Report

Consumption-based effects on land use and biodiversity

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Report

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SUMMARY
This report compiles scientific evidence (based on published articles, reports, and case studies) of the impacts on land use and biodiversity from consumption with focus on Norway.

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Table of contents

Version update

The current version of the report, version 2, is an update of the initial report. In this newer version several percentage mistakes have been corrected, and an additional “Sammendrag av metoder” chapter in Norwegian as well as a corresponding one in English are added. They present the main methods in short.

In addition, on several places along the report, more explanations were included for better understanding of the results presented.

Preamble

This current report is a collection of three originally independent reports commissioned by Naturvernforbundet. Chapters 1, 2 and 3 are these initial reports in their updated version. Each of the three reports is an overview of the available current scientific literature on a specific topic of interest for Naturvernforbundet.

The first report's objective is to collect and present findings and insights on the data and method from the study of Bjelle et al. (2021)[1] with focus on the impacts from the Norwegian consumption on land use and biodiversity for the period 1995 – 2015. Thus, report 1 is based on the framework developed and the database underlying the article "Trends in national biodiversity footprints of land use", namely EXIOBASE 3rx (which is currently only available in current prices).

The aim of the second report is to further summarize the already available scientific literature reporting on the environmental impacts due to Norwegian consumption. The main impacts considered are biodiversity and land use and the scope is to find other studies, in addition to the study from report 1. The second goal of the report 2 is to find reported results for the period after 2015 and closer to the current year. The consumption categories clothing, electronics, and food were the focus.

In the third report, the two main methods (Input-Output Analysis and LC-Impact) that are currently used to assess the impacts on biodiversity and land use from consumption are briefly presented. In addition, the limitations and uncertainties surrounding these methods and the results they provide are highlighted.

[1] *Bjelle, E. L., Kuipers, K., Verones, F. & Wood, R. Trends in national biodiversity footprints of land use. Ecol. Econ. 185, 107059 (2021).*

Sammendrag av metoder

Denne rapporten er satt sammen av tre selvstendige rapporter. I de tre rapportene presenteres vitenskapelig litteratur på temaet som handler om å kvantifisere virkninger på naturen av forbruk, med fokus på norsk forbruk, i henhold til oppdrag fra Naturvernforbundet.

Input-output-analyse

For å estimere miljøpåvirkningene av forbruk (fotavtrykk) brukes i den vitenskapelige litteraturen ofte metoden miljøutvidet flerregional kryssløpsanalyse (environmentally extended multi-region input-output (EE-MRIO Analysis). Virkningene av forsyningskjeden refereres ofte som forbruks-fotavtrykk, eller virkninger av forbruk. Input-output databaser (nasjonale, regionale eller multiregionale) er satt sammen av statistiske byråer, internasjonale organisasjoner eller forskningsgrupper, og de beskriver produksjonssystemet som et nettverk av input til og output fra alle sektorene i hele økonomien. Kryssløpsanalyse er et verktøy for en systematisk analyse av et komplisert system av transaksjoner mellom sektorer i en økonomi. Når input-output databaser utvides med regnskap om miljøpåvirkninger kan metoden brukes til å koble forbruk av varer og tjenester til alle virkningene som oppstår i deres forsyningskjeder.

Standard input output-tabeller er gitt i pengeverdier, f.eks. amerikanske dollar, og består av tre hoved-datasett: 1) Sluttkonsum, som består av data om sluttforbrukeres forbruk (pengebruk) i de ulike sektorene i økonomien. Sluttforbrukere kan for eksempel være offentlige eller husholdninger; 2) Transaksjoner mellom industrier, som består av utgiftene industri X har hatt som den har brukt på varer/tjenester kjøpt fra industri Y, for alle sektorer i økonomien; og 3) Verdiskaping i hver sektor, som består av alle andre (ikke-industrielle) input til produksjonen, slik som kompensasjon til de ansatte og skatter minus subsidier. De monetære dataene i de flerregionale input-output-databasene som er tilgjengelige rapporteres ofte i løpende priser.

Miljøutvidede input-output databaser gir et tilleggs-datasett på miljøavtrykk. Dataene om miljøpåvirkninger rapporteres i fysiske enheter, og summerer seg til det totale avtrykket per indikator (indikatorer som f.eks. globalt totalt utslipp av CO2, hvis databasen dekker hele verdensøkonomien).

Det er viktig å merke seg at uansett hvilken verdisetting som er valgt for å gjøre analysen (løpende eller faste priser, dvs. justert for inflasjon), så er den totale forbruksbaserte påvirkningen dekket av databasen (alle fotavtrykk kombinert) alltid den samme (per år). For eksempel, hvis man ser på ett miljøutvidede input-output system før kun Norge for en gitt tidsserie, så er det totale miljø-fotavtrykket per år det samme, enten det er beregnet ved hjelp av data i løpende priser eller inflasjonsjusterte faste priser.[2] Da det totale avtrykket i fysiske termer er gitt, endrer bruk av løpende i stedet for faste priser kun intensiteter, det vil si miljøavtrykk per økonomisk aktivitet, og med det fordelingen av miljøpåvirkninger langs verdikjeder, når de ulike økonomiske aktivitetene er underlagt ulike inflasjonsrater.

I tillegg er det viktig å være bevisst de store forskjellene i sektorenes detaljer, hvilke land som dekkes og hvordan ulike land dekkes i de ulike databasene. Disse ulikhetene kan føre til betydelige forskjeller mellom høydetaljerte fotavtrykksresultater. Dette kan skyldes bl.a. utfordringer knyttet til disaggregering, hvordan sammenstilling og balansering av ulikheter er gjort, og forskjeller i selve regnskapene over miljøvirkninger.

[2] Merknad: Når fotavtrykk for spesifikke sektorer beregnes og sammenlignes over tid, så blir det avvik på sektornivå avhengig av om man bruker løpende eller faste priser, men det blir ikke avvik på totalen.

LC-IMPACT

Endringer i arealbruk er en faktor som påvirker fotavtrykk/artstap, og dette er derfor en viktig faktor når vi ser på betydningene til norsk forbruk. Arealbruk påvirker biologisk mangfold negativt, og virkningene er ikke jevnt fordelt over hele kloden. På lokal skala kan feltstudier brukes til å estimere tapet av biologisk mangfold og å dokumentere utryddelse av arter Men når vi foretar vurderinger på global skala hvor forbruk er geografisk og fjernt knyttes til virkninger på biologisk mangfold (der man bruker metodikk som kryssløpsanalyse og LCA), er det ikke mulig å gjennomføre slike feltstudier.

Blant de som jobber med livsløpsstudier, og mer spesifikt LC-IMPACT-metodikken, måles virkningene på biologisk mangfold med "potensielt forsvunnet fraksjon av arter" ("potentially disappeared fraction of species", PDF), som står for den andelen av artsrikdommen som potensielt kan gå tapt på grunn av press på miljøet (f.eks. arealbruk, økotoksisitet, klimaendringer, eutrofiering osv.). Innenfor denne metodikken er potensialet for artsutryddelse basert på artsrikdom som representerer antall ulike arter til stede i et økosystem, landskap eller i en region. Det er viktig å påpeke at artsrikdom og biologisk mangfold ikke er synonymt. Biologisk mangfold omfatter både variasjonen i antall arter og deres relative rikdom(?) i antall, samt økosystem- og genetisk variasjon. Nedgang i artsrikdom kan imidlertid være en indikator for tap av biologisk mangfold.

For å estimere virkningen av arealbruk på artsrikdom, bruker LC-IMPACT -metodikken områdets art-område forhold (species-area relationship, SAR), som kvantifiserer regionalt artstap som skyldes endringer i tilgjengelig areal for fem forskjellige taksonomiske grupper (pattedyr, fugler, amfibier, krypdyr og planter), og for seks forskjellige arealbrukstyper ("intensivt skogbruk", "ekstensivt skogbruk", "årlige avlinger", "permanente avlinger", "beite" og "urban"), i 804 terrestriske økoregioner over hele kloden.

Økoregioner er definert som relativt store landenheter som inneholder en distinkt samling av naturlige samfunn og arter, med grenser tilnærmet den opprinnelige utstrekningen av naturlige samfunn før store endringer i arealbruk. For hver økoregion og hver taksonomisk gruppe beregnes det dermed en faktor (kalt karakteriseringsfaktor innenfor metodikken) ved å bruke en formel som tar i betraktning: den tilsvarende allokeringsfaktoren for hver av de 6 arealbrukstypene i den økoregionen, sårbarhetsscoren til taksonomisk gruppe i den økoregionen, antall arter i den taksonomiske gruppen på global skala og en global sårbarhetsscore. Sårbarhetsscore for hver økoregion er basert på andelen av hver arts geografiske utbredelse (endemisk rikdom) som lever i den respektive økoregionen, samtidig som man vurderer IUCN-trusselnivået for hver art.

Videre i metodikken beregnes landsspesifikke faktorer som areal for å vekte gjennomsnittet for arealbrukstyper. Dermed vil PDF-målet sammenligne den opprinnelige artsrikdommen fra den naturlige tilstanden (uforstyrret av menneskelig aktivitet, og som representerer referansen) med andelen som er igjen etter et menneskelig inngrep.

I våre rapporter representerer det biologiske mangfoldet som følge av norske husholdningers forbruk i 1995 tapet i artsrikdom i 1995 i forhold til artsrikdommen uten menneskelig inngrep. På samme måte er fotavtrykket for år 2015 relativt til den samme naturlige referansetilstanden uten menneskelig inngrep.

PDF for et gitt år representerer andelen av arter som forventes å bli utryddet hvis det nåværende presset fortsetter, og representerer ikke faktiske utryddelser som allerede har skjedd.

Summary of the methods

The three independent reports collected here, present the scientific literature on quantifying impacts of consumption with focus on Norwegian consumption as commissioned by Naturvernforbundet.

In a large part of the studies reviewed, the method used to quantify the supply chain impacts of consumptions, often referred to as consumption footprint or impacts of consumption, is environmentally extended multi-region input output (EE-MRIO) analysis. Input output (IO) databases (national, regional, or multi-regional) are compiled by statistical offices, international organisations or research groups and describe the production system as a network of input to and output from all the sectors of an economy. Input output analysis provides a tool for a systematic assessment of the complicated inter-industry transactions in an economy. When input output databases are extended with environmental accounts, the method can be used to link consumption of goods and services to all the impacts that occur in the supply chain.

