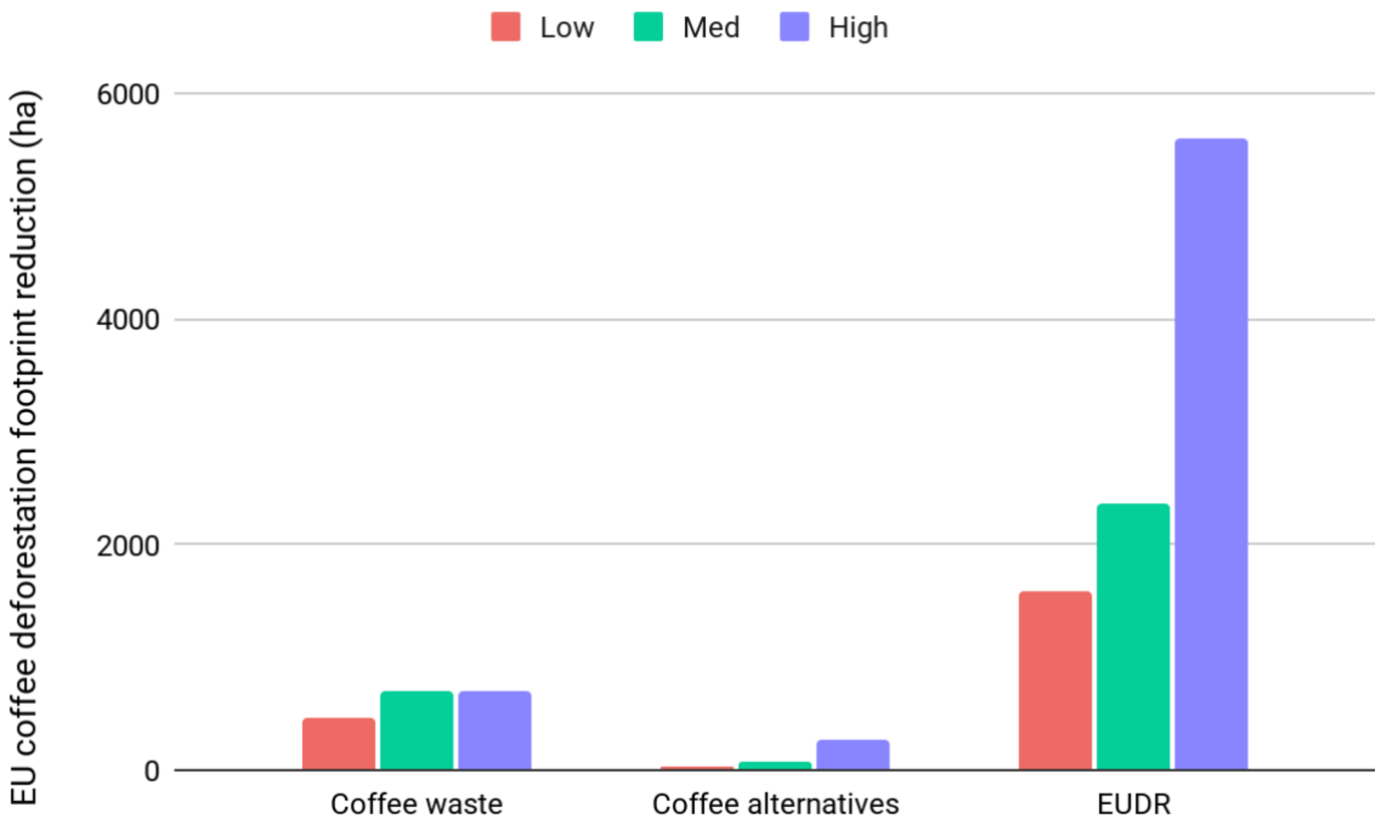

Figure 13. Changes (under low, medium and high ambition implementation) to the EU's commodity coffee-deforestation footprints for individual levers as-implemented in the scenario model. Positive values are reductions to footprint.

4.5.2.2. Combined levers

Figure 14 shows results of scenarios when levers are combined. When all non-EUDR levers are applied, the reductions in deforestation footprint compared to the baseline are 464 ha (7.80% reduction), 756 ha (12.7%) and 919 ha (15.4%) for low, medium and high ambition scenarios respectively. These are thus below the deforestation footprint reductions achieved when the low ambition implementation of the EUDR is applied in isolation.

Combining the low ambition EUDR lever in combination with high ambition non-EUDR levers results in the coffee footprint falling to 3,536 ha, a reduction of 40.6% from the baseline, i.e. the addition of non-EUDR levers induces an additional 14.1% reduction (838 ha) in footprint from the baseline compared to the application of low ambition EUDR on its own. When a high ambition implementation of the EUDR is applied in combination with high ambition non-EUDR levers the coffee deforestation footprint falls to 319 ha (a 94.6% reduction from the baseline), with the non-EUDR levers therefore only inducing an additional 0.5% reduction in footprint compared with a high ambition EUDR implementation alone.

To summarise, non-EUDR levers (SDC and SDP) applied for coffee can have a substantial impact on the EU27 coffee footprint, even if applied under low ambition scenarios. However, even if applied together, under our high ambition application, they do not achieve the reductions of a standalone low ambition EUDR implementation.

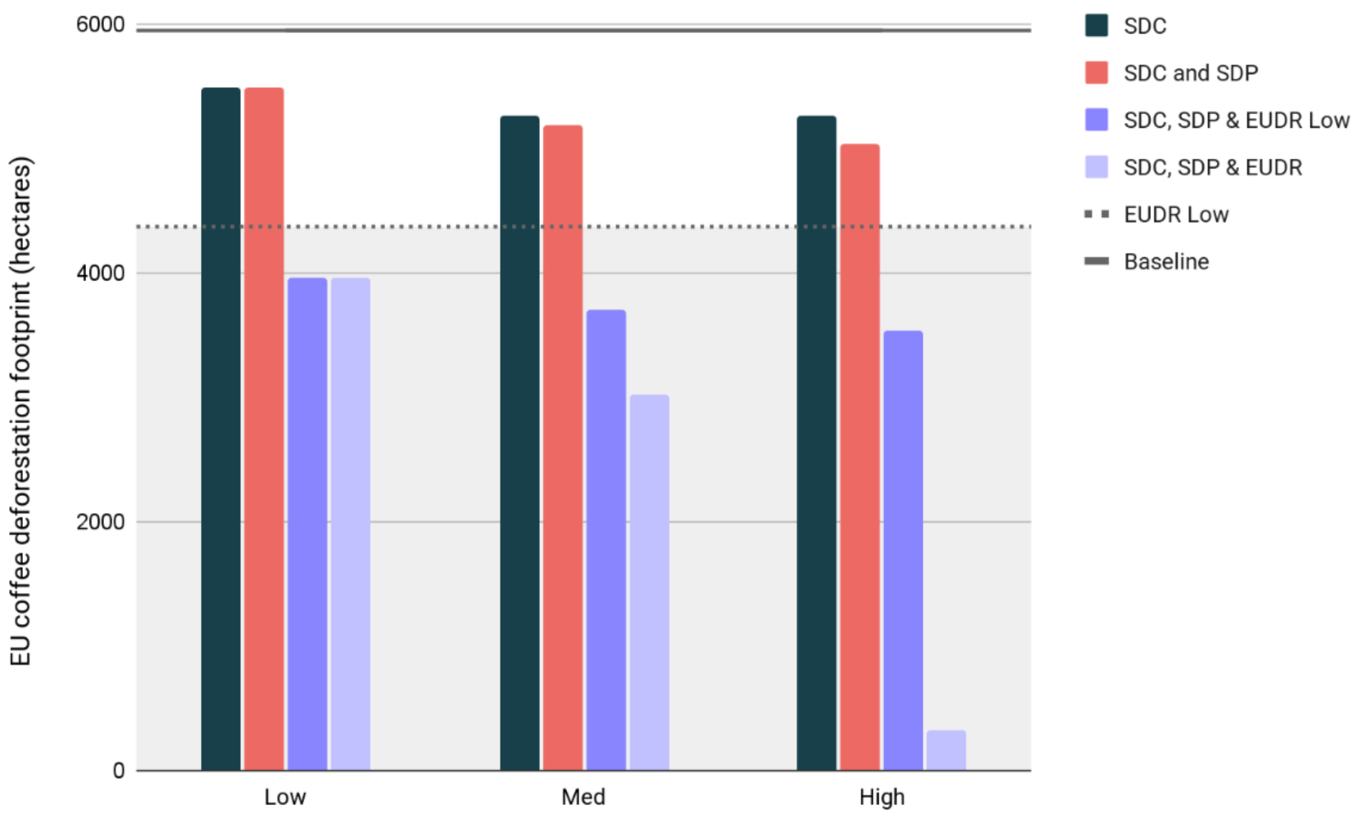

Figure 14. The EU's coffee deforestation footprints for combined levers as implemented in the scenario model. The solid horizontal line shows the baseline footprint and the dashed horizontal line shows the coffee footprint under the EUDR low ambition scenario when applied in isolation. For bars (with the exception of the bar including 'EUDR Low' where the EUDR is applied with low ambition), the level of ambition is stated on the x-axis, i.e. 'Med' = combinations of all levers with medium ambition.

4.5.2.3. Impacts at origins

When high ambition implementation of non-EUDR levers (SDC and SDP) is combined with the low ambition EUDR lever, footprint reductions associated with Peru are most substantial, making up a 21.9% impact reduction compared to the EU27 baseline (Figure 15). Emissions reduction contributions from Peru are even more substantial, making a 35.6% contribution relative to the baseline. Peru's contribution to biodiversity footprint reductions is more modest, however, at 9.97%. In contrast, Costa Rica makes up 5.04% of the change in biodiversity impact relative to the baseline, despite only contributing a change in deforestation impact of 1.28% relative to the baseline.

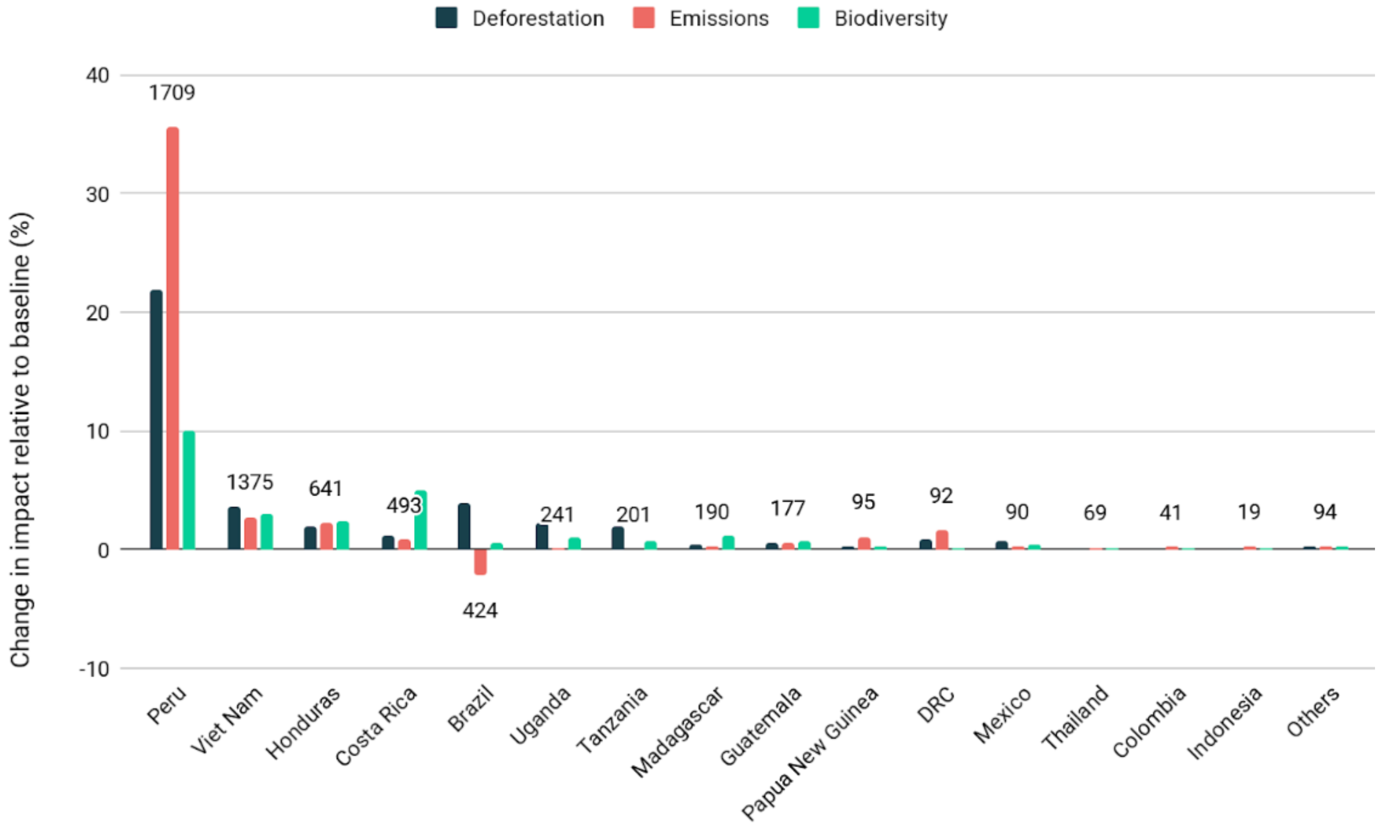

Figure 15. Change of impact in points of origin of the EU's coffee footprint relative to the baseline. Data is shown for high ambition non-EUDR levers combined with low ambition EUDR. Contributions to overall deforestation, emissions and biodiversity (Forest-LIFE) changes are provided. Labels show the original coffee deforestation footprint (ha) associated with each country.

4.6. Oil palm consumption

4.6.1. Lever description and implementation

Overall, mechanisms to reduce oil palm consumption in Europe are complicated by the fact that it is a highly-efficient (and therefore cost-effective) crop and - whilst palm oil is closely connected to deforestation - efforts to consume (and therefore scale up) alternatives would necessitate additional land requirements (i.e. land use change) with the potential for equivalent or more adverse environmental outcomes and lower cost- and resource- efficiency. We have therefore not explored a sustainable domestic production lever for oil palm, on the expectation that substitution for alternative crops within Europe is unlikely to be viable under reasonable scenarios. Furthermore, rather than assuming substitutability for other crops as an alternative for palm oil in consumed materials, for the sustainable domestic consumption lever we explore the potential for recycling waste as a mechanism to reduce the amount of palm oil required for biodiesel production. We also explore the role of an extension to the EU's carbon border adjustment mechanism to palm oil. Table 7 provides a summary of the levers employed.

Table 7. Summary of policy levers impacting the oil palm footprint, the application of these levers across 'ambition' levels, and whether or not Member State-specific scaling occurs.

Area	Description	Lever and scenario level	Member State specificity
SDC	Recycling waste for biodiesel	- Regulation, technological and logistics investment to allow diversion of food waste (remaining after diversion to produce animal feed) away from incineration towards biodiesel production. (High ambition scenario only).	Yes - using Sustainable Governance Indices
BAM	Border adjustment price applied to palm oil	- Carbon pricing (medium scenario) - Combined carbon and biodiversity pricing (high scenario)	No - changes applied in equivalent manner across all Member States

4.6.1.1. Sustainable domestic consumption

Palm oil is used in a wide variety of consumer products, with the particular properties that it provides combined with its high cost-efficiency, making it a particularly attractive ingredient in product formulations. However, two-thirds of palm oil used within the EU is actually linked to biodiesel production, with the EU recognising it as a potentially unsustainable feedstock and looking to phase it out by 2030 from use as a 'renewable' energy source where it is associated with a high risk of indirect land use change. Here we explore the potential for a stringent use of food waste recovery from households and restaurants and a ban on incinerating food waste for energy recovery as a mechanism to displace current palm oil use for biofuel[43]. In addition to these regulatory levers, this would require further research and development on the production of biodiesel from food waste, and investment in improved logistics for waste collection. Given these requirements, we treat this lever as 'high ambition'.