Standard input output tables are provided in monetary values, e.g. US Dollars, and contain three main datasets: 1) Final demand, which contains information such as money spent by final consumers like governments or households on different sectors, 2) Inter-Industry transactions, which contains Industry X's spendings on products/services used from industry Y for all industries of the economy, and 3) Value Added, which records all other (non-industrial) inputs to production, such as compensation of its employees and taxes less subsidies, for each industry. The monetary data of the multi-regional input output databases available is most often only reported in current prices. Environmentally extended IO databases provide an additional dataset containing data on environmental impacts. These are reported in physical units and sum to the total environmental pressure per indicator included (e.g., global total amount of CO_2 emitted, if the IO database covers the whole world economy).

It is important to note that no matter what valuation is chosen to do the analysis in (current prices or constant prices, i.e., adjusted for inflation), the total consumption-based impact across all coverage of the database (all footprints combined) is always the same (per year). For example, given a single country environmentally extended input output system for Norway as a time-series, the total environmental footprint per year will be the same no matter if it is calculated using data in current prices or inflation adjusted, in constant prices[3]. Since the total environmental footprint in Norway in physical terms is given, the use of current instead of constant prices only changes intensities, that is environmental footprint per economic activity, and with that the allocation of environmental impacts along value chains, when the different economic activities are subject to different inflation rates.

There also needs to be awareness of the large differences in sector-level detail and country coverage between the available databases, which can lead to significant differences between detailed footprint results, which can be due to among others disaggregation challenges, compilation and balancing differences and differences in the environmental impact accounts themselves.

[3] Note: When footprints of specific sectors are calculated and compared over time, current and constant price data will yield deviations for sector level results, but not on total level.

Land use negatively impacts biodiversity, and the impacts are not uniformly across the globe. When interested in impacts at a local scale, field studies can be used to estimate the biodiversity loss and document species extinctions, but for assessments at the global scale where geographically distant consumption is linked to biodiversity impacts (as is the case of the IOA and LCA methodologies), such studies are not feasible.

In the life-cycle community, namely in the LC-IMPACT methodology, the impacts on biodiversity are measured with “potentially disappeared fraction of species” (PDFs), which accounts for the fraction of species richness that potentially may be lost due to an environmental pressure (e.g., land use, ecotoxicity, climate change, eutrophication, etc). Within this methodology, the potential for species extinctions is based on species richness which represents the number of different species presented in an ecological community, landscape, or region. It is important to highlight that species richness and biodiversity are not synonymous as biodiversity encapsulates both the variation in the number of species and their relative abundance, as well as genetic and ecosystem variation. However, declines in species richness can be an indicator for biodiversity loss.

For the estimation of land use impacts on species richness, the LC-Impact methodology uses the countryside species-area relationship which quantifies regional species loss due to changes in the available area for five different taxonomic groups (mammals, birds, amphibians, reptiles and plants), and six different land use types (“intensive forestry”, “extensive forestry”, “annual crops”, “permanent crops”, “pasture”, and “urban”) in 804 terrestrial ecoregions across the globe. Ecoregions are defined as relatively large units of land containing a distinct assemblage of natural communities and species, with boundaries that approximate the original extent of natural communities prior to major land-use change.

Thus, for each ecoregion and each taxonomic group there is calculated a factor (called characterisation factor within the methodology) using a formula which considers: the corresponding allocation factor of each of the 6 land use types in that ecoregion, the vulnerability score of the taxonomic group in that ecoregion, the number of taxa, the number of species in the taxonomic group at the global scale and a global vulnerability score. Vulnerability scores for each ecoregion are based on the fraction of each species’ geographic range (endemic richness) living in the respective ecoregion while also considering the International Union for Conservation of Nature (IUCN) threat level of each species.

Further, in the methodology, country specific factors are calculated as area-weighted averages over land use types. Thus, PDF is comparing the original species richness from the natural state (undisturbed by human activity, which represents the reference) to the fraction left after a human intervention. In our reports, the biodiversity footprint due to Norwegian households’ consumption in 1995 represents the species richness loss in 1995 relative to the species richness without any human disturbance. Similarly, the footprint for year 2015 is relative to the same natural refence state without human intervention. PDF for a certain year represents the fraction of species expected to go extinct if the current pressures prevail and do not represent actual extinctions that have occurred already.

Report 1: Biodiversity and land use footprints

In this report we gather the already published data for the biodiversity and land use footprints due to the total annual Norwegian consumption as they are made available for the interval 1995 – 2015 (Bjelle et al., 2021). We compare the Norwegian per capita footprints with the European and global ones in addition to presenting the biodiversity footprint due to the clothing and footwear category.

Land use, resulting in habitat loss and degradation, is the pressure with the largest relative impact on ecosystems (Reid, 2005). In global Life Cycle Assessment (LCA) models, species richness is used to indicate the potential for species extinctions with the resulting biodiversity impacts measured as “Potentially Disappeared Fraction of species (PDF)” (Verones et al., 2017). The amount of land used, and the geographical location of the land used are the dominant drivers for the biodiversity footprint. The results presented for biodiversity footprints in this report are only considering biodiversity loss from land use. However, global warming and water use are also significant drivers, but there are not included in the methods reviewed.

Total annual consumption-based Norwegian footprints

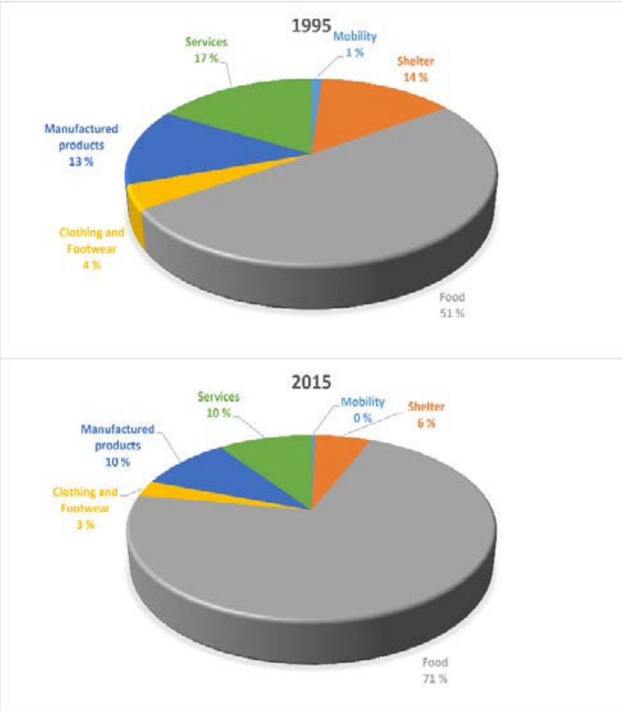

Figure R1.1. Annual Norwegian consumption-based biodiversity footprint with breakdown on the 6 categories (shelter, food, clothing and footwear, mobility, manufactured products, and services).

The consumption-based biodiversity footprint has a breakdown into 6 consumption categories: shelter, food, clothing and footwear, mobility, manufactured products and services.

In Figure R1.1, we show these 6 categories’ shares of the total annual Norwegian consumption-based biodiversity footprint for years 1995 and 2015. The “food” category is the one which registers the largest increase in the share within the total footprint, from 51% in 1995 to 71% in 2015.

The biodiversity footprint due to total Norwegian annual consumption increased by 163% from 1995 to 2015 (see Table R1.1 below). This trend could be linked to the increase in the share of categories with high biodiversity footprint intensities (like “food”) but can also be the result of a change of consumer’s consumption patterns as well as changes in national trade patterns (i.e., which countries we import from).

At the same time, the land use footprint decreased by 8,41% for the same interval, which can be explained by the increasing intensification of land use (more intense use of the same amount of land) (values presented in Table R1.1).

The biodiversity footprint from the consumption of products within the “clothing and footwear” category increases between 1995 and 2015 (see Table R1.1) and the relative share of this category of products within the total consumption-based Norwegian biodiveristy footprint is about 4% in 1995 and 3% in 2015.

Table R1.1: Total annual Norwegian consumption-based footprints

	Biodiversity (PDF)	Land (km^2)
1995	Total: 0, 00171 Clothing and Footwear: 0,00007 (4%)	192186
2015	Total: 0,00450 Clothing and Footwear: 0,00012 (3%)	176025

Per capita footprints

The Norwegian-specific biodiversity footprint per capita for 2015 was 8.67E-10 PDF (see Table R1.2) which corresponded to a 0.11% of the global total biodiversity footprint (Bjelle et al., 2021). In addition, this footprint is 2.2 times larger in 2015 than in 1995, which when compared with the other two regional and global footprints highlights an opposite trend for Norway. Important factors to investigate to understand these trends better would be trade pattern changes and their differences, consumption expenditure composition and its changes as well as development of affluence and household expenditure levels.

Table R1.2: Comparison of consumption-based per capita footprints

Footprint	Year	Norway	EU-27	Europe	Global
Biodiversity (PDF* 10^{-10})	1995	3,92	5,02	6,70	6,60
	2015	8,67	4,93	6,14	5,40
Land (km^{2}* 10^{-2})	1995	4,41	1,59	2,02	1,22
	2015	3,39	1,50	1,78	0,97

In 1995, Norway has similar consumption-based biodiversity footprint per capita as Switzerland and Germany, while in 2015, the Norwegian footprint is the highest across the seven countries below and well above the mean European one (see Figure R1.2).