Using data on food waste availability from Eurostat (and accounting for potential reduction in availability due to the introduction of food waste utilisation in the soy-linked policy levers described above), we assume that currently-composted waste continues to undergo this treatment. We also assume that food waste destined for landfill is converted to biogas, meaning that 10.3 million tonnes that would otherwise have been destined for incineration is theoretically available for conversion to biodiesel. Conversion of food waste to biodiesel is a product of the type of waste and technologies

43. Alternative mechanisms to reduce absolute biofuel use, such as electrification, are not considered in this study.

used, but adopting a 16% conversion efficiency (Searle and Malins, 2016) to food waste after dehydration (30% fresh weight) results in the potential for around 500 kilotonnes, or 561 million litres, of biodiesel production. The EU produced 15 billion litres of biodiesel in 2020, of which 31% (4.7 billion litres) was palm oil-derived in 2020 (IEA Bioenergy, 2023; Rangaraju, 2021). Thus, a reduction of 561 million litres via food-waste derived alternatives has the potential to reduce the use of palm oil for biodiesel by 12.1%. We apply these reductions to EU Member State palm oil consumption, with adjustments to the successful implementation of this measure (i.e. the potential for full food waste recovery) based on the Sustainable Governance Indices of Member States.

4.6.1.2. Border adjustment mechanism

For the border adjustment mechanism (BAM) levers, under medium and high ambition scenario space we include oil palm/palm oil as a product covered by an extension to the existing regulation. As for soy and beef, we explore a medium ambition scenario on the basis of a carbon price of €70 per tonne of GHGs emitted. With an average of 0.86 tonnes for carbon equivalent emissions arising per tonne of palm oil[44], this results in a potential BAM price of €60 per tonne of palm oil, which is somewhat lower than the equivalent prices for soy and beef explored above. Assuming bulk commodity prices of €900 per tonne (Statista, 2025b), the extra price of carbon would result in around a 6.7% increase in the price of palm oil. With all palm oil currently imported (i.e. no potential for exact substitution domestically) and with demand elasticities of oilseeds comparatively low, we estimate a relatively small decrease in palm oil consumption in this scenario of 2.5% which affects imports from all palm oil origins. Under the high ambition scenario, the effects of an additional price linked to biodiversity impacts is explored. Palm oil also has a lower LIFE score per tonne than either soy or beef. Palm oil's LIFE score is 36% of soy's and with a biodiversity price for soy set at €100 per tonne, we therefore impute a biodiversity price for palm oil of €36 per tonne. Acting in addition to the price for carbon, this results in a total price of €96 per tonne (a 10.7% increase against the bulk commodity price) which we translate to a further 1.5% reduction in demand, with overall palm oil-associated demand reductions thus applied at 4% in our model (applied across all import sources).

44. Associated with growing and refining crude palm oil (Efeca, 2022).

45. Given that no production of palm oil takes place domestically, all sources are considered high risk for palm oil and therefore equally affected.

4.6.2. Results

4.6.2.1. Individual levers

When taken individually, the levers seeking to recycle food waste as an alternative to palm-oil derived biofuel reduce the deforestation footprint compared to the baseline by 3.28% (668 ha) (applied under high ambition scenarios only) (Figure 16). The introduction of a border adjustment mechanism targeting palm oil results in a reduction from the baseline of 2.63% (536 ha) in the medium ambition scenario and 4.17% (849 ha) in the high ambition scenario. In contrast, the low ambition implementation of the EUDR results in a reduction of 29.8% (6,067 ha) from the baseline.

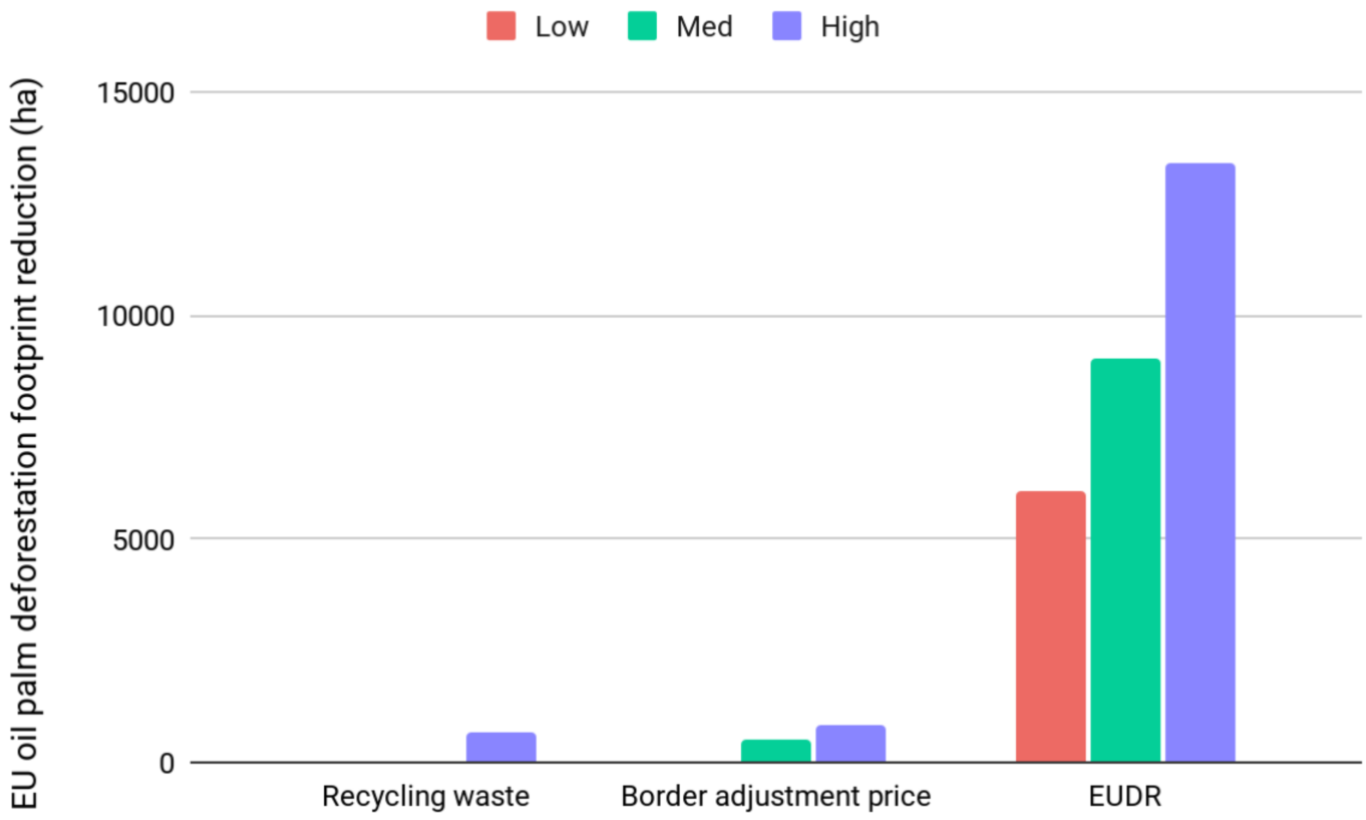

Figure 16. Changes (under low, medium and high ambition implementation) to the EU's commodity oil palm-deforestation footprints for individual levers as-implemented in the scenario model. Positive values are reductions to footprint.

4.6.2.2. Combined levers

The results from scenarios combining policy levers is shown in Figure 17. When all non-EUDR levers are applied, the reductions in deforestation footprint compared to the baseline are 687 ha (3.37% reduction) under a medium ambition scenario and 1,697 ha (8.34%) under a high ambition scenario. These are therefore substantially below the deforestation footprint reductions achieved when the low ambition implementation of the EUDR is applied in isolation.

Combining the low ambition EUDR lever with high ambition non-EUDR levers results in an oil palm footprint of 12,994 ha, a reduction of 36.2% from the baseline, i.e. the addition of non-EUDR levers induces an additional 6.35% (1,292 ha) reduction of the footprint from the baseline in comparison to an isolated application of low ambition EUDR. When high ambition EUDR implementation is applied alongside high ambition non-EUDR levers the oil palm deforestation footprint falls to 6,046 ha (a 70.3% reduction from the baseline), i.e. the addition of non-EUDR levers results in an additional 4.54% reduction in footprint compared to isolated implementation of high ambition EUDR.

Overall, the non-EUDR levers applied for oil palm have a modest impact on the baseline deforestation footprint when applied under high ambition scenarios, and these are substantially lower than the footprint reductions that are achieved under the low ambition EUDR implementation.

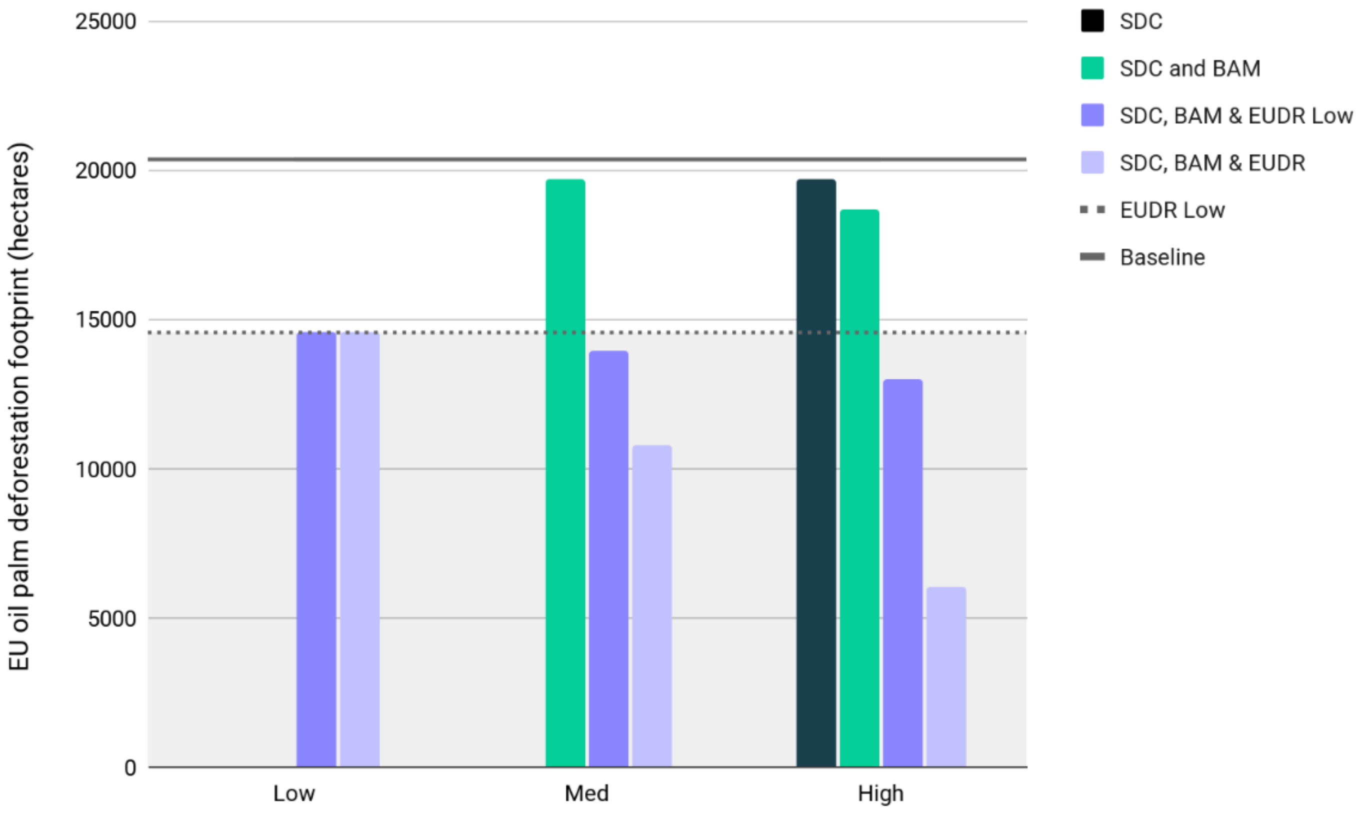

Figure 17. The EU's oil palm deforestation footprints for combined levers as implemented in the scenario model. The solid horizontal line shows the baseline footprint and the dashed horizontal line shows the oil palm footprint under the EUDR low ambition scenario when applied in isolation. For bars (with the exception of the bar including 'EUDR Low' where the EUDR is applied with low ambition), the level of ambition is stated on the x-axis, i.e. 'Med' = combinations of all levers with medium ambition.

4.6.2.3. Impacts at origins

Exploring results from the combination of the high ambition implementation of non-EUDR levers (SDC and BAM) with the low ambition EUDR lever reveals that Indonesia (25.2%) and Malaysia (19.0%) contribute most substantively to changes in deforestation impact relative to the baseline (Figure 18). Emission reduction contributions from Indonesia are even more substantive, representing an impact change of 33.2% relative to the baseline. Malaysia, on the other hand, makes an outsized contribution to biodiversity footprint reductions, with a change in impact of 17.4% relative to the EU27 baseline biodiversity impact.

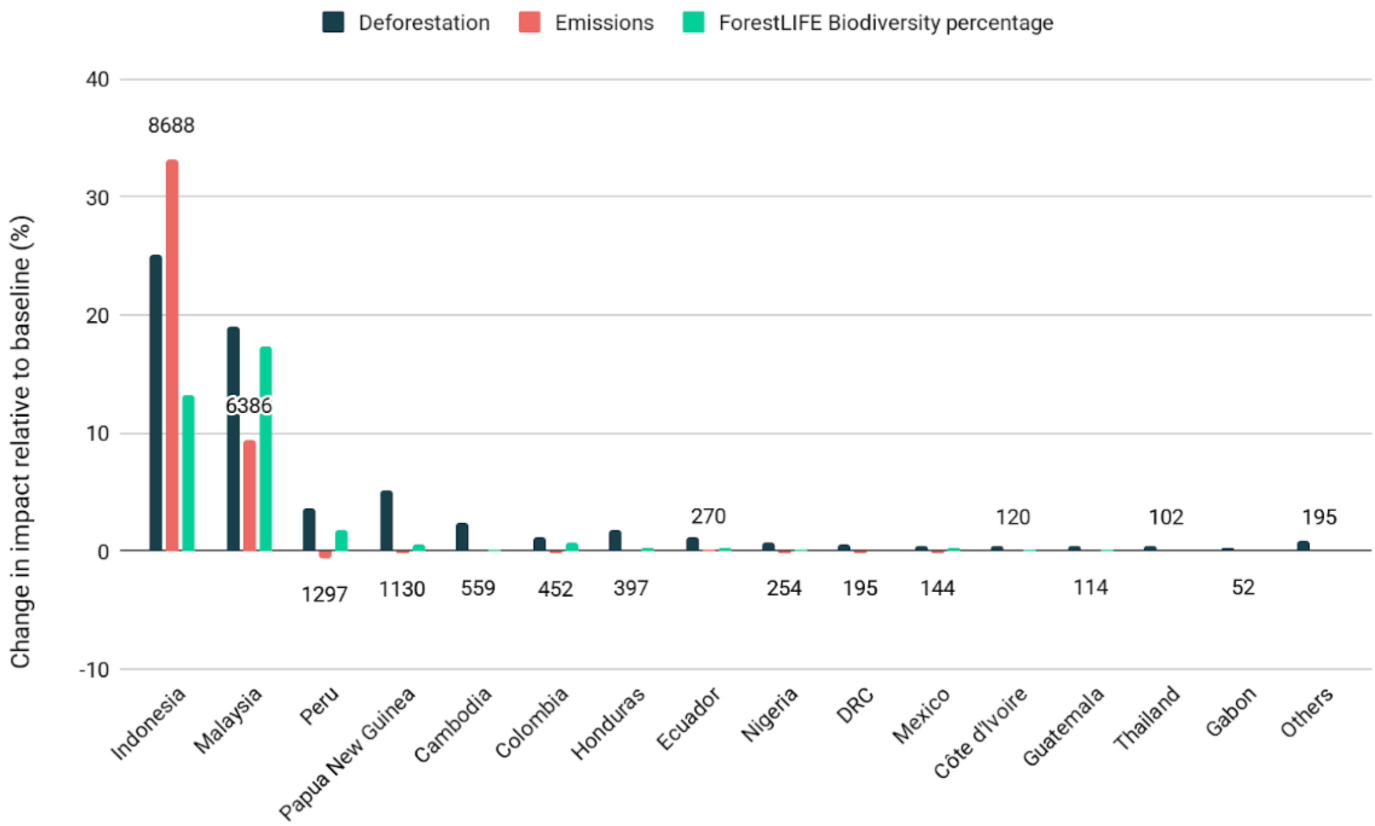

Figure 18. Change of impact in points of origin of the EU's oil palm footprint relative to the baseline. Data is shown for high ambition non-EUDR levers combined with low ambition EUDR. Contributions to overall deforestation, emissions and biodiversity (Forest-LIFE) changes are provided. Labels show the original oil palm deforestation footprint (ha) associated with each country.

4.7. Timber consumption

4.7.1. Lever description and implementation

For consumption of timber, we explore two sustainable domestic consumption levers: waste reduction via a shift to prefabrication techniques in the construction industry, and a diversion of timber away from energy use lever which reduces the use of wood in biomass or waste-to-energy incineration. Under the sustainable domestic production area, we explore the potential for increased domestic timber production via enhanced forest management and the expansion of agroforestry systems over abandoned agricultural land or pasture. Finally, we explore the implications of border adjustment mechanisms on timber demand, which operates indirectly in response to an increase in steel prices envisaged under the current implementation of the EU's carbon border adjustment mechanism. We do not consider timber to be a likely candidate for direct inclusion in border adjustment mechanism policy. Table 8 provides a summary of the levers employed.

Table 8. Summary of policy levers impacting the timber footprint, the application of these levers across 'ambition' levels, and whether or not Member State-specific scaling occurs.

Area	Description	Lever and scenario level	Member State specificity
SDC	Waste reduction via prefabrication in construction	- Investment in training, R&D, and regulation lead to increased share of prefabrication in construction projects and potential for increased rates of waste recovery compared to traditional building methods. (Increasing shares of prefabricated construction with improved waste recovery occurring across low, medium and high scenario space).	Partial - uptake applied EU-wide but with uptake under low ambition scenarios depending upon baselines which vary by Member State.
	Timber diversion away from energy use	- Regulation to end practice of primary timber being used for energy (medium ambition) - Additional investment in enhanced waste recovery to re-use wood that would otherwise be incinerated (high ambition; applied on top of diversion of primary timber)	Yes - reductions applied consistently across the EU but according to Member State-specific biomass flows.
SDP	Increased domestic timber production	- Market-driven increases in production via enhanced forest management (low ambition and above) - Support for farmers to promote agroforestry over degraded and priority pasture land (high ambition).	Yes - potential increases in output from existing forest systems based on Member State-specific projections; availability of abandoned and priority pasture land varying by Member State.
BAM	Border adjustment implications of increased steel prices	- Carbon pricing on steel leads to substitution by timber in construction (low ambition)[46] - Combined carbon and biodiversity pricing (high scenario)	No - sourcing changes applied in equivalent manner across all Member States.

4.7.1.1. Sustainable domestic consumption

For our waste reduction via prefabrication (SDP) lever we observe the potential for a shift in material processing away from sites of construction where materials can be prepared with more precision in a more controlled environment. Studies (Hao et al., 2021; Lu et al., 2021; Tavares et al., 2021; Zhang and Pan, 2022) have suggested waste-saving opportunities from prefabrication to range widely (from 26% to 80%), but a recent study using data from over 400 construction projects estimates the use of prefabrication can result in reductions in organic waste (including wood) of 28%. Foreseen reductions in timber demand will also be a result of the extent to which the

46. Technically, this level does not require the introduction of 'new' policy, being covered already by the existing scope of the EU border adjustment mechanism to reduce steel demand. However, we envisage that the push towards timber as an alternative may still require encouragement via EU and national policies.

industry shifts methods from in-situ construction to prefabricated materials. With modular construction in Europe projected to grow by 5.8% per annum it would reach a value of US$27.3 billion by 2030, but this is still a small share of the construction sector as a whole. Increasing shares of modular and prefabricated building techniques will likely therefore require a combination of regulation to make some prefabrication mandatory in construction processes, financial incentives, training, and investment in research and development. That said, approximately 32.4% of all construction projects throughout Europe integrate some form of prefabricated construction methods, with adoption highest in the Netherlands and Belgium at 47% and 46%, respectively. In our low ambition scenario, we assume that background market growth is accompanied by some investment in training to promote uptake of prefabrication. We envisage that this would have the effect of increasing the share of prefabrication by 5% compared with baseline levels[47]. In a medium ambition scenario, we assume more rapid growth of prefabricated construction which would require, for example, the provision of explicit financial incentives for R&D, investment in infrastructure and capital, and further company-wide training to drive uptake. A push from the European Commission to 'level up' all Member States to a share of prefabrication use of 52%, (the share of the Netherlands under the low ambition scenario) is applied EU-wide under this scenario. Furthermore, additional R&D investment contributes to an increased waste reduction potential for the prefabricated share of the market of 5% (from 28% to 33%). Under high ambition scenario space we assume a 100% adoption rate of some prefabrication methods within construction projects. Such shifts would likely require regulation that mandates implementation as well as further investment in training and logistics reorganisation. Here, we also envisage a further 5% increase in waste reduction potential (to 38%). To translate changes in uptake of prefabrication into resultant changes in the construction industry's timber demand (based on available statistics) we estimate that 14.6% of current construction sector wood demand is wasted, and we account for the shares in this waste that would be allocated between prefabricated and traditional construction methods baselines in order to calculate 'timber requirements-for-waste' for each construction type.

The EU currently uses primary and waste timber for energy generation in large quantities. Diversion of wood away from energy use would therefore require significant forward planning combined with increases in alternative renewable energy sources, ultimately likely requiring EU-level regulation (such as a ban on the practice of burning primary timber[48] for energy production, improvements to waste sorting procedures to facilitate waste recycling rather than incineration, and investment in alternative energy sources to replace energy from biomass). We therefore consider the timber diversion away from energy use lever to act only under medium and high ambition scenarios. We use published biomass flows for each EU Member State that allow the proportion of original roundwood supply currently used for energy (compared to total roundwood requirements in a Member State) to be calculated. We then assume primary demand for timber is reduced by these proportions for each Member State. Under the medium ambition level, primary wood flows and 'unaccounted' wood flows to domestic energy recovery are diverted to other industries, thereby reducing overall wood demand.

47. Specific baselines are available for the Netherlands, Belgium, Germany, Poland, France, Spain and Italy and for other EU countries we use the average across these countries of 32.4%.

48. I.e. materials from virgin wood sources.

Under the high ambition level - which we envisage would also require investments in improved waste sorting schemes on top of regulation to end primary wood use for energy - primary wood flows, 'unaccounted' flows and fifty-percent of 'industry byproduct' flows to domestic energy recovery are diverted (i.e. 50% of industry byproducts can still be used for energy based on the assumption that some byproducts cannot be recovered, particularly if they have already previously been diverted away from energy use).

4.7.1.2. Sustainable domestic production

For the increased domestic timber production lever we explore mechanisms to increase EU domestic production as a substitute for overseas demand. We envisage that expansion of agroforestry onto previously abandoned agricultural land or onto non-occupied pasture[49], plus increased output from existing timber plantations, offer potential routes to increasing domestic supply. Under low ambition space, we assume that enhanced forest management occurs in existing forest areas based on published Member State-specific projections[50] of increased roundwood productivity (Vauhkonen et al., 2019). Change in projected felling intensity was used as a proxy for changes in future roundwood production and we assume that growth is largely driven by market demand, requiring some broader investments by industry.

A high ambition scenario[51] adds the potential for additional timber production under agroforestry systems. This may require funding for farmers to establish and maintain new agroforestry systems through direct payments, support and training for farmers and land managers on agroforestry system methods, and potential subsidies for sellers and purchasers of agroforestry timber to ensure price competitiveness with traditional forest systems. Using projections (Perpiña Castillo et al., 2021) that 3% of EU agricultural land will be abandoned by 2030, and areas of agricultural land provided by FAO, we calculate the area of abandoned land available for each Member State. This land is then assumed[52] to be available for mixed silvopastoral agroforestry plantations, with planting assumed to take place at a quarter of the density of traditional mixed broadleaf forest plantations to enable its future joint use as pasture. Accounting for this density difference, this new land area is then compared to existing Member State forest area to calculate the potential timber-output increase. In addition to occupation of abandoned land, we also explore the potential for agroforestry to utilise 'priority area' land which (as defined by Kay et al., 2019) is degraded pasture and could be improved by agroforestry systems. Kay et al., (2019) provide estimates of priority area availability across 11 Member States and, where Member State data are unavailable, we assume that 5.5% of pasture is available (which is the average percentage for the 11 Member States). Making the same assumption that timber production takes place with one-quarter of the productivity of traditional mixed broadleaf plantations, we calculate potential timber-outputs for this land use change.

4.7.1.3. Border adjustment mechanism

Here, we consider how the EU's current implementation of the carbon border adjustment mechanism may implicate timber demand. The premise here is that a

49. Agroforestry is selected on the basis of its potential role to improve degraded agricultural lands or abandoned pasture. Traditional forest systems may provide more output and be more suitable in some Member States. See also Discussion.

50. Data for 18 Member States is available, and we use the EU-average where it is not.

51. We do not envisage a 'medium' ambition scenario, as expansion of agroforestry across land in Europe will require large shifts in production practices and associated regulatory and investment levers which we deem to be one the more ambitious end of policy space.

52. After deducting an area of land which is destined for use in our Sustainable Domestic Production lever applied to rubber, described below.

key use of steel is for construction (making up 37% of total EU steel demand), where alternative - low-carbon/renewable - resources such as timber may offer lower-cost substitutes for the industry to offset any reductions in steel use from overseas. We focus particularly on material utilisation by the construction industry rather than other sectors because steel use in automotive/transport, mechanical engineering, metalware and tubes and domestic appliances have no direct analogues for steel-substitution across our focal commodities. In construction, however, it is reasonable - also in light of the EU's broader sustainable construction agendas - that some uses of steel in the industry (such as for structural beams, or cladding) could be replaced by products derived from timber. Currently, approximately 20-30% of the EU's total steel consumption is imported; we adopt the 30% value along with EC (European Commission, 2021b) expectations that imports of iron and steel under CBAM could reduce by 12% by 2030. Combined, this results in an estimate that total steel demand reductions of 3.6% could take place, with a 1.33% total reduction linked to construction demand. We assumed a one-to-one substitution with timber, which is reasonable based on (D'Amico and Pomponi, 2020). In 2022, steel consumption in the EU was estimated at approximately 148 million metric tonnes, meaning that there is potential for 1.97 million metric tonnes to be replaced by timber as a result of the border adjustment mechanism. We estimate that timber use for engineered wood products and timber frames amounts to 27.9 million tonnes currently[53], and thus an estimated 7.1% increase in timber used in the EU construction industry. We assume that this increase in timber demand is spread across all of the producer countries which currently supply timber to the EU (including within the EU) in accordance with the current supply relationships.

53. Based on estimates of 31m cubic metres (Haisma et al., 2023) combined with a conversion of cubic-metres to tonnes of 1.11 (Teeuwen et al., 2021).

4.7.2. Results

4.7.2.1. Individual levers

Applied in isolation, the introduction of measures seeking to reduce timber waste via prefabrication (SDC) have a marginal impact on the footprint across all ambition levels, with only a 0.44% (87 ha) footprint reduction even under high ambition levels (Figure 19). In contrast, potential reductions in footprint associated with the diversion of timber away from energy (SDC) are much more pronounced, with medium ambition application resulting in a 33.7% (6,585 ha) footprint reduction and high ambition application resulting in a 38.5% (7,532 ha) reduction. Reductions associated with sustainable domestic timber production levers are also quite pronounced, with a 8.26% (1,617 ha) reduction achieved when this lever is applied in isolation under a low ambition scenario and a 18.9% (3,696 ha) reduction under high ambition. The application of the CBAM steel lever (which increases timber consumption) has a modest negative effect on the timber deforestation footprint, with a 0.87% increase (171 ha). Timber diversion from energy and sustainable domestic timber production levers exceed the footprint reductions modelled under low (1.49%, 292 ha) and medium (2.57%, 502 ha) scenarios for the EUDR lever applied in isolation.

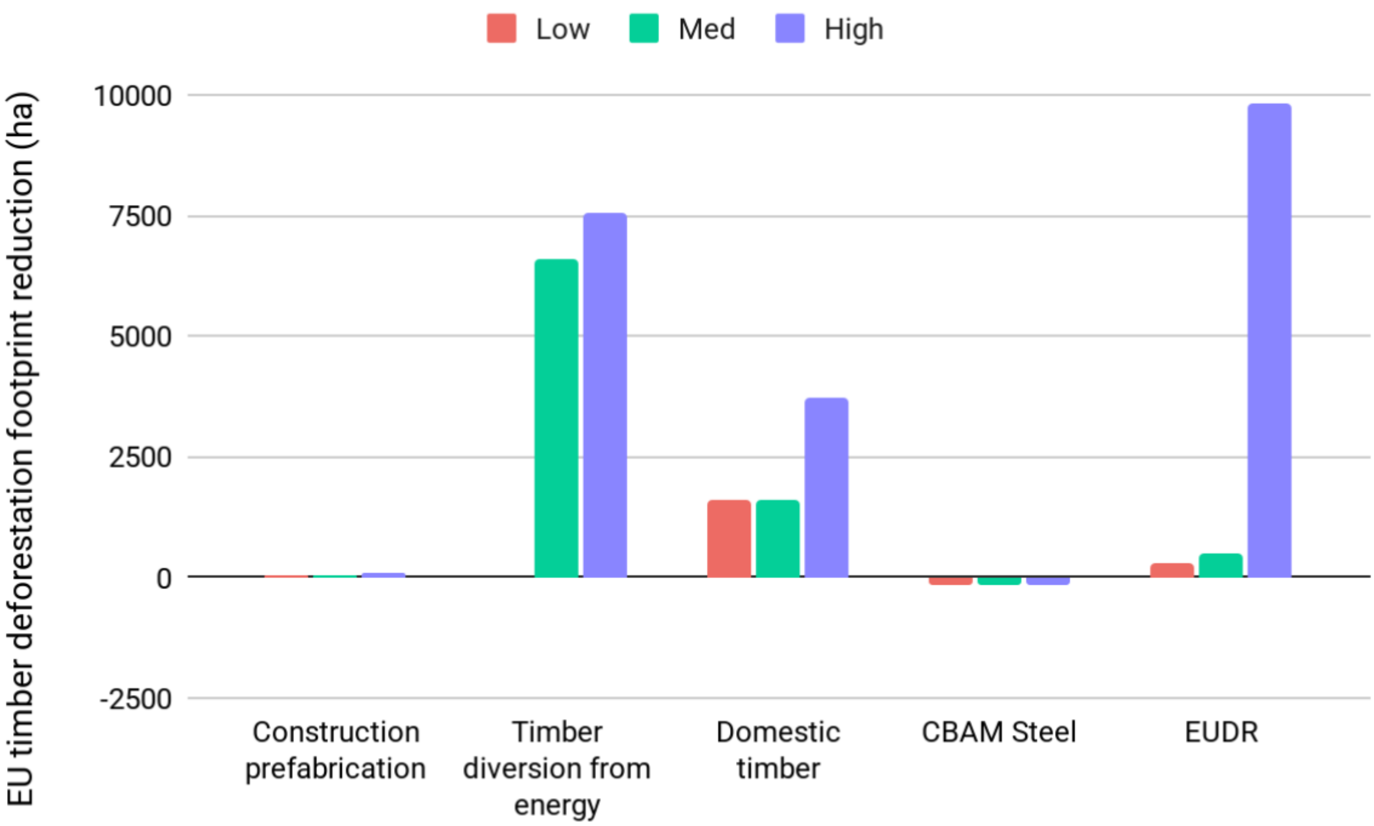

Figure 19. Changes (under low, medium and high ambition implementation) to the EU's commodity timber-deforestation footprints for individual levers as-implemented in the scenario model. Positive values are reductions to footprint.