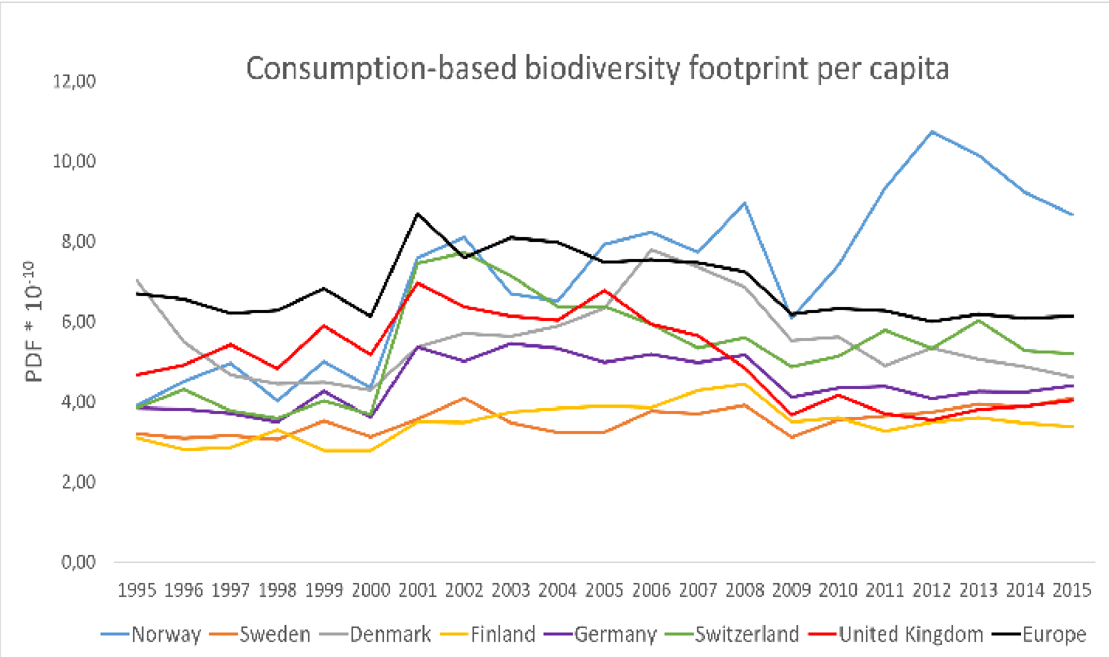

Figure R1.2: Consumption-based biodiversity footprint per capita for selected countries and the European mean

The land use footprint per capita was 3.39E-02 km^2 in 1995 (see Table R1.2), which translates into 0.25 % of the global land use footprint for the total Norwegian consumption .

The consumption-based land footprint has a breakdown into six land use categories: urban, annual and permanent crops, internsive and extensive forestry and pasture. The share of “pasture” and “permanent crops” of the land use footprint increase the most from 1995 to 2015, while the share of “extensive forestry” sharpely decreases (see Figure R1.3).

Among the seven countries presented, the Norwegian consumption-based land use footprint is the second highest, behind Finland, across the entire period 1995-2015 (see Figure R1.4). Norway, Finland, and Sweden register higher footprints than the mean European, with Norway the only country presenting a slightly decreasing trend.

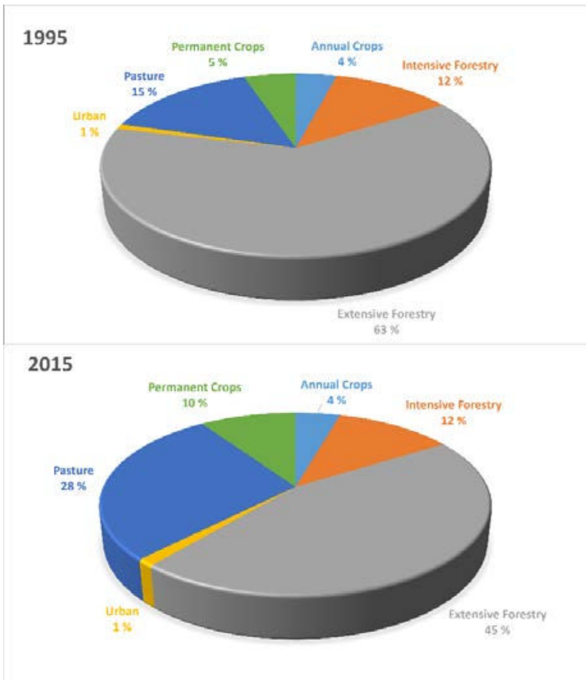

Figure R1.3. Norwegian consumption-based land use footprint with the breakdown on the 6 categories (pasture, annual and permanent crops, urban and intensive and extensive forestry) for 1995 and 2015

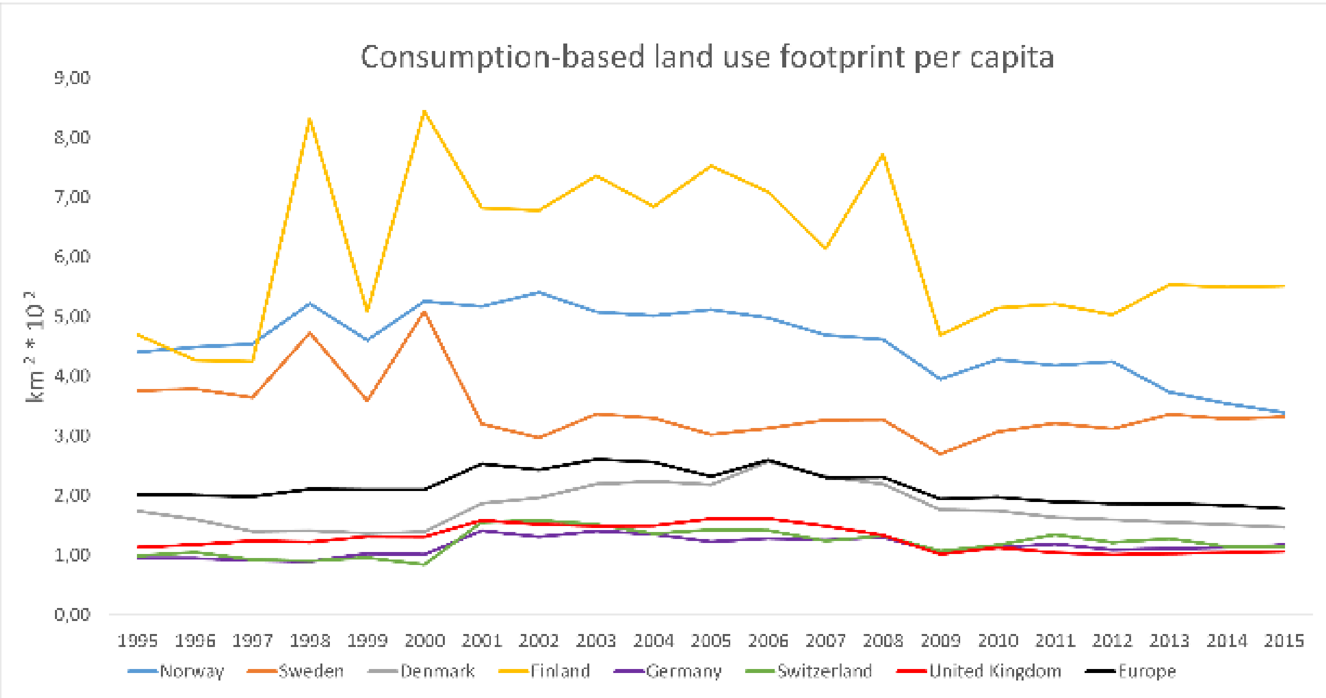

Figure R1.4: Consumption-based land use footprint per capita for selected countries and the European mean.

Clothing and Footwear footprints per capita

The Norwegian biodiversity footprint per capita due to consumption of clothing and footwear has increased by 47% from 1995 to 2015. This increase is smaller than the mean EU-27 (51%) but above the mean European (30%). At the same time, the global mean biodiversity footprint per capita due to clothing and footwear consumption is slightly decreasing (-13%) (see Table R1.3).

Table R1.3: Biodiversity footprints (PDF* 10^{-11}) due to clothing and footwear consumption per capita

Year	Norway	EU-27	Europe	Global
1995	1,63	1,14	1,65	1,24
2015	2,39	1,72	2,14	1,10

When comparing the different biodiversity footprints per capita from consumption of clothing and footwear products across the seven different European countries, Norway and the UK have in 1995 similar values (and both around the mean European one) and in 2015 only Switzerland has a higher footprint than the Norwegian one. Norway, Switzerland, Germany, and Denmark have all higher footprints than the mean European one (see Figure R1.5).

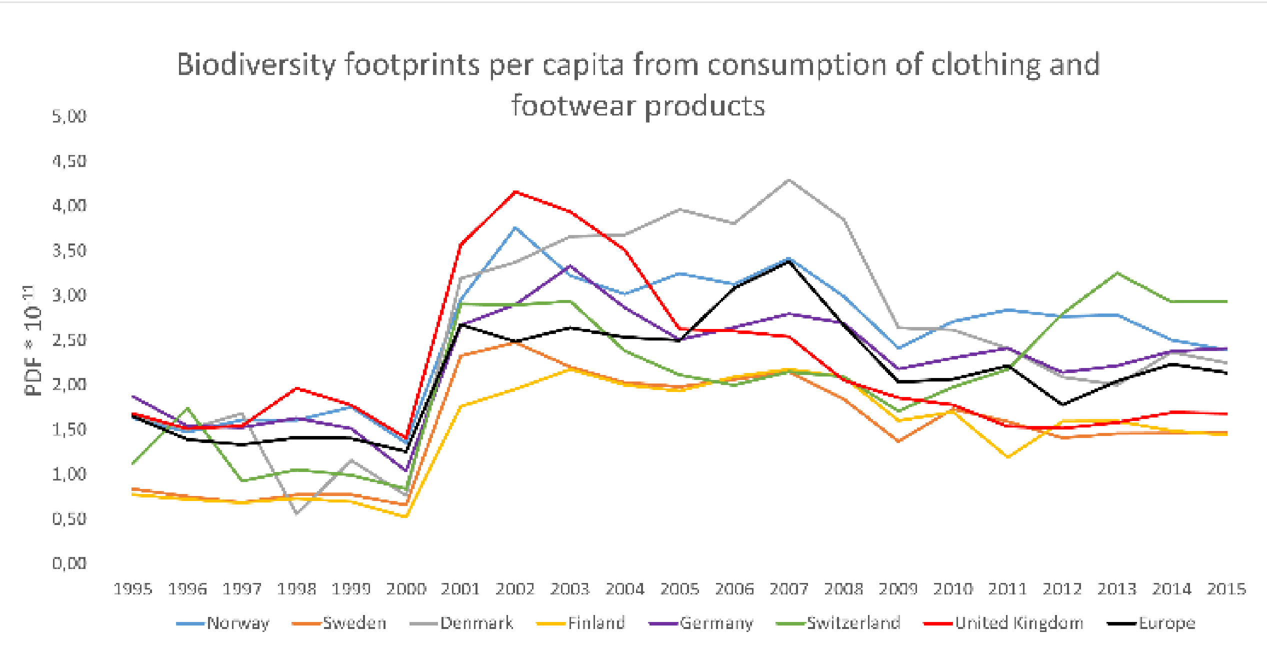

Figure R1.5: Biodiversity footprint per capita from consumption of clothing and footwear products for selected countries and the European mean

All seven countries show a sharp increase and several of them show a peak in the early 2000s. There could be several reasons behind this increase in the footprint. Since numbers for biodiversity footprint from clothing consumption are so small, a change in e.g., trade patterns (import from a country with rich and vulnerable biodiversity) can have a large effect on biodiversity footprint change from year to year in this category. In their study, the authors find the "peak in the high-income group's biodiversity footprint in the early 2000s was caused by land embodied in imports rather than increasing income, showing the importance of addressing trade in policy design" (Bjelle et al., 2021), which gives an indication of the potential reason behind the observed feature of the clothing and footwear footprint in Figure R1.5. Further investigations are needed to determine the reasons of this increase and spike.