4.7.2.2. Combined levers

Figure 20 shows the combined scenario results. Applying non-EUDR levers in combination results in reductions in the deforestation footprint compared to the baseline of 1,337 ha (6.83% reduction), 7,723 ha (39.5%) and 10,273 ha (52.5%) for low, medium and high ambition scenarios. Under all ambition levels these therefore exceed the deforestation footprint reductions achieved by the low ambition implementation of the EUDR in isolation, with medium and high ambition applications of non-EUDR levers greatly exceeding low ambition EUDR results.

Combining the low ambition EUDR lever with high ambition non-EUDR levers results in the timber footprint falling to 9,053 ha, a reduction of 53.7% from the baseline, i.e. the inclusion of non-EUDR levers induces an additional 52.2% reduction (10,221 ha) in the footprint from the baseline compared to the application of low ambition EUDR in isolation. When high ambition EUDR implementation is applied alongside high ambition non-EUDR levers the timber deforestation footprint falls to 4,773 ha (a 75.8% reduction from the baseline), i.e. the inclusion of non-EUDR levers results in an additional 25.6% reduction in footprint compared with the isolated implementation of the high ambition EUDR.

In summary, the non-EUDR levers applied here for timber have a substantial impact on the deforestation footprint, particularly when applied under medium and high ambition scenarios. When the low ambition (and medium ambition) EUDR implementations are applied in combination with non-EUDR levers, only marginal additional reductions are obtained (i.e. the EUDR low and medium ambition scenarios are comparatively weak for timber, as modelled).

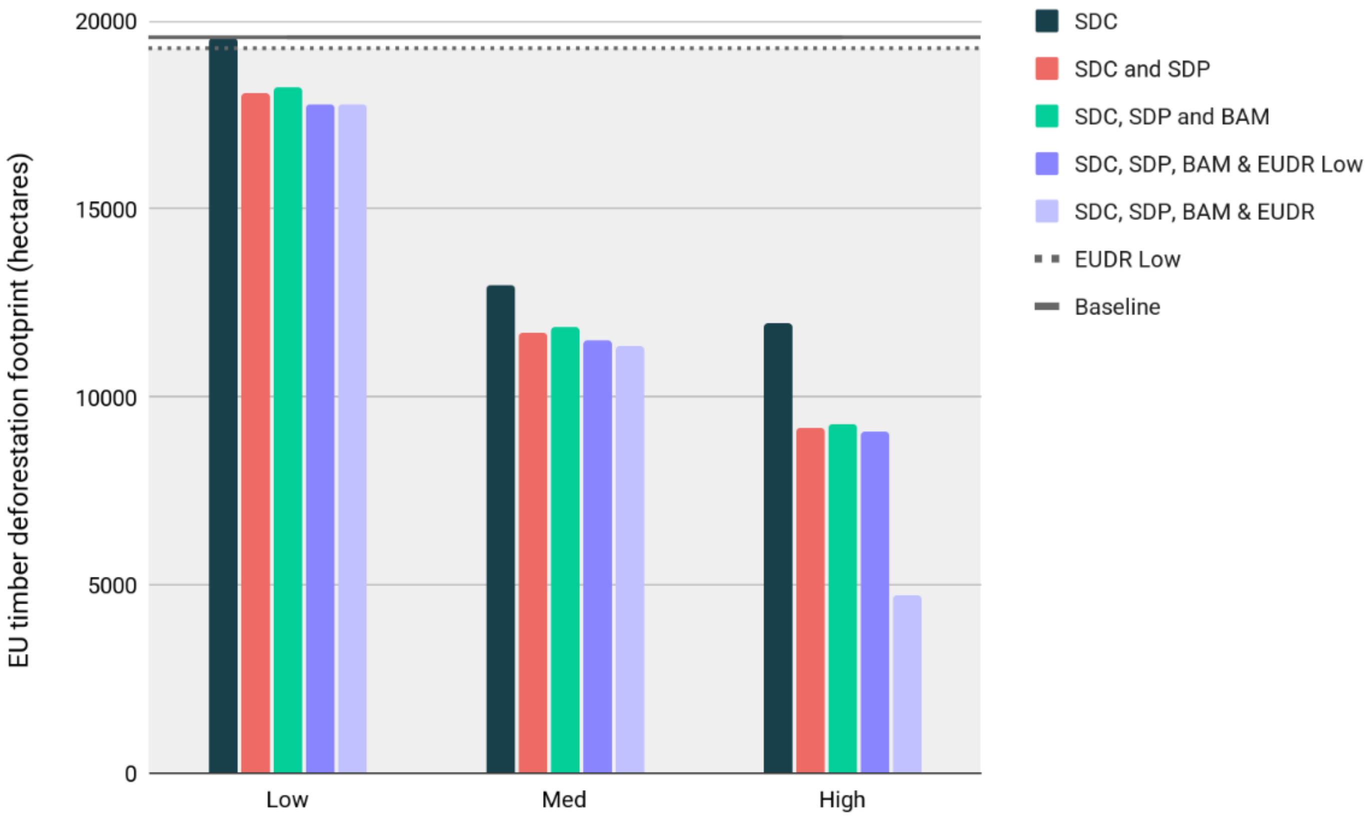

Figure 20. The EU's timber deforestation footprints for combined levers as implemented in the scenario model. The solid horizontal line shows the baseline footprint and the dashed horizontal line shows the timber footprint under the EUDR low ambition scenario when applied in isolation. For bars (with the exception of the bar including 'EUDR Low' where the EUDR is applied with low ambition), the level of ambition is stated on the x-axis, i.e. 'Med' = combinations of all levers with medium ambition.

4.7.2.3. Impacts at origins

Exploring how countries of origin contribute to footprint reductions under the high ambition implementation of non-EUDR levers (SDC, SDP and BAM) combined with the low ambition EUDR lever reveals that reductions from China dominate the total experienced reduction (Figure 21). Overall, deforestation footprint reductions originating from China contribute a 32.3% change in impact relative to the EU27 baseline. Note that, in comparison to most other commodities[54], conversion of forest to timber plantations is usually associated with a net decrease in emissions within the DeDuCE dataset, meaning that relative emissions contributions in Figure 21 (where positive in sign[55]) are associated with emissions increases rather than reductions.

54. Emissions increases can be associated with other commodities also (e.g. see rubber below, where some countries are associated with emissions increases, and others decreases, linked to deforestation).

55. e.g. for Cambodia and India an emissions reduction is experienced with reduced deforestation.

However, the contribution of China to biodiversity impact is relatively lower at 22.9% of the baseline. Viet Nam also makes an outsize contribution to the total reductions in biodiversity impact (13.1% relative to the baseline, compared to a contribution to deforestation change of 2.76%).

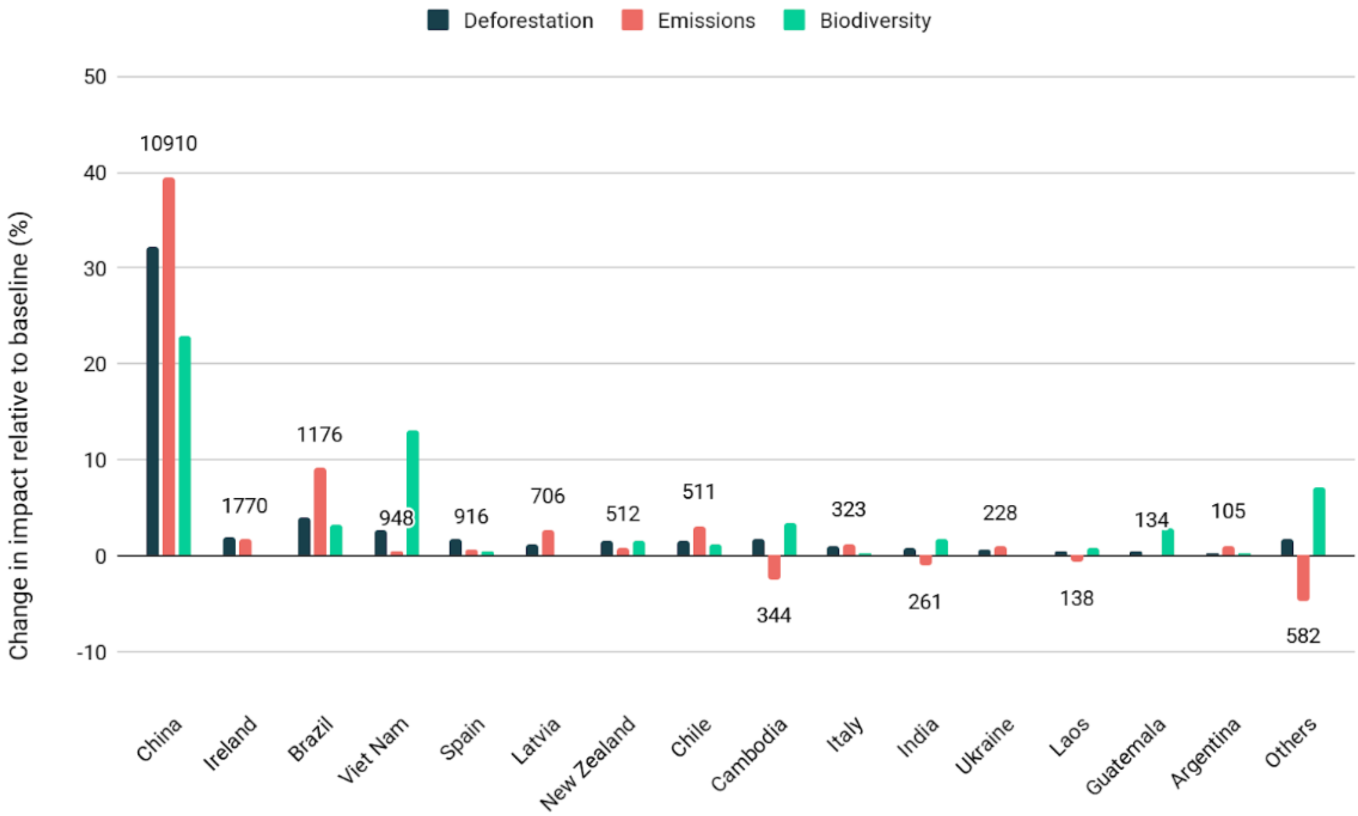

Figure 21. Change of impact in points of origin of the EU's timber footprint relative to the baseline. Data is shown for high ambition non-EUDR levers combined with low ambition EUDR. Contributions to overall deforestation, emissions and biodiversity (Forest-LIFE) changes are provided. Labels show the original timber deforestation footprint (ha) associated with each country.

4.8. Rubber consumption

4.8.1. Lever description and implementation

For rubber, for the sustainable domestic consumption area we explore the potential to reduce demand for natural rubber via implementation of circular economy approaches in the tyre industry; specifically extending the lifespan of natural rubber in the tyre market (which is a major natural rubber consumer) via retreading and devulcanisation of tyres. For the sustainable domestic production area we explore the potential for domestic cultivation of alternative rubber crops. The traditional source of rubber, Hevea brasiliensis, is not suitable for cultivation within Europe, but guayule (Parthenium argentatum) can also be used as a latex source. We deem rubber to be outside of the likely scope of any border adjustment mechanism policy. Table 9 provides a summary of the levers employed.

Table 9. Summary of policy levers impacting the rubber footprint, the application of these levers across 'ambition' levels, and whether or not Member State-specific scaling occurs.

Area	Description	Lever and scenario level	Member State specificity
SDC	Retreading and devulcanisation of tyres	- Regulation for retreading and diversion of waste away from incineration, with investment in research and investment to promote devulcanisation scale-up (medium ambition scenario).	No - applied equivalently across all Member States.
SDP	Domestic cultivation of alternative rubber crops	- Research and development investment and potential subsidies to foster domestic production of guayule on abandoned agricultural land (increasing uptake under low, medium and high scenarios)	No - reductions in overseas demand for rubber supported by availability of domestic rubber are applied equivalently across all Member States

4.8.1.1. Sustainable domestic consumption

For the retreading of tyres, it is likely that regulatory policy would be needed to set higher production standards for tyres (to improve tyre-casing construction to allow for retreading). This type of legislation is not unlikely, given its alignment with other 'right to repair' type legislation, and although some resistance from the tyre industry might be experienced, it should not face major hurdles. For devulcanisation, support might be required in the form of further research and development work for upscaling, including to make it cost-effective compared to use of primary rubber (particularly compared to imports of cheaper tyres from overseas). Devulcanisation could be further incentivised with mandatory targets for shares of recycled rubber content. Retreading and devulcanisation approaches are linked in that the latter will depend on the number of tyres that are not available for recycling via retreading.

For this lever we start with estimates of the number of tyres that need replacing on an annual basis for cars and trucks and current tyre recovery (94%) and retreading rates (which are 40% for trucks and 15% for cars) alongside estimates of rubber content, assuming retreading requires 25% of the natural rubber compared to new tyre manufacture. This baseline case is then compared against more stringent retreading rates with tyre recovery of 98% and retreading rates of 62%[56]. Overall, it is estimated that approximately 275 thousand tonnes of natural rubber could be saved by retreading, which equates to 22.4% of EU rubber imports.

56. A retreading rate of 62% is based on the requirement for some tyres to be replaced due to overall age (11%) or after reaching maximum repair limits (27%), based on Ingram (2018). I.e. 62% = 100% minus 11% minus 27%.

Tyres rejected for retreading are then destined for devulcanisation. As a relatively new technology, we assume zero devulcanisation at present. That said, some tyres are recycled for other uses (such as construction) and therefore we focus on recovery of tyres that would otherwise be incinerated (43%). For these tyres, and a devulcanisation efficiency of 66.4% (derived from Abbas-Abadi et al., 2022), we estimate the availability of a further 195 thousand tonnes of rubber, reducing natural rubber demand by a further 15.9% of total imports[57], and therefore - when combined with retreading - leading to total demand reductions of 38.3%. Given the reliance on regulation and investment in new technologies we consider these levers to occupy a 'medium' ambition level, applying equally across the EU as a whole.

4.8.1.2. Sustainable domestic production

Here we explore the potential for the cultivation of alternative rubber crops with the EU market, via the provision of funding for research and development linked to production scale up and optimisation, and potential subsidy for EU-grown products to increase competitiveness compared with imported natural rubber. Furthermore, there is potential for guayule to be grown on degraded land (in contrast to Russian dandelion - another potential latex source - which requires more productive land and thus may be in competition with other crops). A further advantage of rubber sourced from guayule is its hypoallergenic properties which could give it some competitive advantage for some products, although, overall, investment to support competitiveness with other sources will be required. We therefore develop low, medium and high ambition scenarios based on varying levels of potential investment. The European Tyre and Rubber Manufacturers' association (Palu et al., 2015) has indicated that alternative rubber products occupy 2-3% of the market, and predicted a maximum market saturation at 20% of EU natural rubber demand, which would require around 250 thousand hectares of land. Abandoned agricultural land could be used for this production[58]. However, the ETRMA also states that guayule's higher quality rubber is less suited to the tyre industry which makes up the bulk of the market for rubber. Based on the above, we assume that there is potential for natural rubber produced from guayule to occupy a steadily larger market share across our ambition levels. This is capped at 20% in the high ambition scenario, 10% in medium ambition and 5% in low ambition, representing increases of 18%, 8% and 3% from a 2% baseline market share, which in our model substitutes rubber demand from Hevea-based sources.

57. Natural rubber reclaimed via devulcanisation could be used either for tyre manufacture or within other parts of the EU economy, but the overall effect would still be a reduction in overall natural rubber demand from virgin sources.

58. We therefore assume this amount of land is unavailable for agroforestry-based timber production, see above.

4.8.2. Results

4.8.2.1. Individual levers

Applied individually, the introduction of retreading and devulcanisation of tyres (SDC) (applied under medium scenario space) results in reductions in the rubber deforestation footprint of 14.0% (1,170 ha) (Figure 22). The introduction of sustainable domestically-produced rubber alternatives (SDP) has lesser impact reductions of 1.10% (92 ha), 2.94% (245 ha) and 6.6% (551 ha) under low, medium and high ambition implementations, respectively. In comparison, the low ambition implementation of the EUDR results in a reduction in the rubber deforestation footprint of 19.8% (1,654 ha) from the baseline.

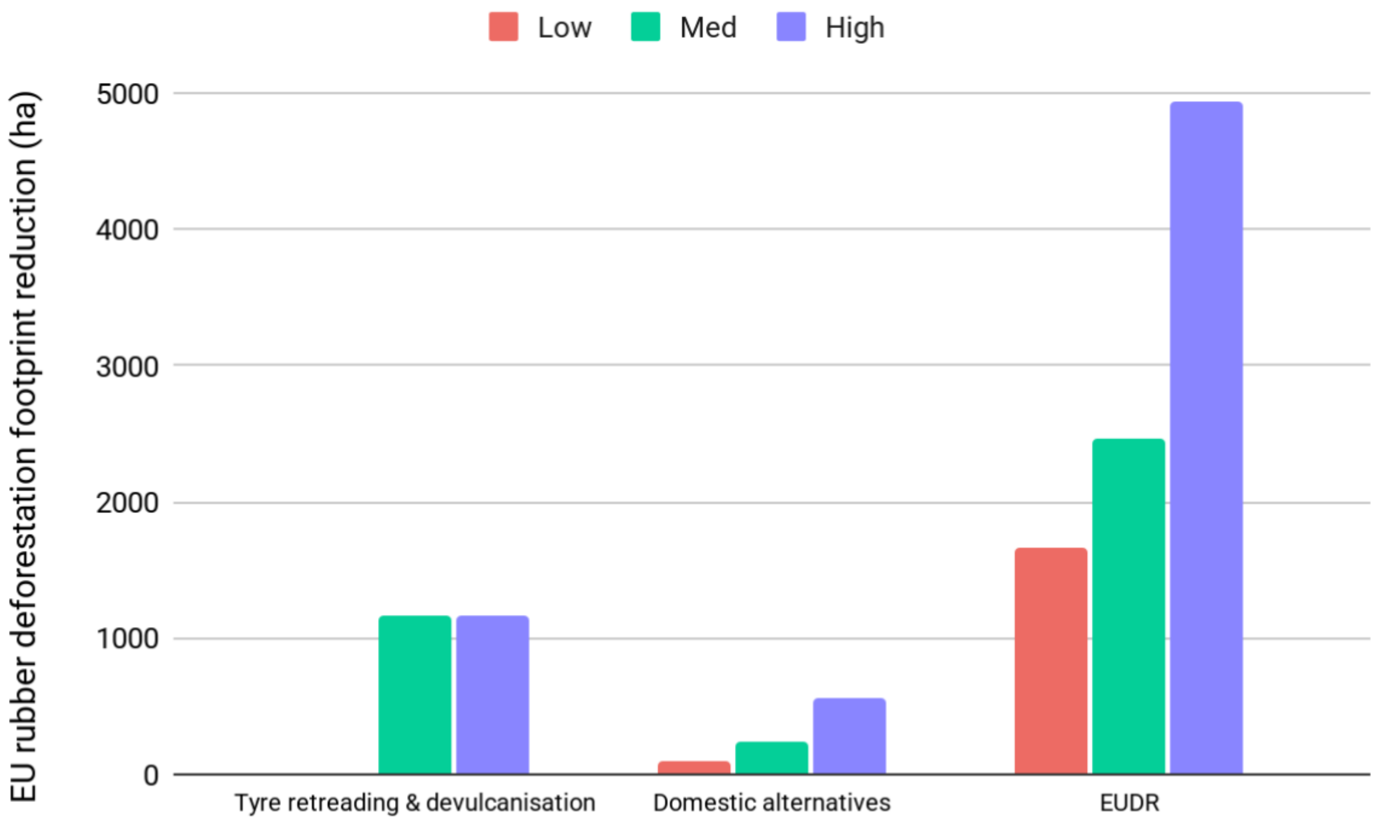

Figure 22. Changes (under low, medium and high ambition implementation) to the EU's commodity rubber-deforestation footprints for individual levers as-implemented in the scenario model. Positive values are reductions to footprint.

4.8.2.2. Combined levers

Figure 23 shows results of scenarios when rubber-linked levers are combined. When all non-EUDR levers are applied, the reductions in deforestation footprint compared to the baseline are 92 ha (1.10% reduction), 1,413 ha (16.9%) and 1,716 ha (20.6%) for low, medium and high ambition scenarios respectively. These are therefore slightly above the deforestation footprint reductions achieved when the low ambition implementation of the EUDR is applied in isolation.

When the low ambition EUDR lever is combined with high ambition non-EUDR levers, the rubber deforestation footprint falls to 4,246 ha, a reduction of 49.1% from the baseline. In other words, the inclusion of non-EUDR levers promotes an additional 29.3% (2,447 ha) reduction in footprint from the baseline compared to the application of low ambition EUDR on its own. When a high ambition implementation of the EUDR is applied in combination with high ambition non-EUDR levers the rubber deforestation footprint falls to 1,950 ha (a 76.6% reduction from the baseline), i.e. the non-EUDR levers therefore induce an additional 17.5% reduction in footprint compared with a high ambition application of the EUDR implementation alone.

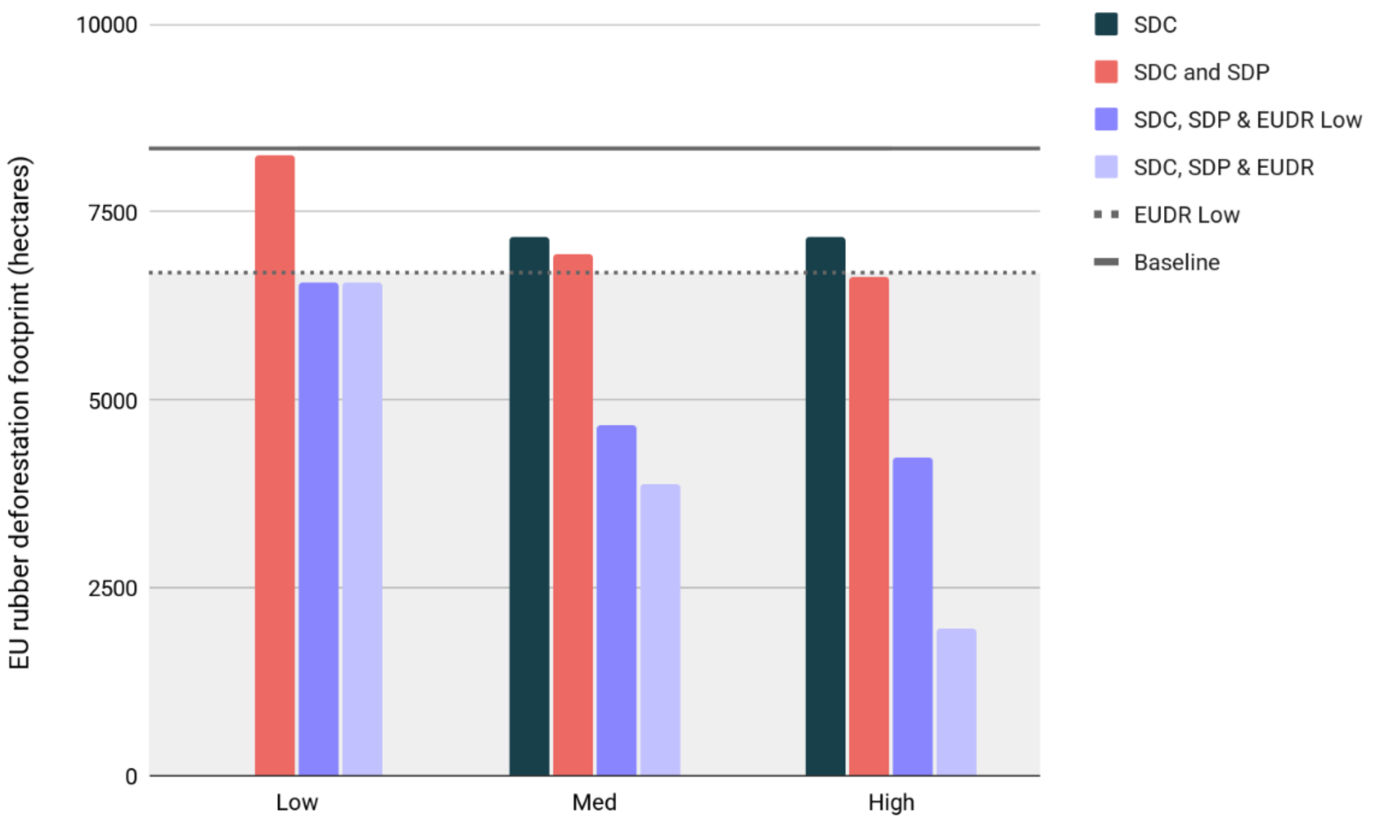

Figure 23. The EU's rubber deforestation footprints for combined levers as implemented in the scenario model. The solid horizontal line shows the baseline footprint and the dashed horizontal line shows the rubber footprint under the EUDR low ambition scenario when applied in isolation. For bars (with the exception of the bar including 'EUDR Low' where the EUDR is applied with low ambition), the level of ambition is stated on the x-axis, i.e. 'Med' = combinations of all levers with medium ambition.

4.8.2.3. Impacts at origins

Exploring results from the combination of the high ambition implementation of non-EUDR levers (SDC and SDP) with the low ambition EUDR lever reveals that reductions from Cambodia contribute most (29.2%) to the change in deforestation relative to the EU27 baseline (Figure 24)[59]. The Philippines contributes 2.16% to the change in biodiversity impact relative to the EU27 baseline, compared with a 0.68% contribution to deforestation change relative to the baseline.

59. Cambodia is associated with a large increase in emissions through avoided deforestation as deforestation for rubber in Cambodia is associated with net emissions reductions according to DeDuCE.

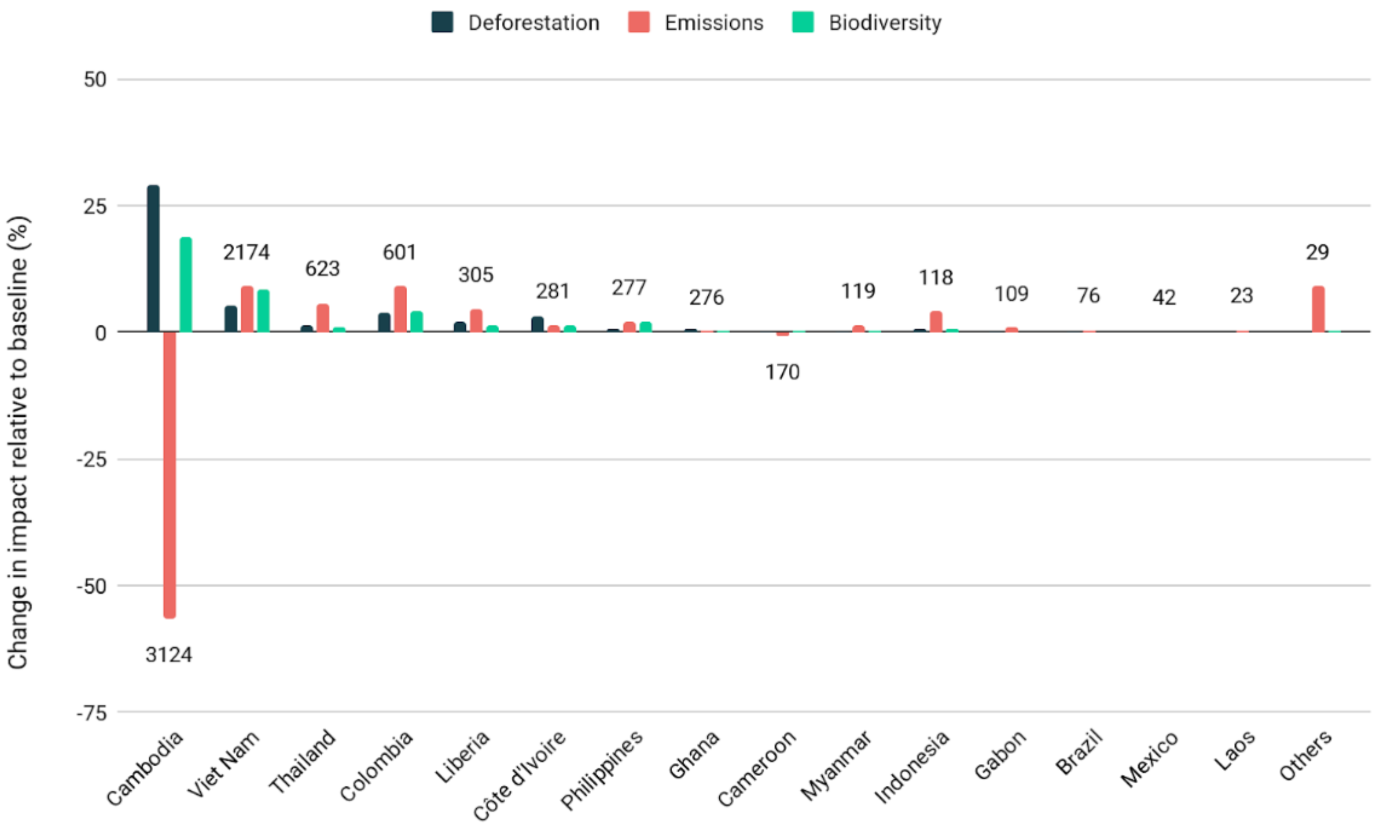

Figure 24. Change of impact in points of origin of the EU's rubber footprint relative to the baseline. Data is shown for high ambition non-EUDR levers combined with low ambition EUDR. Contributions to overall deforestation, emissions and biodiversity (Forest-LIFE) changes are provided. Labels show the original rubber deforestation footprint (ha) associated with each country.