Limitations and method description

The data presented in this report are the outcome of the research publication by Bjelle et al. (2021). The two data sources used by the authors for biodiversity impact calculations are the multiregional input-output (MRIO) database EXIOBASE 3rx (2020) which provides the economic and land use data, and the life cycle impact method LC-IMPACT by Verones et al. (2020) providing characterization factors of biodiversity impacts from land use with results at the extinction level (potential species loss).

Land use impact factors estimating the PDF (bird, mammal, amphibian, reptile, and plant) per area occupied by specific land use types are used, and these species act as a proxy for the entire "biodiversity".

The MRIO database EXIOBASE 3rx contains data on 200 sectors and 214 countries describing production requirements and demand in national economies. Whilst official input-output tables are not available for many of these countries, in EXIOBASE 3rx proxy estimates were made based on technology data, estimated outputs and trade data. The database contains extensions for six land use types: urban, annual and permanent crops, intensive and extensive forestry and pasture. EXIOBASE 3rx is currently only available in current prices. Care should hence be taken when interpreting weak trends over time of individual product categories' impacts.

Impacts from land use are modelled in LC-IMPACT for land occupation (use) and land transformation, but only land use was applied in Bjelle et al. (2021). The model is based on the countryside species-area relationship (SAR), taking into account that species may be able to survive in the absence of natural habitat, i.e. live in human-modified land only.

Land use impacts are modelled for mammals, birds, amphibians, reptiles and plants individually for local losses and then adapted with a "vulnerability score" to transform local losses to global species extinction.

The European mean per capita is calculated as the average of the following 45 countries from the data published by Bjelle et al. (2021): Albania, Andorra, Austria, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Greenland, Hungary, Iceland, Ireland, Italy, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Monaco, Montenegro, Netherlands, Norway, Poland, Portugal, Moldova, Romania, Russia, San Marino, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Ukraine and United Kingdom.

The EU-27 mean per capita is calculated based on the data published by Bjelle et al. (2021) as the average for the following 27 countries: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, and Sweden.

Recommendations for further research

Based on the results collected for this report, our main three suggestions for further steps would be the following:

- Analysis of the Norwegian consumption patterns and consumption levels for better understanding of the trends in footprints presented in this report, including considerations of the impacts of inflation
- Investigation of the Norwegian trade patterns to better explain the increasing trend in the biodiversity footprint and the decreasing one in the land use footprint.
- Investigation of the domestic versus imported shares of biodiversity and land use footprints.
- Comparison with the most recent studies published after the first submission of Report 1

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Report 2: Impacts of Norwegian Consumption

The aim of this report is to summarize further the already available scientific literature reporting the environmental impacts due to Norwegian consumption, with focus on the effects on biodiversity and land use. The review was made with focus on the clothing, electronics, and food consumption categories. In addition, we present the Norwegian consumption expenditure for the period 1995 – 2021.

Norwegian household consumption 1995 – 2021

The total annual Norwegian household consumption expenditure increased by 168% from 54113 million Euro in 1995 to 145127 million Euro in 2021 according to the data presented in the EXIOBASE 3.8.2 (Table SI.R2.1)(Stadler et al., 2019). This environmentally extended multiregional input-output (EE-MRIO) databases describes the world economy at the detail of 43 countries, five rest-of-the-world regions, and 200 product sectors, all in current prices. Figure R2.1 below presents the breakdown on 12 different consumption categories from the household consumption for the period 1995 – 2021 based on the EXIOBASE 3.8.2 (Stadler et al., 2019) database.

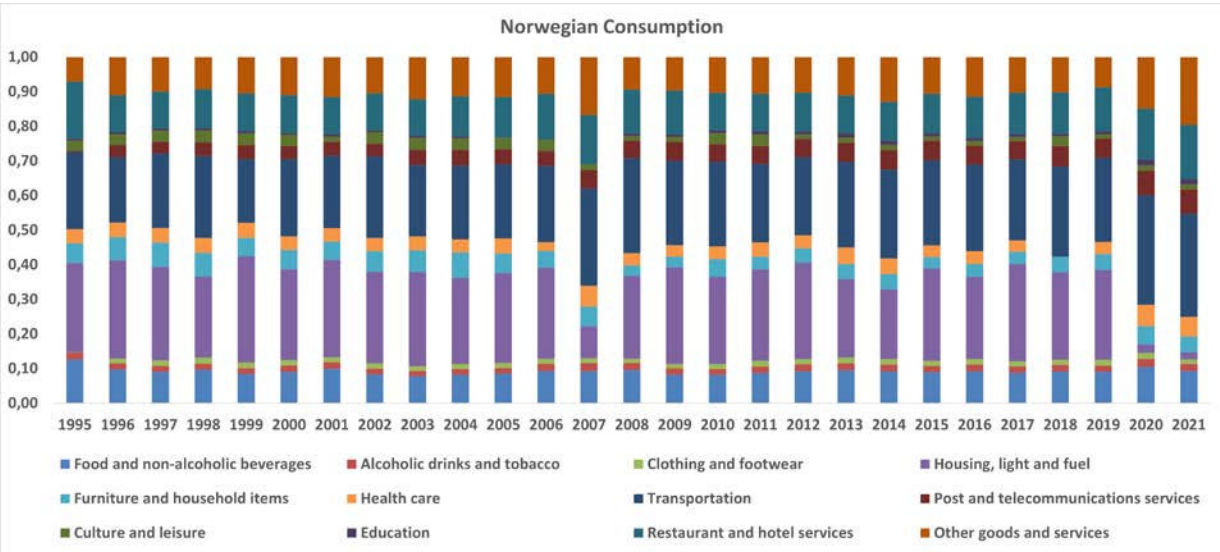

Figure R2.1: Annual Norwegian consumption shares from households with a breakdown on 12 different categories based on the EXIOBASE 3.8.2 database.

There is a decrease in the “Housing, light and fuel” category for both 2006-2007 and 2019-2020 periods. It is important to note that the original EXIOBASE 3 data series end in 2011, which means that this is the last year where actual data from national statistics were gathered. In addition, the database offers estimates up until 2022 based on auxiliary data, mainly trade and macro-economic data considering International Monetary Fund (IMF) expectations. The end years of real data points used are: 2015 for energy, 2019 for all GHG (nonfuel, non-CO_2 are nowcasted from 2018), 2013 for material, and respectively 2011 for most others, land, water. For the moment, data is only available in current prices (Stadler et al., 2019).

The Norwegian household consumption of items within the clothing and footwear category has doubled in 2021 in current price expenditure (2012 million Euro) when compared with 1997 statistics (1053 million Euro). Figure R2.2 also highlights the drop from 2009 and the peak from 2019 when the highest level of consumption was registered for this category at 2595 million Euro. For the same period the consumption within the food and non-alcoholic beverages has almost doubled from 7076 million euro in 1995 to 14110 million Euro in 2021 according to the data from the same source.

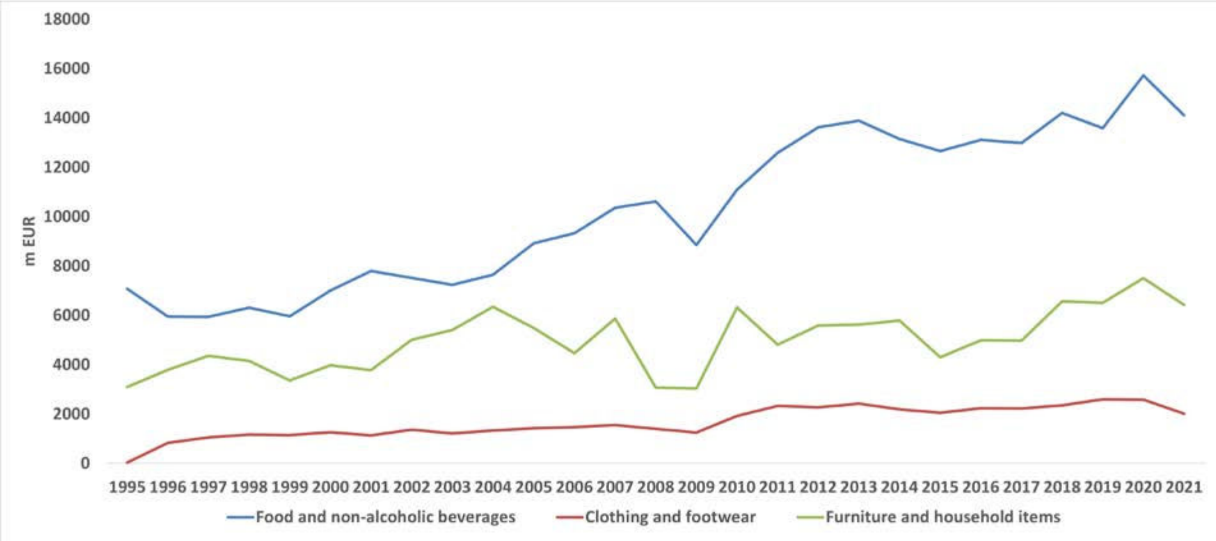

Figure R2.2: Annual Norwegian household consumption expenditure for the categories food and non-alcoholic beverages, clothing and footwear and furniture and household items in units of million EUR and based on the EXIOBASE 3.8.2 database.