4.9. Results across commodities

As per the description in Section 2: Baselining the EU's impact, the baseline deforestation footprint for the EU27 was estimated at 162,240 ha, the associated emissions footprint at 59,417,088 tonnes and the biodiversity footprint at 0.2946 annualised species-extinctions. Implementation of the EUDR under a low ambition scenario results in a decrease in deforestation across all commodities to 127,096 ha, a 21.7% reduction from the baseline (Figure 25).

When low ambition non-EUDR levers are combined (in the absence of EUDR), the footprint drops to 151,436 ha[60], a 6.7% decrease from the baseline. Thus, in our modelled scenarios, a low ambition implementation of sustainable domestic consumption and production in line with a circular-economy and border-adjustment levers has an impact on reducing the EU's footprint that is lower than the low ambition implementation of the EUDR.

Under medium ambition non-EUDR scenarios, however, aggregated deforestation footprint reductions exceed those achieved with low ambition EUDR with a resultant footprint of 119,891 ha (a 26.1% decrease from the baseline). This requires the inclusion

60. As described above, the inclusion of the BAM levers under low ambition scenario space imposes a slight increase due to increased timber demand, without BAM the footprint is 151,274 ha, a 6.8% decrease from the baseline.

of BAM levers on top of the SDC and SDP levers, which are on their own insufficient to exceed low ambition EUDR reductions (Figure 25).

High ambition SDC levers, however, come close to meeting the reductions resulting from low ambition EUDR (a resultant footprint of 130,324 ha or 19.7% reduction), with the addition of high ambition SDP levers crossing the threshold (footprint of 121,448 ha, 25.1% reduction), and the further addition of high ambition BAM measures greatly exceeding low ambition EUDR results (97,613 ha footprint, a 39.8% total footprint reduction from the baseline).

Implementation of the low ambition EUDR on top of high ambition non-EUDR levers results in a footprint of 64,845 ha, which is a 60.0% reduction from the baseline. If a high ambition implementation of the EUDR is implemented on top of other high ambition levers, then the resultant footprint is 23,849 ha, which is a 85.3% reduction from the EU27 baseline. This compares to a footprint of 51,582 ha if the high ambition EUDR scenario is applied in isolation (which is a 68.2% reduction from the baseline). Therefore, the inclusion of non-EUDR levers has significant potential to reduce the EU's deforestation footprint whether or not applied in addition to the EUDR.

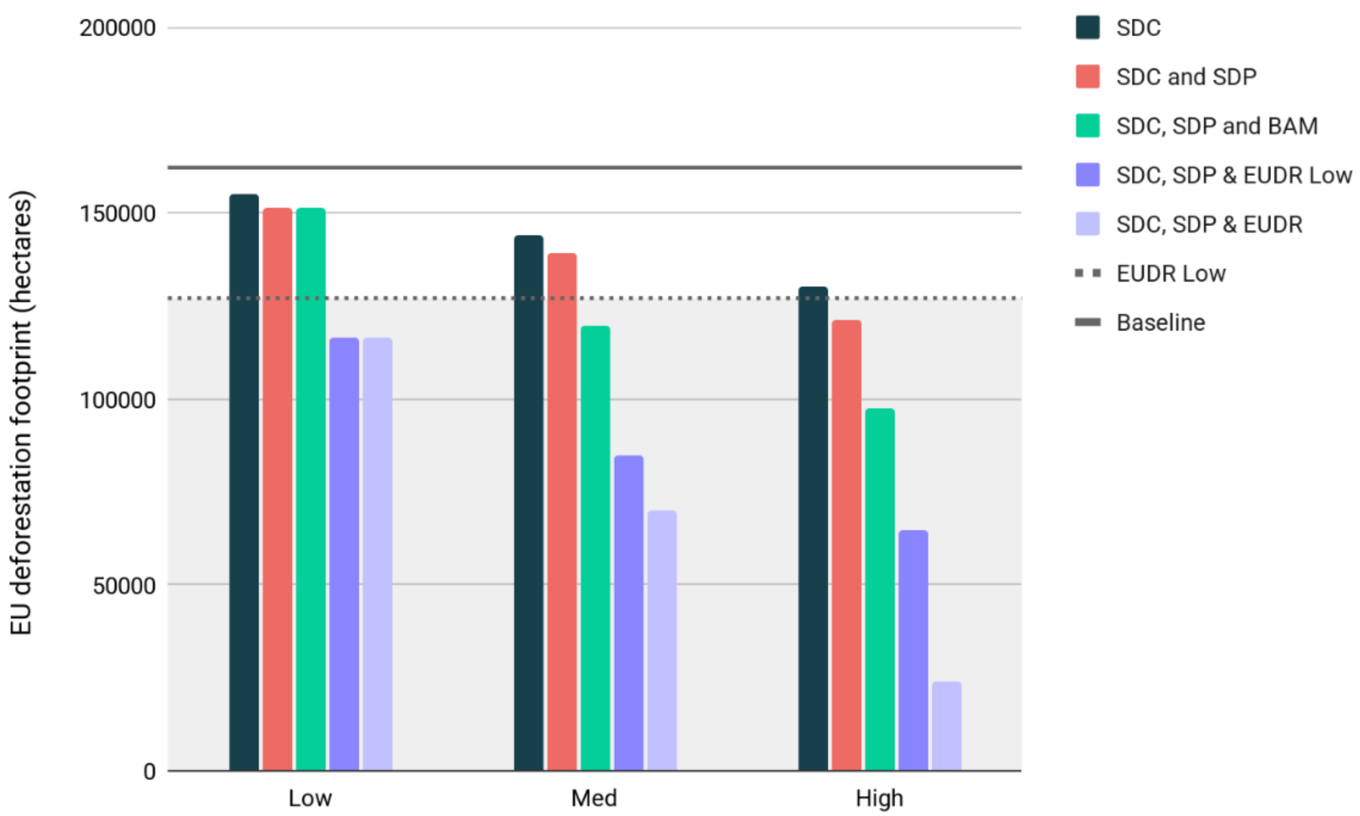

Figure 25. The EU's deforestation footprint (across all in-scope commodities) for combined levers as implemented in the scenario model. The solid horizontal line shows the baseline footprint and the dashed horizontal line shows the total footprint under the EUDR low ambition scenario (across all commodities) when applied in isolation. For bars (with the exception of the bar including 'EUDR Low' where the EUDR is applied with low ambition), the level of ambition is stated on the x-axis, i.e. 'Med' = combinations of all levers with medium ambition.

Reduction in footprint varies across EU Member States. Table 10 shows results arising from the application of the low ambition EUDR lever in addition to high ambition non-EUDR levers. Compared to the baseline (Table 1), Germany sees a footprint reduction of 24,322 ha meaning that its remaining footprint is 35.9% of its baseline. However, other countries experience greater relative footprint reductions. Italy, for example, sees its footprint drop to 31.9% of the baseline (a 13,397 ha reduction) with greater-than-average reductions in its timber-linked deforestation footprint (dropping to 16.6% of its baseline in comparison with an EU average of 46.3%) . In contrast, Latvia's footprint only drops to 71.6% of its baseline (a 232 ha reduction; and - with the exception of cattle and rubber - most of its commodity deforestation footprints dropping by substantially less than the EU-average). Reasons for these differences include, but are not limited to: countries having different sourcing profiles (i.e. different source countries seeing different levels of footprint reductions); countries having different levels of direct/indirect exposure to commodity origins in supply chains (i.e. some countries having more direct sourcing from commodity origins); countries having different supply chain roles (e.g. countries acting more as supply intermediates might pass on more of their reductions in direct sourcing to downstream countries); different consumption-behaviour patterns (e.g. certain commodities see bigger relative/absolute changes, and certain supply chains are likely to be impacted by more policy lever interventions than others); and the different enforcement strengths per-country encapsulated in the EUDR implementation. For example, in our parameterisation of the low ambition EUDR, Latvia has a relatively low enforcement strength based on the criteria specified in Section 3: The impact of the EUDR, whereas Italy has high (but not the highest) implementation strength. The top five countries account for 62.3% of the total remaining footprint, compared to 70.3% of the baseline footprint.

Table 10. The deforestation footprint of the EU27 Member States for each focal commodity following implementation of all non-EUDR high ambition levers combined with the low ambition implementation of the EUDR (arranged in order of their total baseline footprints). Main heat-map is derived from contributions of all commodities. Heatmaps per capita and per billion € also individually derived.

Member State	Cattle	Cocoa	Oil Palm	Timber	Soy	Rubber	Coffee	Total	% of baseline	Ha per 10,000 people	Ha per billion € (GDP)
Germany	3,283	2,331	2,753	2,195	974	1,158	931	13,625	35.9%	1.6	3.4
France	2,056	1,853	1,376	1,071	553	435	384	7,727	36.6%	1.1	2.9
Italy	2,416	1,097	1,220	306	587	388	399	6,413	31.9%	1.1	3.2
Spain	1,828	928	1,210	834	500	540	335	6,175	33.6%	1.3	4.5
Netherlands	1,683	2,049	1,082	578	419	313	322	6,445	39.1%	3.7	6.5
Belgium	1,285	1,229	1,264	647	372	359	325	5,482	51.3%	4.7	9.7
Poland	701	555	848	342	223	265	162	3,097	53.3%	0.8	4.7
Ireland	903	165	469	1,378	197	60	60	3,232	62.3%	6.3	6.2
Sweden	586	248	378	265	101	79	105	1,762	40.5%	1.7	3.2
Austria	572	171	232	160	108	37	38	1,318	51.3%	1.5	2.9
Portugal	360	145	182	215	93	49	45	1,091	46.0%	1.0	4.5
Finland	366	145	124	100	50	73	76	933	41.1%	1.7	3.5
Czech Republic	354	108	183	122	51	53	44	916	41.5%	0.9	3.2
Denmark	262	100	249	97	106	45	36	895	43.7%	1.5	2.4
Luxembourg	237	278	340	78	68	82	77	1,161	61.7%	18.0	15.1
Greece	285	97	300	103	141	42	36	1,005	53.6%	1.0	4.8
Romania	99	84	116	59	64	26	32	480	37.7%	0.3	1.7
Hungary	190	83	128	56	48	82	34	620	49.6%	0.6	3.7
Slovakia	176	76	67	37	23	57	25	462	51.3%	0.9	4.2
Latvia	21	24	203	300	16	14	8	586	71.6%	3.1	16.2
Slovenia	123	48	59	33	24	21	13	321	53.3%	1.5	5.6
Estonia	95	126	39	17	11	18	16	322	60.8%	2.4	8.8
Bulgaria	45	59	52	17	16	28	15	232	44.9%	0.4	2.7
Lithuania	82	45	57	15	17	11	9	236	55.2%	0.8	3.5
Croatia	93	33	40	17	31	7	6	228	54.0%	0.6	3.4
Malta	13	8	12	8	5	3	2	50	40.6%	1.0	2.8
Cyprus	10	3	11	3	3	2	1	32	50.1%	0.3	1.1
Total	18,125	12,089	12,994	9,053	4,803	4,246	3,536	64,845	40.0%	1.5	4.0
% of baseline	23.3%	59.1%	63.8%	46.3%	49.7%	50.9%	59.4%	40.0%			

Table 11 shows the country of impact for the footprint which remains after implementation of the EUDR low ambition scenario on top of high ambition non-EUDR levers. The footprint in Brazil shows the greatest absolute reduction (22,740 ha), falling to 25.6% of the baseline. In contrast, much lower reductions are experienced in Ghana (74.0% of the baseline) and Viet Nam (67.9% of the baseline) which is partly explained by their status as 'low risk' sources according to the EUDR benchmarking (which are then not a target for action within our EUDR low ambition implementation). The footprint associated with China experiences a reduction to 42.2% of its baseline, but notably these relatively deep reductions are induced despite the EUDR lever not further-reducing the footprint originating in China given its classification, also, as a low-risk country under the EUDR benchmarking. Nigeria experiences the most pronounced fall in footprint relative to its baseline (to 12.3%, with a footprint reduction of 3,659 ha), concentrated particularly around reductions to the cattle deforestation footprint.

Table 11. The EU27's deforestation footprint according to producer country following implementation of all non-EUDR high ambition levers combined with the low ambition implementation of the EUDR (Top 15 origins for the baseline footprint, overall, shown plus 'other' aggregated countries). Heatmaps generated on a per-commodity basis.

Country	Cattle	Cocoa	Oil Palm	Timber	Soy	Rubber	Coffee	Total	% of baseline
Brazil	4,972	38	16	398	2,168	37	186	**7,815**	**25.6%**
China	25	-	0	4,597	-	2	-	**4,624**	**42.2%**
Indonesia	5	-	5,121	33	120	65	11	**5,355**	**58.8%**
Paraguay	970	-	2	11	350	-	0	**1,333**	**18.2%**
Ghana	645	4,244	25	0	84	216	-	**5,215**	**74.0%**
Malaysia	110	0	3,862	-	-	1	-	**3,973**	**59.1%**
Bolivia	678	1	-	-	246	-	12	**936**	**14.2%**
Côte d'Ivoire	-	1,183	76	-	0	21	-	**1,281**	**19.5%**
Colombia	463	863	257	8	88	279	34	**1,991**	**32.1%**
Viet Nam	235	43	-	408	3	1,729	1,159	**3,576**	**67.9%**
Peru	159	458	738	1	3	-	404	**1,764**	**35.0%**
Cambodia	52	-	502	0	146	683	0	**1,383**	**30.9%**
Nigeria	67	191	161	-	94	1	-	**513**	**12.3%**
Democratic Republic of the Congo	54	270	123	2	35	0	40	**523**	**15.6%**
Argentina	306	-	-	45	459	-	-	**809**	**23.6%**
Others	9,384	4,798	2,112	3,549	1,009	1,213	1,690	**23,756**	**52.3%**
Total	**18,125**	**12,089**	**12,994**	**9,053**	**4,803**	**4,246**	**3,536**	**64,845**	**40.0%**

5. Discussion

Our analysis explores the potential impacts of the EU's Deforestation Regulation (EUDR) alongside a complementary suite of non-EUDR mechanisms which encompass a selection of levers - representing realistic and near-term solutions promoting sustainable domestic consumption (SDC), sustainable domestic production (SDP), or applying penalties on more damaging imports via border adjustment mechanisms (BAM). These levers influence the EU's deforestation footprint (and associated emissions and biodiversity footprints) linked to the seven commodities of the EUDR: cattle, cocoa, oil palm, timber, soy, rubber and coffee.

The results demonstrate the substantial potential for policy interventions to reduce the EU's footprint associated with these commodities. The EUDR alone leads to at least a 21.7% decrease in the EU's deforestation footprint (under a low ambition implementation scenario), which rises to 68.2% under the highest ambition scenario. The most transformative change, however, results from combining high ambition non-EUDR levers with either low- or high ambition EUDR, resulting in 60.0%-85.3% deforestation footprint reductions from the baseline, respectively, and leaving a footprint of as little as 23,849 ha compared to a current EU baseline of around 162,240 hectares. Ultimately, a combination of levers is therefore necessary for maximum deforestation footprint reduction.

While in this analysis deforestation drives the associated changes in emissions and biodiversity, the results highlight some important differences in how these three footprints manifest themselves. In the baseline, for example, palm oil accounts for 12.6% of the deforestation footprint but 22.1% and 25.4% of the emissions and biodiversity footprints respectively, and these differences are also reflected in the scenario outcomes. For example, relatively minor deforestation footprint reductions in biodiversity hotspots can have an outsize influence on the potential reductions in biodiversity footprints of global commodities. Examples include cattle production in Madagascar, cocoa production in Ecuador, and rubber production in Viet Nam. These differences serve to highlight that targeting areas with the highest absolute decrease in deforestation may not always be associated with regions where biodiversity is highest or most vulnerable.

The EUDR serves as a mechanism - explicitly targeted towards reducing the EU's supply chain exposure to deforestation - that 'de-risks' the supply chain of the EU. In contrast, the non-EUDR mechanisms modelled - inspired by circular economy and sustainable production efforts - aim to influence the demand and supply of deforestation-implicated materials. As a direct measure, when implemented in isolation, the low ambition EUDR generally surpasses the impact of combined low ambition non-EUDR levers. But non-EUDR levers applied with medium-to-high ambition can exceed the deforestation reductions of the low ambition EUDR implementation, achieving a 39.8% reduction of the deforestation footprint from the baseline (under high ambition).

These broader measures can therefore be effective in reducing the aggregate load that the EU market places on international production systems and resultant deforestation and biodiversity impacts. As one example, the cattle footprint dominates the EU's deforestation footprint baseline (making up 48% of the total), but - in combination - the levers that we modelled achieve a 56.2% reduction in footprint under high ambition applications, and 38.8% reductions under medium ambition. The implementation of dietary shift levers and the introduction of a border adjustment mechanism for beef explain the majority of these reductions and it is important to highlight that these measures are feasible in the context of existing policy space and technologies. For example, carbon border adjustment policy exists, and could be feasibly extended for high-impact commodities such as beef. Dietary shifts - whilst not trivial given their reliance on widespread behavioural change - can be facilitated both by reinforcing an understanding of the benefits for consumers linked to health and cost concerns (see also below), and by supporting already-viable alternative protein sources.

These results have implications with respect to the current direction of travel. At the time of writing, the EUDR has been delayed in its implementation twice (European Union, 2025a). Technical capacities have also been relatively slow to develop and concerns remain about the resourcing of Competent Authorities. Thus (whilst being an imperfect analogue for the eventual impact that the EUDR will have on the EU's supply chain), our low ambition EUDR scenario appears likely to err towards a more probable approximation of the EUDR's eventual implementation. In other words, with the difficulties experienced to date and continued political pressure against the regulation, it would appear more likely that the EUDR will have lower, not greater, impact.

This provides a point of concern: our scenarios suggest that the EUDR could have a much greater impact if enforcement is strengthened, if the breadth of commodities scrutinised in practice widens, and if positive spillover effects are induced. Therefore, continued promotion of the EUDR as an effective policy instrument remains timely and critical.

However, the realities also serve to highlight the concurrent importance - and potential future influence - of other measures in decreasing the EU's footprint, and these measures are of increased importance if they are required to take up the slack from difficulties in implementing or enforcing the EUDR. These measures may also be important, and attractive, in the face of ongoing pressures on consumer-prices and resource security, and against the backdrop of a broader push towards a necessarily-more resource efficient and sustainable economy in the face of the growing threat of climate change and wider environmental concerns.

5.1. Societal implications

The levers explored in this analysis have significant implications for the way in which the EU interacts with the commodities in focus, from the provisions it places on how companies conduct due diligence, to the potential for price-increases to be imposed on more environmentally damaging materials, to changes in the way in which land is used and products (including waste products) are utilised, through to changes in consumer behaviour and preferences. Our analysis has focused on the development of policy options and their implications for deforestation and biodiversity footprints, without quantification of the wider costs and benefits of such interventions, but it is worth briefly discussing the implications for society that such transition (and the implementation of wider transitions necessary to fully realise global zero-deforestation targets) would bring.

5.1.1. Implications for EU consumers

Changes to consumption are central to a number of the policy levers explored in our analysis, including shifts away from beef, which - alone - induces a deforestation footprint reduction of up to 18,375 ha (26.5% of the EU's beef-linked deforestation footprint baseline) (Figure 7), and choices linked to the consumption of snacks (implicating cocoa) and coffee-portion sizes. Even where firmer policy measures such as taxation (e.g. on meat or snack foods) are envisaged in high ambition scenarios, consumers would still make the ultimate decisions on consumption in our scenarios. Lower ambition levers commonly involve the implementation of behavioural-change campaigns (e.g. linked to meat consumption or waste reduction). And even where the explicit role of consumers is more tangential (e.g. retreading of tyres), there will be an interface between consumer attitudes and the success of potential policy intervention (e.g. tyre collection rates). More generally, if the variety of levers envisaged here are employed, consumers across Europe would notice differences, ranging from the way local land is utilised to provide food and other materials, through to differences in production practices on construction sites, through to potential price rises for some products to encourage the consumption of others (but also falling prices in other areas as alternative products reach price-parity or are promoted more broadly as part of circular economy interventions).

Here, there is an important consideration. Whilst a subset of consumers will support transition towards more sustainable consumption for reasons of sustainability, how - in a time of continued pressure on wages and cost-of-living affordability - can policy and wider practice be designed to avoid potential perceptions of 'nanny state' intervention and to circumvent a rising 'greenlash' (Chapron, 2024; Jones and Youngs, 2025) against policies which seek more sustainable development? Key to this is the communication - and more broadly the active policy support - of the positive benefits of transition. For example, shifts away from meat and snack foods will have significant benefits not just on individuals, but also on the provision of healthcare services which are paid for by tax-payers' money (Godfray et al., 2018). Dietary transitions also have the potential to reduce grocery costs, particularly if support for healthier and more environmentally sustainable diets is provided to ensure cost-competitiveness (Springmann et al., 2021). In addition to achieving potential timber deforestation footprint reductions of 7,532 ha (38.5% of the EU's baseline timber footprint; Figure 19), shifts away from biomass-based energy production could have positive implications for local air pollution (Tomlin, 2021). Re-treading of tyres as standard practice could reduce the overall lifetime costs of consumer transportation (Fortune Business Insights, 2025). Investment in agroforestry systems could provide recreational opportunities and improve the visual amenity of local environments (Stewart et al., 2022). Making the case for these positive outcomes will ultimately determine support for policy change which is critical for any voluntary activities that are promoted by consumers or businesses, but also the long-term success of regulatory measures which can fluctuate in form and function across political cycles.

5.1.2. Implications for EU businesses

As for consumers, businesses will also need to change practice, and make investments on mid- or long-term time scales with reassurances that these will pay off. In general, resource efficiency measures, such as - in our implementations - the reduction of coffee waste in retail outlets, or reduction in waste production on construction sites, or (subject to technologies to promote efficient recovery of materials) the re-use of materials linked to tyre production, make good business sense as a mechanism to increase potential profit margins or market competitiveness. This is not to imply that no financial implications exist, for example upfront investment (either government or privately-supported) may be required for technology development, for changing supply chain- and processing-systems, or for training. Where regulatory levers are imposed to change practices, it is important that businesses are able to source alternative products or introduce new processes in a manner that does not lead to competitive disadvantage, something that may be a concern particularly for small businesses who may not always have the internal resources, expertise or capacities to rapidly respond to changing demands (European Commission, 2015).

Transition also provides opportunities for existing and new businesses to develop and thrive. For example, subject to carefully costed incentives, farmers may benefit from the production of agroforestry on degraded lands (Mayr et al., 2025). The growth in alternative proteins or alternatives to cocoa and coffee provides opportunities for businesses seeking to expand novel technologies and product lines (Bunge et al., 2025; Good Food Institute, 2025). And diversion of materials away from waste streams provides opportunities for businesses to introduce new technologies and processes for the re-use of materials (Mavropoulos and Nilsen, 2020). That said, there is also the potential for increased threats and costs to businesses. For example, despite the potential for border-adjustment mechanisms to lead to substantive reductions in footprint (particularly for soy and beef where reductions of 21.9% and 31.8% of respective baselines are achieved with independent high ambition implementation; Figure 4 and Figure 7), an increase in cost associated with the introduction of carbon or biodiversity-pricing has the potential to make products produced in the EU market more expensive. In the absence of alternative cost-equivalent products available in the EU market, this could have implications for company competitiveness, especially if consumers are able to purchase equivalent materials from businesses outside of the EU. Likewise, with energy and transportation costs making up a large portion of business expenditure (Deloitte, 2025), efforts to remove palm oil from biodiesel production could have significant implications for some businesses if alternative fuels do not have price-parity. Ultimately, in any transition there are winners and losers and - whilst the private sector overall will adapt to the regulatory and market-environment under any future pathway - it will be important to carefully design policy to ensure feasibility of uptake and broader sectoral- and international-competitiveness.

5.1.3. Implications for producers

Changing the EU's patterns of supply and demand - as envisaged in the scenarios explored in this analysis - has the potential to dramatically reduce the EU's footprint, but also has the potential to negatively impact producers in the regions supplying the EU as a destination-market. The implications of different policy levers are likely to vary. We have not explicitly analysed these impacts but some inferences can be drawn from the policy levers that we have explored.

For example, in our EUDR implementation, the policy acts to 'de-risk' the EU's supply chain. In some instances, producer groups that remain linked to deforestation may simply react by supplying alternative markets, which could represent a 'leakage' of the policy's impact (Boysen, 2025; Meyfroidt et al., 2020). In other cases, particularly where exports to the EU occupy a significant share of the markets, or where there are contracts in place with organisations placing materials on the market, there may not be such flexibility (Grabbe and Moffat, 2024; Hill Dickinson, 2024). The potential impacts on producers in this case are complex; in some cases support may be provided (from the supply chain or via other mechanisms; FSC, 2023; Li et al., 2025) to enable compliance with the requirements of the EUDR. In other cases there is a risk of exclusion from EU supply chains, effectively forcing producers to supply their commodities to other markets, to switch production systems, or to find other mechanisms to provide for their livelihoods (Zhunusova et al., 2022).

The other levers implemented in our scenarios will also implicate producers. Measures to reduce EU consumption of focal commodities will ultimately reduce EU demand, so (unless this co-occurs with increased prices per unit supplied) this implies a reduction in income for producers who may need to seek other markets. Sustainable domestic production measures modelled in our scenarios generally seek to substitute overseas production with EU domestic production, and the application of additional prices on imports applied under the BAM levers result in similar effects.

The 'vulnerability' of producers to such effects will also be a product of the type of production system. For example, in contrast to soy which is majority-produced by large-scale farming, products like cocoa, coffee, palm oil and rubber are significantly or predominantly produced under smallholder farming models (Daymond et al., 2021; IISD, 2023; Panhuysen and Pierrot, 2021; Partnerships for Forests, 2021). Without support, therefore, it is possible that smallholders are adversely affected by the EUDR and other policy measures. Activities such as Team Europe (European Union, 2025b) can provide such support, with existing examples including the European Sustainable Cocoa Initiative in West Africa (European Commission, 2022b) that is helping to improve alignment between the EUDR and existing regulations on cocoa production in Côte d'Ivoire, to ensure regulatory compliance. This includes knowledge sharing with cocoa stakeholders in West Africa (e.g. farmers, traders, NGOs and industry representatives) alongside direct budgetary support of €25 million in technical assistance. Evaluation of this initiative has concluded positive benefits in helping to establish dialogue between EU Member States and consumer governments in a manner that was previously lacking, but also that further improvements to scale up support could be made (FERN, 2024b).

5.2. Scaling up action

5.2.1. Supporting progress outside the EU

The impacts of the EU's interventions will be limited if policy measures to improve the sustainability of supply chains, and their deforestation-free credentials, only impact upon supply linked to EU demand. In our analysis we focus solely on the reduction of the EU's footprint, with policy interventions elsewhere (and resultant impacts on global deforestation in sum) exogenous to our analysis. For the EUDR and the EU's wider zero-deforestation commitments to be most successful in reducing global deforestation, mechanisms for 'de-risking' the EU supply chain or reducing the discrete connection between the European economy and deforestation must also be supported by policy measures and development assistance that targets both production and demand beyond Europe.

Many policy-linked forces can ultimately determine rates of deforestation in regions of production and their implications for global supply chains. For example, the change in rates of deforestation observed under successive Brazilian administrations (Cavalcante and Costa, 2023) is indicative of how the landscape of forest loss can rapidly develop via shifts in systems of governance. It is also worth highlighting that despite rates of forest loss being high in global terms, Brazil's international commitments and associated policy landscape does recognise and take steps to protect forests. For example, Brazil's new Nationally Determined Contribution (NDC) contains further commitments to "efforts to achieve zero deforestation", with financial support via the Amazon Fund, Tropical Forests Forever Facility and other initiatives (Government of Brazil, 2024a, 2024b). Brazil's Forest Code (aka 'Natural Vegetation Protection act') sets legal limits on the amount of deforestation that can occur on private property (Brock et al., 2021) and 80% of private land in the legal Amazon must be protected, with 20%-35% protection in other biomes. The governments of Côte d'Ivoire and Ghana have also developed a cocoa certification framework, the African Regional Standard for Sustainable Cocoa (ARS-1000), organised around improved social, environmental and economics standards for cocoa production (African Organisation for Standardisation, 2021).

A mechanism which has been publicised extensively as an example of a successful voluntary commitment to avoiding deforestation is that of the Amazon Soy Moratorium (ASM). However, this is currently under substantial threat, which could have significant consequences for soy-linked deforestation risk (Heilmayr et al., 2020; Wright, 2025). The Indonesian government highlights two significant moratoriums as instrumental to the deforestation declines observed over the past decade: the 2011 Forest Moratorium and the 2018 Palm Oil Moratorium (Euractiv, 2024), although there have been concerns about the effectiveness of implementation (Drost et al., 2021). Production-side measures such as these are critical in the context of global deforestation risk where a major share of deforestation linked to agriculture is linked to domestic markets. For example, according to data from the Global Environmental Impacts of Consumption indicator, Indonesian domestic consumption accounted for 35.3 thousand hectares (45.5%) of the 77.6 thousand hectares of deforestation linked to Indonesian palm oil in 2023 (SEI and

JNCC, 2025). Addressing the sustainability of this local demand is crucial, otherwise production linked to deforestation may simply be redirected to non-EU markets, resulting in 'leakage' and limiting the global success of European policy. The EU's AL-INVEST project is an example of an existing project (Team Europe Initiative, 2023a) connected to the broader agendas of resource efficiency and sustainable production in Brazil. Other major centres of consumption such as China, will also be critical targets for engagement with recent efforts towards bilateral cooperation to promote more sustainable demand across regions (Government of Brazil, 2023; Vasconcelos et al., 2024).

There are several opportunities for European actors to influence policy and narrative internationally. Perhaps most direct is the multinational nature of some of the largest supply chain players and how a shift in their EU markets influences their global processes. For example, many of the world's largest traders (e.g. ADM, Bunge, Cargill, JBS, Marfrig, Royal Golden Eagle, Sinar Mas, Wilmar) serve both EU markets and other major markets opening up space for further dialogue with these companies to promote them as deforestation-free 'suppliers' in more global terms. Existing voluntary measures are also in place, and could be further supported - for example a public-private partnership of cocoa operators (Barry Callebaut, Cargill, ETG, OFI, and JS Cocoa), supermarkets, certification bodies, government ministries, knowledge institutes and civil society organisations, have developed a strategy to eliminate deforestation, child labour and improve farmer incomes before 2030, under the Dutch Initiative on Sustainable Cocoa (DISCO) (IDH, 2025). The EU also already has a programme of work via the Team Europe initiative, for example in Indonesia where it is supporting more sustainable palm oil production (Team Europe Initiative, 2023b) and in its Europe-Brazil 'Green Deal' strand which includes an initiative on tropical forests (European Commission, 2025h). These external support mechanisms are important in their own right but also help to enable compliance with the EUDR's obligations by providing sources of sustainable, deforestation-free, supply. Other examples include the Sustainable Agriculture for Forest Ecosystems programme (SAFE) (Team Europe Initiative, 2024) that is designed to empower smallholders and strengthen local capacities. Extensions of this type of project are warranted to cover additional commodity production systems and regions of production.