Table R2.1 presents annual Norwegian household consumption expenditure data from two separate sources: in million Euro from EXIOBASE 3.8.2 database for the period 1995 – 2021 and in million NOK from Statistics Norway (SSB) for the period 1995 - 2020. Total national consumption in million NOK as reported by the SSB highlights an increase as well of 216% for the period 1995 – 2020 (last available year). According to the SSB data, the clothing and footwear consumption increased by 2.5 times while the food and non-alcoholic beverages consumption increased by 2.6 times for the period 1995 – 2020 (see Table SI.R2.2).

Table R2.1: Comparison of annual household consumption data for Norway as reported in EXIOBASE 3.8.2 in million EUR from Stadler et. al. (2019) and from Norwegian Statistics (SSB) in million NOK, both in current prices.

Consumption	1995	2000	2005	2010	2015	2020
mil.Euro (EXIOBASE)	54113	74440	100046	130160	136196	142926
mil.NOK (SSB)	446598	605116	774472	1004127	1215007	1409225

Remarks about Norwegian consumption

1) The total annual Norwegian household consumption expenditure increased by 168% from 1995 to 2021 (in million Euro in current prices based on the figures from EXIOBASE 3.8.2).
2) Within the consumption categories, the clothing and footwear, and food category have doubled (EXIOBASE) and about a factor of 2,5 (SSB) in comparison with 1995.
3) There the two main data sources (SSB and EXOBIOBASE) show similar trends in the development of total household consumption and in the categories clothing and footwear and food.

Consumption-based biodiversity impacts

Biodiversity footprinting can help with informing choices by linking consumers to the biodiversity pressure their consumption induces. Nevertheless, there are limited scientific efforts trying to link consumption to the impacts on biodiversity loss with some exceptions (Koslowski et al., 2020; Moran and Kanemoto, 2017; Wilting et al., 2021). These studies are mostly concentrated around EU consumption (thus Norway is not always covered in these studies), highlighting the region's role in advancing the frontiers of knowledge in this field.

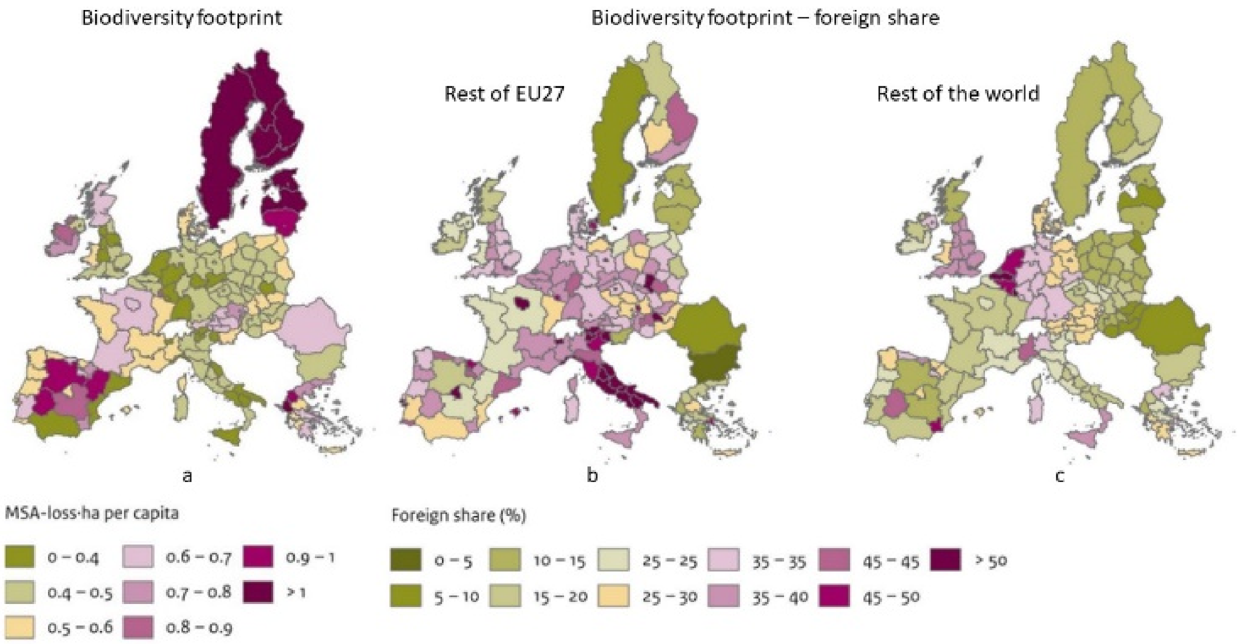

Figure R2.3: Biodiversity footprint for 162 regions (excluding Croatia) for year 2010 and measured in the Mean Species Abundance (MSA) metric: a) biodiversity footprint per capita b) foreign shares from rest of EU27 and c) foreign shares from rest of the world. Figure from (Wilting et al., 2021).

Figure R2.3 with results collected from Wilting et al. (2021) offers insights into subnational land-based biodiversity footprints in the European Union (EU) from a consumption-based perspective for year 2010 using the Mean Species Abundance (MSA) metric as indicator of biodiversity loss. Norway is not part of this study. The MSA indicator expresses the mean abundance of original species in a disturbed situation relative to their abundance in undisturbed ecosystems (Alkemade et al., 2009).

Figure R2.3a shows the per capita land-based biodiversity footprints (measured as MSA-loss·ha). Among the countries selected in Wilting et al. (2021), Finland (with all its regions) has the highest reported per capita biodiversity footprints, with values of 1,5–2,0 MSA-loss·ha followed by Sweden, Latvia and Estonia (between 1,0 and 1,5 MSA-loss·ha). The lowest per capita biodiversity footprints (below 0,35 MSA-loss·ha) are reported in Malta, Spain (Valencia and the Canary Islands) and Campania and Liguria in southern Italy. Figure R2.3b shows the share of the foreign biodiversity losses that occurred outside their territory but in other EU regions while Figure 2.3c shows the share of biodiversity losses imported from countries outside EU.

Most EU regions (115 out of 162) are already net importers of biodiversity losses (more than half of their land-based biodiversity footprint originated outside their territory) highlighting the role of trade in national and regional policies on averting further biodiversity losses, both within and outside the region itself. Countries like Romania, Bulgaria and the Baltic states have foreign shares below 30% and hence domestic shares above 70%. Nevertheless, the study reports that in 129 regions, biodiversity losses imported from other EU regions were larger than losses imported from outside the EU (Figure R2.3). While countries like Belgium, Luxembourg, and the Netherlands, have more than 50% of their consumption-related biodiversity losses occurring outside the EU.

Another study published in 2020, which also evaluates biodiversity impacts of consumption from EU28 and Norway in 2010 ranks Norway on the 7th place (see Figure R2.4) as intensity of its biodiversity footprint per capita (Koslowski et al., 2020). Here, the authors use a similar approach as in Bjelle et al. (2021): an environmentally extended multi-regional input-output (EE-MRIO) model based on EXIOBASE 3.4 coupled with the LC-Impact life-cycle impact assessment (LCIA) method (Verones et al., 2017). This study assesses the European biodiversity footprints on regional, national, and sub-national levels, with a focus on urban vs rural consumption patterns. When comparing the results for 2010 reported by Koslowski et al. (2020) with the ones presented in the first report from the study by Bjelle et al. (2021), Norway is well above the EU-27 average biodiversity footprint in PDF per capita units (7,41 * 10^{-10} PDF/capita for Norway versus the EU-27 average of 5,08 10^{-10} PDF/capita). Norway also shows a higher footprint when compared with neighbouring countries like Denmark and Sweden.

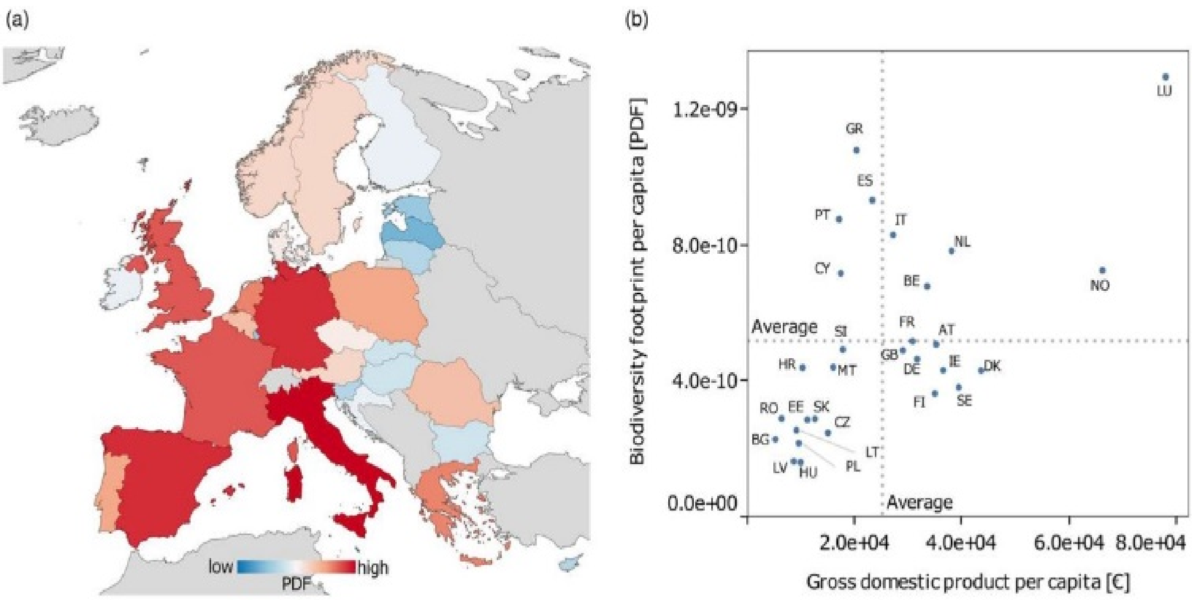

Figure R2.4: Biodiversity footprints of EU28 + Norway for 2010. (a) shows absolute national biodiversity footprints and (b) shows per capita biodiversity footprints against the per capita GDP per country. Countries other than EU28 + Norway are grey shaded in (a). The dotted lines in (b) represent the per capita footprint and GDP averages. Figure from (Koslowski et al., 2020)

Figure R2.5 shows the results from the study by Ivanova et al. (2016) where the authors assessed the environmental impact of EU household consumption using EXIOBASE 2.2. The assessment takes the origin of the products consumed by households into consideration and represent global supply chains for year 2007. Almost 65 million km^2 of global land use was required to meet the global household demand in 2007, which represents 44% of the Earth's total land mass (149 million km^2). For the carbon footprint (Figure R2.5, red graph), mobility shows the highest emissions per unit of household expenditure within the EU, namely 3,4 kg CO_2-eq/Euro while clothing and footwear are on the fourth place with 0,9 kg CO_2-eq/Euro and corresponding to 3.5% of the total carbon footprint of the EU households. Food has an intensity of 0,6 kg CO_2-eq/Euro and is responsible for 9,5% of the carbon footprint. In the case of the land footprint (Figure R2.5, green graph), the consumption of food shows the highest intensity, 7,2 m^2/Euro, and accounts for 51% of the total land footprint of the EU households. Clothing is the second most land-intensive of the consumption categories though it is associated with only 4,3% of the land use by EU households.

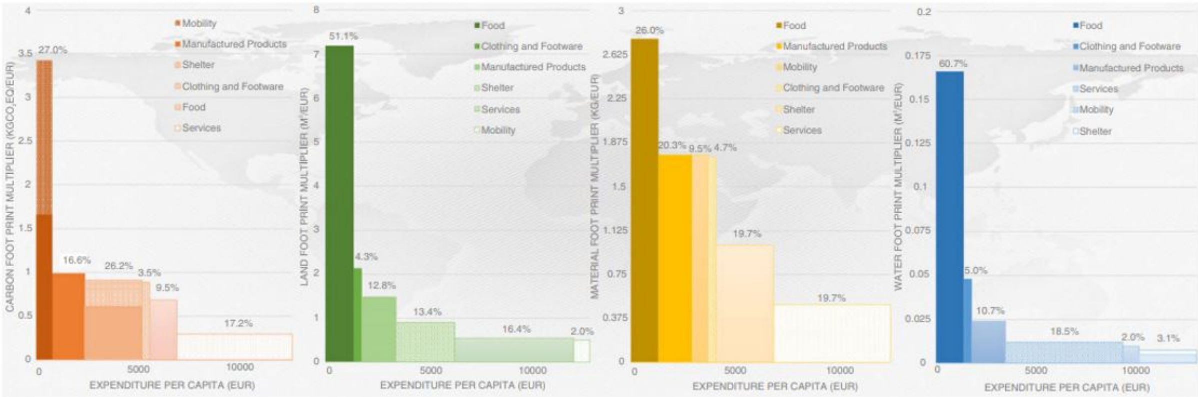

Figure R2.5: Contribution of consumption categories to the carbon, land, material, and water footprint of EU households for year 2007. The contribution of consumption categories to the total environmental footprints can be split into two parts: the quantity of products within the category bought, measured by expenditure per capita in Euro, and the footprint intensities measured by footprint multipliers—the environmental impact per Euro of expenditure in the category. Consumption categories in the legend have been ordered by their environmental intensity (by magnitude of multipliers). The footprint multipliers are measured in kg CO_2-eq/Euro for carbon, m^2/Euro for land, kg/Euro for material, and m^3/Euro for water. The percentage labels describe the share of a category's footprint from the total footprint of household consumption within EU. The lighter shaded parts of "Shelter" and "Mobility" columns denote direct GHG emissions and water use by households. Figure from Ivanova et al. (2016).

In 2007, around 20% of the carbon footprint from Norwegian households were domestic indirect emissions and the country relied strongly on the foreign production (around 60% of the carbon footprint) to satisfy local household demand while the direct emissions accounted for almost 20% (Figure R2.6, red graph). In the case of land footprint, almost 25% comes from indirect domestic production while the rest was from abroad (Figure R2.6, green graph). The overview of the four different footprints highlights that Norway relies heavily on foreign production to satisfy the local household demand (around 75% of material footprint and around 80% of water footprint occurred outside of Norway).

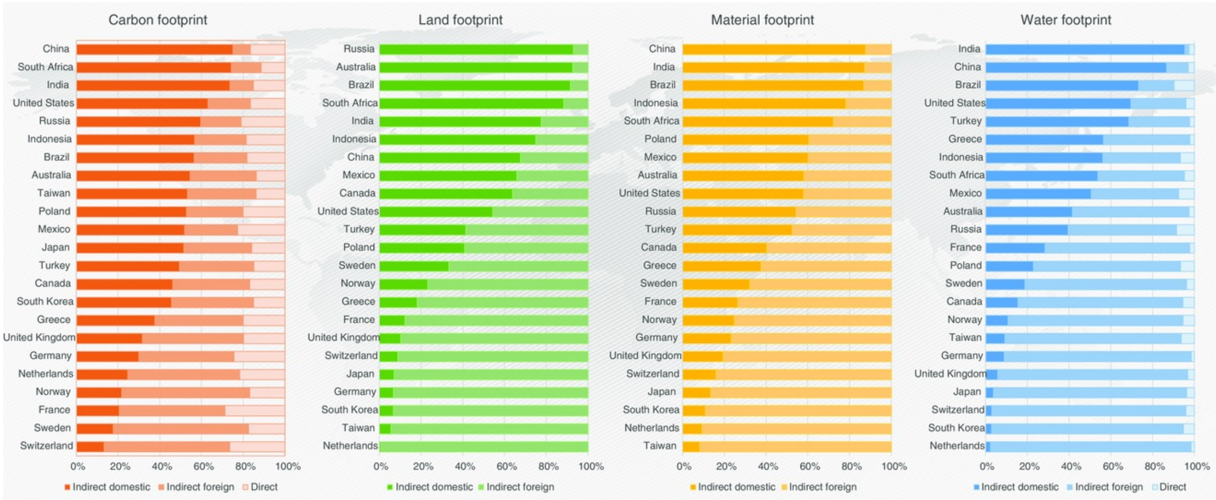

Figure R2.6: Indirect versus direct environmental impacts of household consumption across 23 selected countries for year 2007. The figure separates household consumption footprint on direct (pressures that are emitted directly by consumption activities), indirect domestic (embodied in domestically produced products and services), and indirect foreign (embodied in imported products and services) across selected countries available in EXIOBASE 2.2. Households are not accountable for direct environmental impacts in relation to land and material use in EXIOBASE. Figure from Ivanova et al. (2016).

In 2007, Norway's carbon footprint from household consumption was 10.3 CO_2-eq/cap., while the world average was 3.4 t CO_2-eq/cap, about a factor three difference (Figure R2.7, red graph). The Norwegian land footprint was 37200 m^2/cap in comparison with the world average of 10000 m^2/cap (Figure R2.7, green graph). Norway has the third largest material footprint per capita with 18.6 t/cap in comparison with the 4.9 t/cap global average (Figure R2.7, yellow graph).

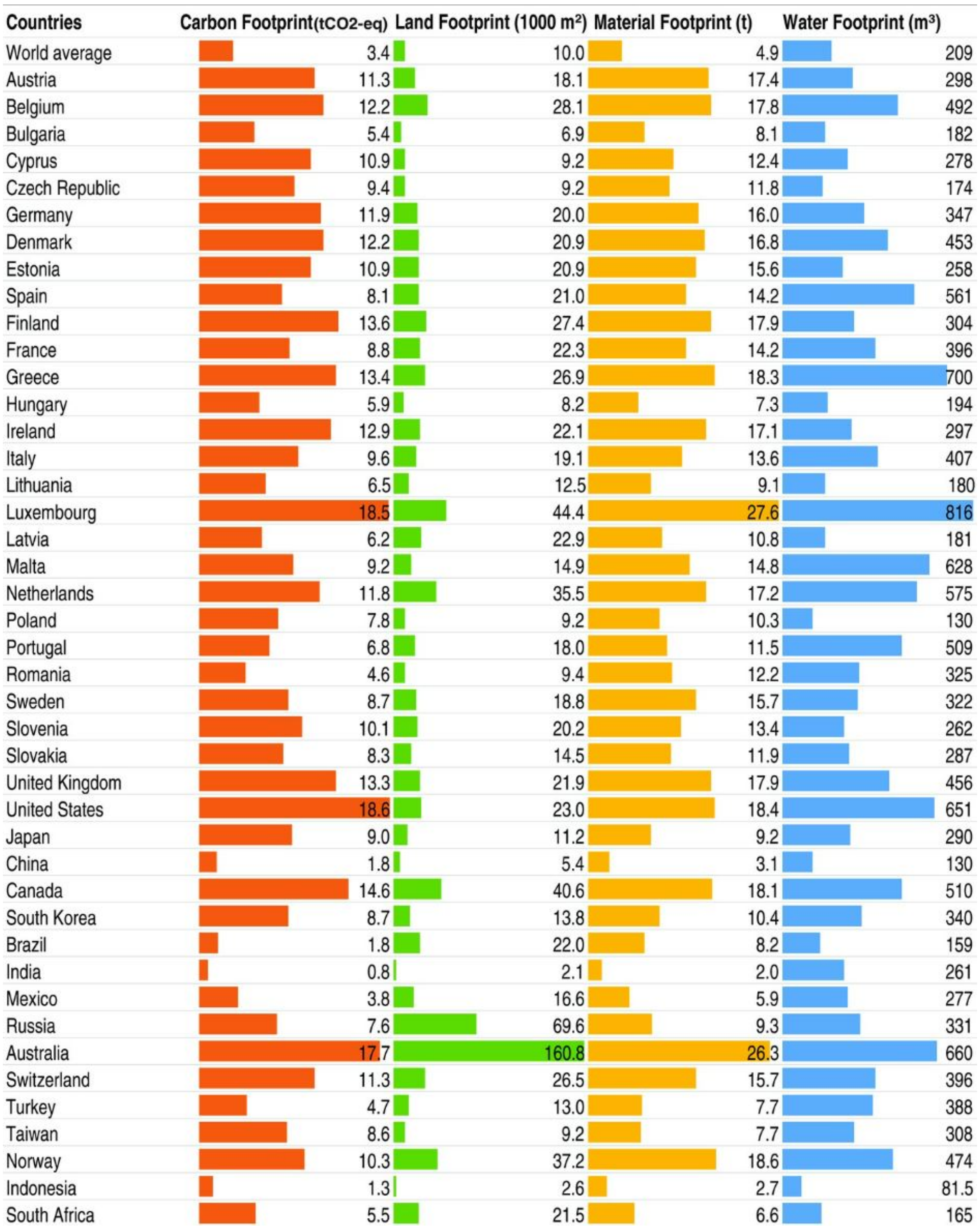

Figure R2.7: Environmental footprints of household consumption across countries for year 2007. The figure includes the world average and 43 selected countries from EXIOBASE 2.2, ordered alphabetically by country codes. The world average includes all 43 countries and the five rest-of-the-world regions. Figure from Ivanova et al. (2016).