5.2.2. Expanding the scope of levers within the EU

The analysis conducted in this study is exploratory in nature, with a focus on relatively detailed investigation and application of selected policy levers across our focal commodities. Even a fairly limited set of interventions - whilst not trivial to implement, especially at the high ambition level which often implies a need for regulatory intervention and associated investment - are envisaged to lead to a substantive reduction in the EU's footprint. Some levers, however, have greater influence than others. For example, the influence on the palm oil footprint is relatively small, with an 8.3% reduction in footprint when high ambition non-EUDR levers are applied (compared e.g. to a 56.2% reduction for cattle). Even when the low ambition EUDR is applied on top, palm oil's reduction is 36.2% compared to a 76.7% reduction for cattle.

This is particularly explained by the relatively marginal change in demand associated with the BAM implementation for palm oil, where we constrain impacts based on palm oil's relative cost-efficiency and role as a purely-imported material (see Section 4.6). Further opportunities for reduction of the palm oil footprint thus warrant further attention (for example, the continued pursuit of widespread electrification of transport and machinery to replace palm oil use in biofuel; an area that remains unexplored in our analysis), even if these involve measures which are difficult to impose and extend beyond the 'realistic yet ambitious' mindset that we have used to characterize this analysis (for example, those linked to palm oil's use more broadly in food where its cost-competitiveness and other characteristics make its substitution for other products challenging).

Even for commodities that exhibit larger reductions in footprint, there are opportunities for an expanded scope of measures. For example, the levers that we explore to reduce timber waste from construction via prefabrication have a marginal impact on the total EU timber footprint (0.44% reduction from the timber deforestation baseline; Figure 19) but are implemented on just one stage of the supply chain (on-site waste) of timber used in construction, and there is scope to reduce timber waste in other segments of the EU economy which utilise timber such as the manufacture of furniture (Furn360, 2018) or the pulp and paper industry (CEPI, 2025). Sticking with timber, the domestic expansion of traditional forestry systems would likely provide more material output (at the potential expense of wider ecosystem services) compared to the expansion of agroforestry explored in this analysis, and may be more appropriate as a policy option in some Member States. Therefore, pursuing more traditional production alongside agroforestry might readily achieve reductions in the timber deforestation footprint that are greater than the 3,696 ha (18.9% reduction compared to the baseline) modelled in this analysis. Even for the cattle footprint, further reductions could be achieved if policy instruments were sought to further reduce the consumption of meat products. Of course, the implementation of additional - or more ambitious - policies implies further resourcing and potential costs which should be considered against the relative return on investment of policies that focus on reducing deforestation at source, such as landscape-based initiatives.

The EU's baseline footprint is highly concentrated geographically within the bloc, with five Member States (Germany, France, Italy, Spain, and the Netherlands) accounting for approximately 70% of the total deforestation footprint. Whilst still dominant, after the high ambition non-EUDR levers are combined with the low ambition EUDR, this share falls to 62.3% indicating, for these countries, a relatively greater decoupling of their supply chains from deforestation. In our scenarios, implementation strength varied for a number of levers based on the attributes of different Member States, but we did not specifically target interventions towards those with higher or lower footprints. However, given the dominance of some countries, a more targeted approach may also be warranted with - for example - an expanded scope of levers being focused on particular states or coalitions of states with higher residual footprints. For example, despite strong reductions following the implementation of our high ambition non-EUDR levers with low ambition EUDR, Germany has a residual beef-linked deforestation footprint that is comparable to France and Italy. Particular efforts to promote further reductions in consumption of beef in these countries could be therefore be warranted (and incentivised, for example, by further country-specific strengthening of levers such as the imposition of meat taxes, or mandatory targets on the purchase of non-meat-based proteins in public procurement), potentially in conjunction with coordinated efforts in Brazil (which remains the main hotspot for cattle deforestation following this scenario).

For rubber, Germany remains with an outsize rubber-deforestation footprint following the implementation of low ambition EUDR with high ambition non-EUDR levers, indicating that further rubber-focused efforts could be targeted specifically towards Germany to achieve further footprint reductions for Europe (for example targeting the non-tyre use of rubber within Germany's large car industry, such as in seals, gaskets and trims). The cocoa deforestation footprints of the Netherlands and Germany also remain fairly high following the application of our policy levers (Table 10), and targeted efforts within these markets to incentivise, for example, alternative ingredients for chocolate-linked products could have an outsize effect given their important roles as suppliers of cocoa derivatives and semi-finished chocolate products to the rest of Europe (CBI, 2024).

It is also important to point out that on a per-capita or per-unit-GDP basis the perspective on which countries are associated with the largest footprints changes, with - for example - Luxembourg standing out as having a very high footprint on both per-capita and per-GDP terms even after policy implementation. Efforts to target future policy at particular countries based on their gross-impact must also be conscious of the per-capita impact on deforestation if the whole European continent is to contribute its fair share to tackling the problem of unsustainable consumption.

There is, of course, also scope to expand interventions beyond the seven focal EUDR-linked commodities that have been analysed here. Our levers were designed with a specific commodity focus, although in some cases the same levers may change the footprint of a wider-set of commodities which we have not quantified in this analysis. For example, reductions in beef consumption have implications for other commodities used in animal feed (e.g. wheat and maize) . Similarly, efforts to reduce European intake of snack foods might have implications for cereal-based crops or sugar, which have their own footprints. Whilst the EUDR-linked commodity list covers most deforestation that can be linked to agricultural commodity-production (72% in 2022), other major contributors according to the DeDuCE dataset include maize, cassava, and rice, and evidence suggests that such staples may be an increasing deforestation driver in certain regions (Ribeiro et al., 2024).

Additionally, if EU - or global - policy is successful at driving down the deforestation footprints of focal commodities, this has the potential to lead to unintended consequences such as the displacement of other crops into deforestation frontiers. The potential for such phenomena is documented for the cattle-soy complex in Brazil (Heilmayr et al., 2020), and there is evidence as well of the role of cocoa in displacing other commodities into deforestation frontiers in Ghana (Renier et al., 2025). This has several implications for European policy makers. For example, it implies the need to develop and improve monitoring systems that measure the deforestation (and biodiversity) footprints of commodities which are not typically classified as 'forest-risk' in prevailing discussions so that such displacement, or leakage, effects can be picked up as early as possible and - where necessary - the scope of mandatory and voluntary supply-chain commitments expanded to accommodate additional high-risk commodities. It also further underlines the importance of supporting landscape-based measures to reduce land conversion which go beyond a simple 'commodity focus'. Furthermore - and given the ultimate driver of production is consumption activities - it speaks to the cross-cutting requirement to develop a strong circular economy, and associated resource-efficiency measures, that work across sectors and global markets.

5.3. Limitations and future work

Our work explores, with some detail, the potential introduction of policy targeting consumption, production and sourcing of focal commodities. The development of 'realistic' levers to reduce the EU's deforestation footprint is then implemented in a multi-regional input-output (MRIO) modelling framework. There are a number of limitations associated with the implementation of our scenarios - both in terms of the assumptions adopted and the modelling methods employed - which could be the target for improvement.

First, there are various limitations associated with translating complex real-world intervention options into associated changes in the demand, production or sourcing of materials. This is especially true within the bounds of developing 'realistic' policy options where evidence of the availability of alternative production techniques, market-demand and so-forth depends on supporting information or the presence of equivalent policy. For example, for our implementation of the border adjustment mechanism, we are able to draw on some insights from the EU's existing CBAM policy but this does not provide information on what carbon-, or biodiversity-, costs would be deployed for an extended set of commodities, or what demand-effects would result from these costs, so assumptions are needed. As another example, the uptake of alternatives to cocoa and coffee is based on the potential for alternative technologies to be introduced, but there is very little information in the public domain on consumer-acceptability if significant market-penetration was targeted. As with other scenario exercises, a simplification of future realities is also likely. Our levers which promote sustainable production of domestic soy, for example, limit the scope to existing producers, but there may be opportunities for a wider set of Member States to produce soy, especially with changing growing conditions under climate change.

Furthermore, as a policy not-yet enacted (and with limited detail in the public domain about constraints that enforcing parties - Competent Authorities - are experiencing), and with key differences to the EU Timber Regulation that it replaces, the assumptions employed in our EUDR scenario are speculative. In some instances this results in relatively 'extreme' results. For example, the low ambition EUDR implementation results in very little change to the timber deforestation footprint because China - a country with high timber-deforestation exposure - is classified as 'low risk' by the

EU's benchmarking process and is therefore excluded from our implementation in this scenario. Sticking with the EUDR example, for high ambition implementation we apply a simple spillover effect whereby all deforestation is halted if the EU has sufficient influence in the region (which is particularly impactful, for example, for the Côte d'Ivoire footprint which is heavily influenced by cocoa exports to the EU), whereas the strength of such spillovers will of course vary in reality, or may be offset by leakage effects. Additionally, choices have been taken to translate policy levers into parameters which are changed in the modelling framework. This includes, for example, the aggregated sectors in the model to which changes are applied, where these rarely provide a one-to-one match to the products (e.g. HS codes covered by the EUDR) or domains (e.g. snack foods) targeted in our levers.

In sum, these challenges have resulted in the incorporation of assumptions that could have been introduced with different strength or with different modelled targets. Along with these assumptions, the MRIO modelling framework employed in this analysis provides further constraints that are described in Annex A. As an exploratory analysis these are not a large problem as the implementation serves to illustrate the comparative potential for wider policy implementation to have a transformational effect on the EU's footprint beyond the EUDR. However, future analysis could explore model parameterisation to test how sensitive outcomes are to the assumptions implemented in our scenarios.

Future analysis could also pay additional attention to the manner in which policy levers work in concert to provide the optimal pathways towards reduced deforestation from a net resource-use perspective. For example, in our food-waste levers, while accounting for some resource re-use for human consumption, we envisage a portion of food waste being diverted to use in animal feed and as an alternative to palm oil in biofuel. However, these scenarios do not necessarily optimise overall resource efficiency. More broadly, while interlinkages between our levers have been made at the policy-development level (for example, we account for availability of one resource based on changes in another policy area) our modelling acts on commodities in an isolated manner. Alternative modelling approaches would be needed to account for potential interactions between commodity-use patterns and to explore opportunities to optimise overall resource use towards a reduced deforestation footprint.

More complex models are also required to explore the potential for feedback loops that might impact on outputs in the economy based on changes in demand or the introduction of additional costs of imports, and for the potential for indirect land-use effects (and therefore associated impacts on expansion or contraction of lands in associated deforestation frontiers and resultant impacts on biodiversity and emissions) to arise with changes in demand in regions of commodity production. Our modelling is limited to more 'linear' effects, but general- or partial-equilibrium models could find potential application for future analysis, although the application of these may require further aggregations (for example, combining commodity-specific analysis into the impacts of coarser global sectors) to be tractable.

5.4. Conclusion and recommendations

The analysis demonstrates that a combination of policy levers is necessary for achieving the greatest potential reductions in the EU's deforestation footprint and associated biodiversity and emissions impacts. Whilst the EUDR is a significant, and targeted, measure, complementary levers that address consumption patterns, domestic production and trade are essential for achieving transformation. This is particularly true in the context of the challenging environment that surrounds implementation of the EUDR. We make the following recommendations and concluding remarks:

Pursue proper implementation of the EUDR: Designed as a key and targeted mechanism to reduce the EU's deforestation exposure, the EUDR has significant potential to de-risk the EU supply chain, but will only do so if properly implemented and enforced. The introduction of the EUDR currently still remains at risk, but substantial reductions in overall deforestation exposure can be obtained even with low–ambition implementation (for example, low enforcement strength and/or limited scope). Therefore, implementing the legislation - even if imperfectly applied in the short term - is highly important. We estimate that deforestation footprint reductions of in-scope commodities of 21.7% are achievable even with low ambition implementation. However, strengthened enforcement and investments in improved information systems will be required for thorough due diligence, and will be critical if the EUDR is to reach its full potential. According to our analysis, this could result in reductions in the deforestation footprint of in-scope commodities of 68.2% from the EU's baseline. Strengthened implementation and support includes seeking opportunities to promote positive spillover effects beyond EU-supply chains, for example via the Team Europe initiative.

Ramp up measures linked to a circular economy for Europe: The measures that we introduce to promote sustainable consumption, production and trade cross-cut a broader strategy towards a circular economy for Europe and its Member States. These measures also help support the EUDR's objectives given that its implementation is under threat. Measures that promote shifts away from damaging diets, the reduction and re-use of waste, the provision of European products as substitutes for more damaging imports, and the introduction of carbon- or biodiversity-linked pricing for damaging imports have significant potential to reduce the EU's deforestation impact. In combination with the EUDR, application of such levers has the potential to reduce the EU's footprint by between 60.0% and 85.3%, depending on the EUDR's implementation ambition. Importantly, they also offer the potential for wider benefits to society. Whilst the introduction of specific levers explored in this analysis provide some challenges, it is striking that a fairly restricted set has the potential to induce deep footprint reductions. For example, on the demand side, substantial reductions are viable for beef-linked footprints via dietary change, or through a transition away from biomass-based energy production for timber. For European manufacturers there are opportunities to use new technologies to recycle and reclaim unused rubber materials in tyres, or to explore lab-based protein manufacture as a further contribution to reducing beef's footprint. And on the primary-production side there are opportunities to expand soy production or domestic timber outputs to reduce dependency on higher-footprint origins overseas. Border-pricing may also be an effective strategy for beef and soy imports. Some measures explored in our analysis (for example, the promotion of prefabrication in the construction industry, or some food-waste levers) result in more marginal footprint reductions. There is therefore a need to carefully consider which measures have the largest potential for 'bulk' change in commodity use. That said, even measures with more marginal impacts on deforestation may provide wider economic and social benefits. In sum, a combination of levers across sectors and supply chains will be needed to transition to a sustainable European economy.

Explore additional levers and deepen analysis for specific Member State contexts: Our exploratory analysis purposefully does not cover every possible type of intervention linked to the circular economy or more broadly to strategies for reduced deforestation (either for the EU or globally). Other levers exist (such as extensions to demand- and supply-side policy outside of the EU, as described in Section 5.2), and there are opportunities to extend or mirror the levers we have explored to other sectors. Broadening the type of analysis to cover other levers is therefore warranted, potentially in combination with alternative modelling approaches in order to compare and contrast results and offer additional insights (for example, on price effects associated with policy implementation). In particular, further exploration at Member State level may result in the identification of levers which are more appropriate at national scale, or those which can be targeted towards countries and/or sectors which are particular hotspots for the European deforestation footprint (for example, the 'big five' Member States from a deforestation footprint perspective of Germany, France, Italy, Spain and the Netherlands).

Invest in knowledge transfer and reduction of deforestation in landscapes of production: Our scenarios and analyses do not account for the potential for indirect effects in landscapes of production, such as bifurcation of markets to support a deforestation-free EU economy while deforestation continues for other markets. In order to reduce the risk of such effects, alongside demand-side measures, continued dialogue and investment is required in regions linked to deforestation on which the EU depends (and more generally even in regions without strong trade-linked connections to the EU, if global climate and biodiversity targets are to be met). Activities aiming to strengthen governance and implement comparable circular economy or trade-linked strategies exist in some regions of high-risk production. However, there remains significant potential for the EU to show leadership both to support effective national and regional governance and to support knowledge transfer on successful policy and practice towards global sustainable and circular economies. This includes support to smallholders and other vulnerable producers who might be impacted by remote EU policy. Such activity can also increase the availability of information on the sustainability of the EU supply chain at source, which will feed back to improve, for example, the EUDR's implementation.

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