SINTEF

Remarks about consumption and biodiversity impacts

1) The annual Norwegian consumption expenditure by households in units of million Euro (current prices) has increased for the period 1995 – 2015 by 152% (see Table R2.1) (data from EXIOBASE), while the associated biodiversity footprint in units of PDF for the same period increased by 163% (see Table R1.1 in Report 1). The annual households' consumption in Norway continued to increase from 2015 to 2021 from 136196 million Euro in 2015 to 145127 million Euro in 2021 (see Table R2.1), however the quantification of the biodiversity footprint for this period is not available. Although the consumption continued to increase, it is rather difficult to assume what the trend looks like for the biodiversity footprint since multiple mechanisms are at play (i.e., changes of the global value chains), and for a robust estimation the link between consumption and impacts should be quantified for this period in a similar manner as it was previously performed for the period 1995 - 2015 in Bjelle et al. (2021).
2) According to the existing studies published, the biodiversity footprint from consumption is highly dependent on the role of trade and it can vary significantly from country to country. Most of the EU regions are net importers of biodiversity footprints, that originate from outside their territory, in other European regions or outside.
3) Wilting et al.(2021) found that Sweden and Finland (Norway wasn't included in the study) registered among the highest biodiversity footprints per capita, compared with the rest of the European countries (Figure R2.3). This is aligned with the findings in Bjelle et al. (2021) (and presented in Report 1), where Norway, Sweden and Finland presented the highest consumption-based land use footprints per capita of the countries presented.
4) The annual Norwegian household expenditure for food in units of million Euro has increased by 79% in current prices for the period 1995 – 2015 (see Table SI.R2.1), while the footprint on biodiversity for the same period due to food consumption by Norwegian households increased by 276% (see Table SI.R2.3). The consumption trend for the food category for the next period, from 2015 to 2021 in units of million Euro show an increase by 11% (see Table SI.R2.1). We can't make estimates on the trend of the potential impacts on biodiversity arising from the consumption development of food in the period 2015 – 2021, since multiple factors (for example intensification of production per unit of land, trade changes, consumption composition, etc.) interact to yield the final effects on the potential disappeared fraction of species indicator.
5) Food consumption is the category that has the highest intensity on land footprint according to Ivanova et al. (2016). This is in line with the land footprints results reported in Bjelle et al. (2021) (Report 1).

Impacts from clothing consumption

The global fashion and textile industry is the world's third largest industry and the one which creates the greatest environmental and social problems according to the Nordic Initiative Clean and Ethical (NICE) (Valente et al., 2015). Global textiles production almost doubled between 2000 and 2015, and the consumption of clothing and footwear is expected to increase by 63% by 2030 (European Commission, 2022a). European consumption of textiles has the fourth highest impact on the environment and climate change, after food, housing and mobility and it represents the third sector for higher use of water and land use, and fifth for the use of primary raw materials and greenhouse gas emissions (European Commission, 2022a).

The environmental impacts from clothing production are mostly due to high water consumption, the use of pesticides (particularly in the production of wool and cotton fibres), the high use of energy (while synthetic fibres are based on non-renewable fossil fuel resources and require high-energy consumption) and from waste generation (Valente et al., 2015).

Nevertheless, the main issue when evaluating the environmental impacts from clothing and other textiles is that most of the studies focus on the fibre production phase overlooking impacts from other stages of the value chain (Klepp et al., 2022). An overview of impacts in different phases of garment production published by (Quantis, 2018) shows that fibre production accounts for 15% of climate impacts from clothing, while dyeing and finishing account for the highest impacts (36%), followed by yarn preparation (28%). The results estimated for the Swedish clothing consumption (Figure R2.8) reveal that 16% of total impacts are due to the fibre production, 23% for dyeing and finishing, yarn preparation for 10% (Östlund et al., 2020).

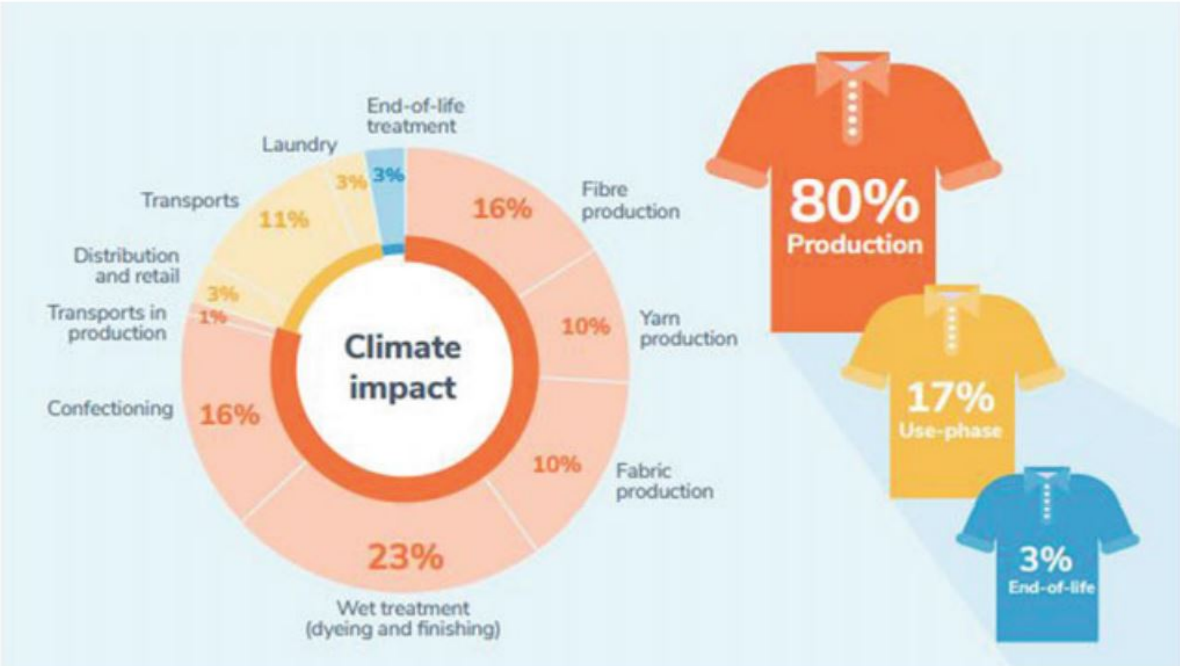

Figure R2.8: Climate impacts of Swedish clothing consumption. Illustration from ECOS, original source Mistra (www.mistra.org). Figure from Klepp et al. (2022).

In a recent cradle-to-grave LCA of a woollen garment, the authors highlighted the importance of impacts arising from the product's use phase (Wiedemann et al., 2020). In the study, the authors calculate an average number of wears (109 times divided between 2 users – based on survey data for woollen sweaters and estimated values for garment reuse) and frequency of use (5.2 days wear per washing event). Their results show that the garment use phase is a significant contributor to fossil energy demand (30%), global warming (13%), and water stress (37%) while consumer transport and the retail of garments in stores contributed to 13% fossil energy demand, 5% to global warming, and 4% to water stress impacts across the entire global value chain. In addition, the study shows results for land occupation of 0,32 (± 0,06) m^2 per garment wear. They also estimate that in the case of disposal of the garment after only one season (assumed to equivalate with 15 uses), the results would have shown a 5,8- to 6,8-fold increase in environmental impacts and resource use (Wiedemann et al., 2020). Another study, focusing on the environmental impacts from the Swedish clothing consumption of six garments concludes that "twice as many uses per garment life cycle eliminated almost 50% of impact, regardless of impact category" (Sandin et al., 2019).

In their report State of the Fashion 2019, the consultancy company McKinsey states that the average consumer purchases 60% more clothing than they did 15 years ago and wears each item for half as long (BOF & McKinsey Company, 2019).

One of the reasons why the focus in the literature is on the fibre content is not due to its relative importance, but rather due to the current labelling requirements. The current lack of requirements for information on the dyeing and finishing chemicals makes these stages of production invisible to the final customer (Klepp et al., 2022).

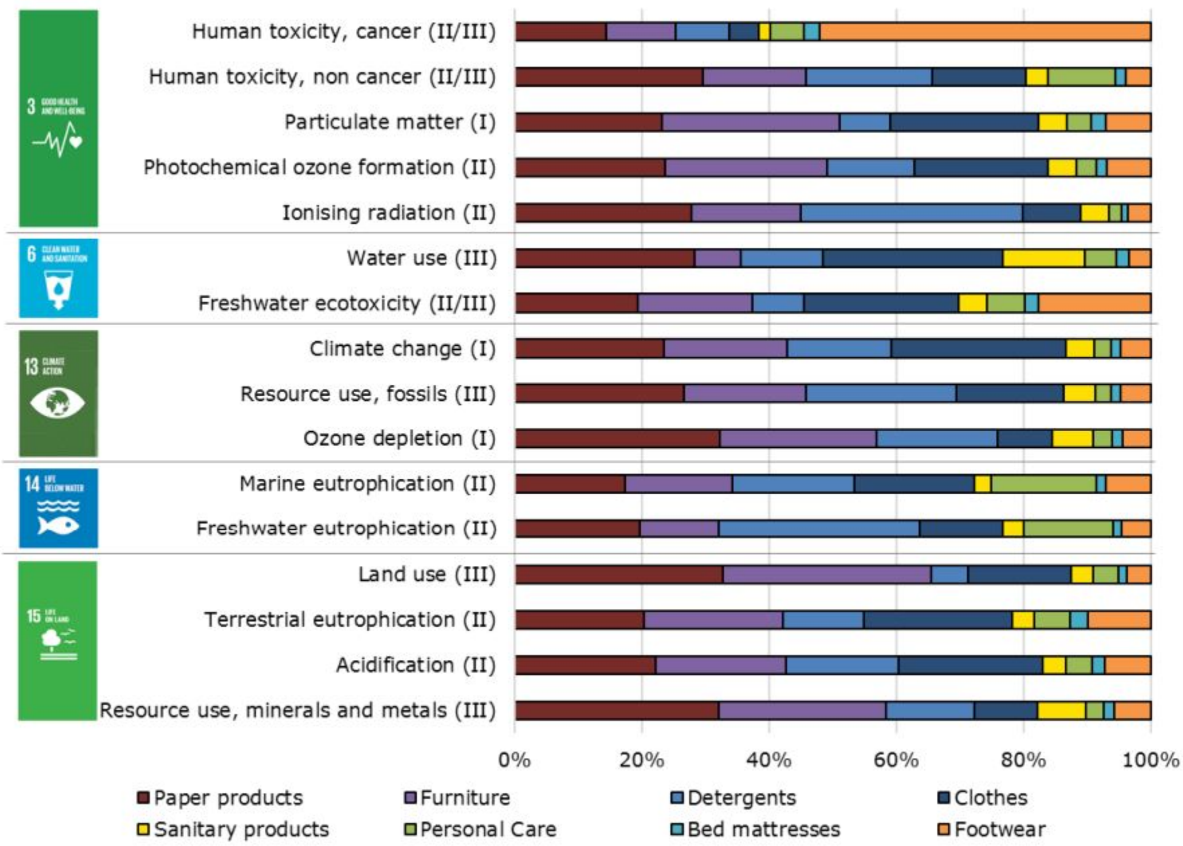

Figure R2.9: Contribution of different products to the impacts of household goods in EU in 2010. The roman numbers in brackets reefer to the robustness of the model used to assess environmental impacts. The lower the number, the higher its robustness. Figure from Beylot et al. (2019).

At the EU level, a study from Beylot et al. (2019) on the impacts from the region's consumption in 2010 on the different SDGs finds that clothing articles are among the main contributors within the household goods category. Despite the rather low shares of consumed clothes (4%) and footwear (2%) from the overall consumption of an average EU citizen in 2010, together these two categories were the third largest contributor on the impacts on SDG14 (Life below water) and SDG 15 (Life on land) (Figure R2.9).

Adequate solutions recommended in the literature for decreasing the environmental impacts from the current textile industry should have the large volumes of production, consumption, usage, and disposal as the focus. Therefore, regulations should target measures which could lead to fewer products to enter circulation, whether through a reorganisation of consumption or through less consumption rather than strategies replacing one product with another (with actual or alleged lower environmental impact), which the literature identifies as having a lower potential (Stø et al., 2008; Tukker et al., 2017).

On 30th March 2022, the European Commission published its Sustainable Products Initiative as part of the Commission's Circular Economy Plan, which has the overall aim to ensure that products placed on the EU market become more sustainable (European Commission, 2022b). The EU is currently developing a consumer-facing product labelling, based on the system called the Product Environmental Footprint (PEF), which the European Commission developed. In addition, they are targeting increasing the consumer-awareness with fact sheets where the Commission's 2030 Vision for Textiles is explained (Publications Office of the European Union, 2022).

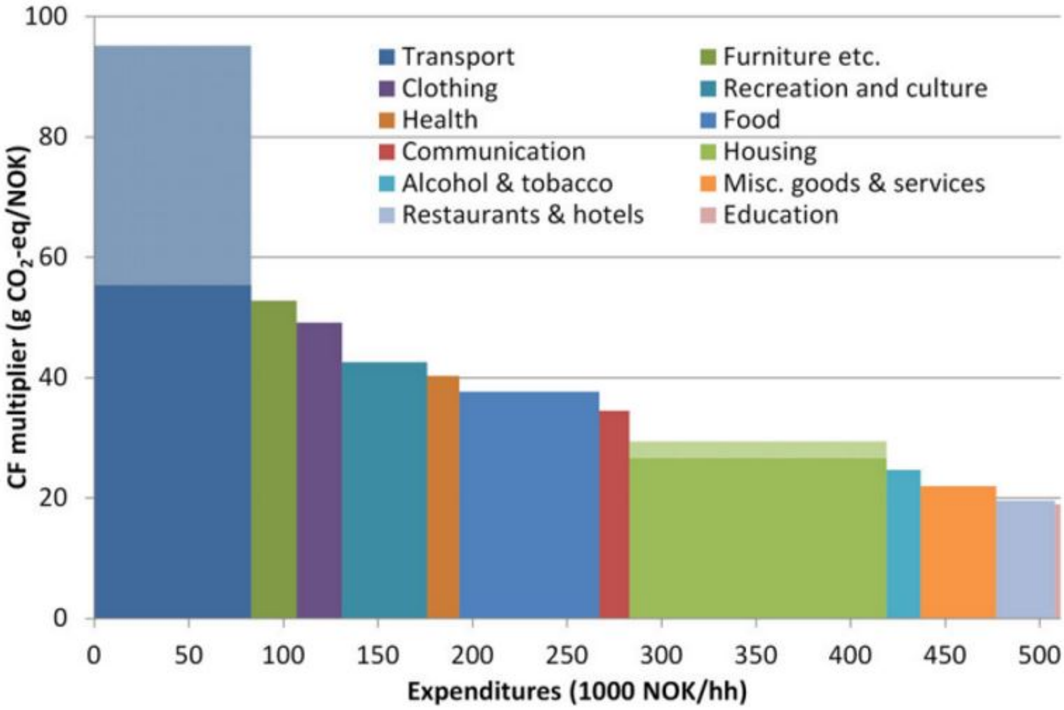

Figure R2.10: Norwegian household expenditure and the average carbon footprint intensities of each COICOP division, for year 2012. The lighter shaded parts of the "Transport" and "Housing" columns constitute direct emissions by households (defined as emissions directly brought about by household members, for example, from gas stoves or private vehicles). COICOP = UN Classification of Individual Consumption by Purpose. Figure from Steen-Olsen et al. (2016).

Studies focusing entirely on the footprints from Norwegian consumption are very few and often several years old. The study by Steen-Olsen et al. (2016) on the carbon footprint from household consumption for the year 2012 highlights the contribution from 12 COICOP divisions among which food (Figure R2.10, dark blue) and clothing (Figure R2.10, in purple). According to the study, the average Norwegian household spent 511000 NOK on consumption of goods and services in 2012, carrying a total carbon footprint of 22,3 t CO_2-eq/household, with an average of carbon emissions embodied in each unit of expenditure of 44 g CO_2-eq/NOK. Whereas food contributes significantly mainly from its large share of the overall household budget, the intensity from clothing is larger, as every NOK spent on clothing led on average to emissions of 50 g CO_2-eq compared to 38 g CO_2-eq./NOK for food.

According to Statistics Norway, the quantity of imported textiles of all types has increased by about 60% since 1995, from 137000 tonnes to 218000 tonnes in 2021 (see Table SR2.4). Figure R2.11 shows the direct imports of clothing articles from EXIOBASE 3.8.2 in units of million Euro for 1995 – 2021 and the breakdown on the most important suppliers. China is the main supplier, followed by Germany and Sweden. The production of clothes in Norway is very small when compared with the consumption, and the import of clothes is therefore very high (Valente et al., 2015).

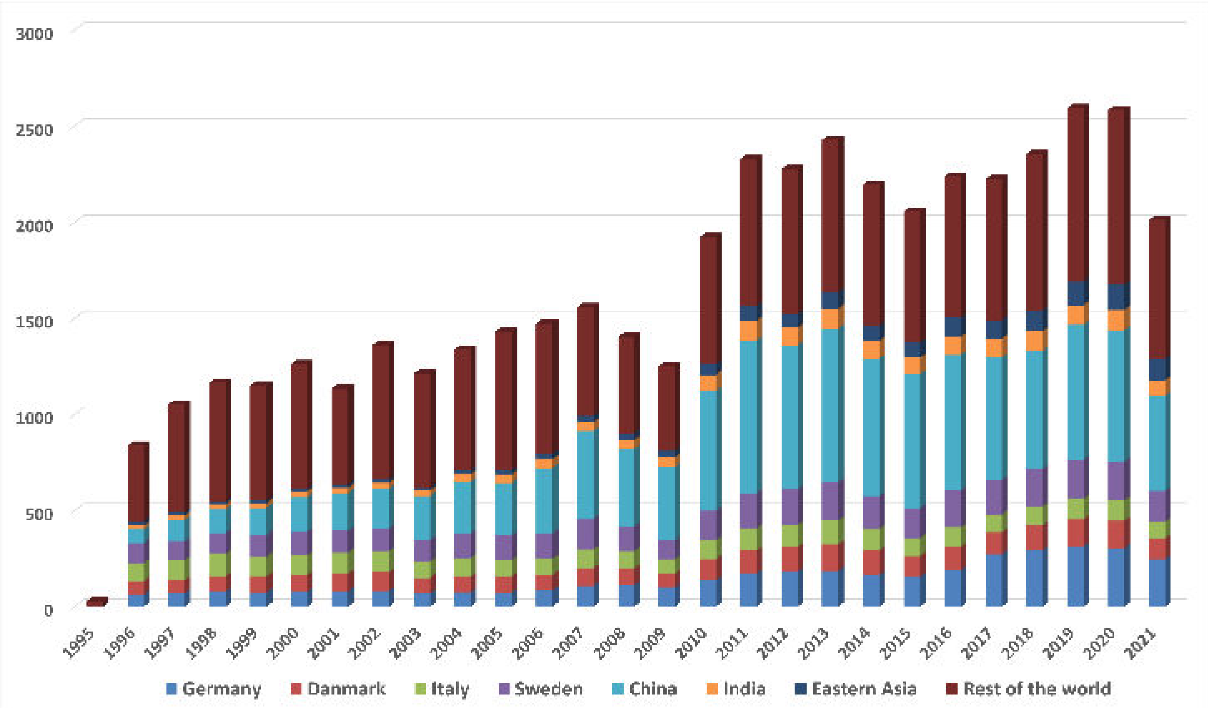

Figure R2.11: Norwegian direct imports of clothing articles from EXIOBASE 3.8.2 with a breakdown on the top supplying countries and regions for 1995 – 2021 in million Euro.

The focus so far in Norway within the clothing consumption seems to have been targeted towards waste. SSB reports in one of their tables on waste, that the amount of textile waste from households amounted to 249 tonnes in 2015 and increased to 1052 tonnes in 2021 (Figure R2.12). Data reported by Valente et al. (2015) for year 2011 show the average textile waste in the EU was 26 kg per person versus 23 kg per person in Norway.

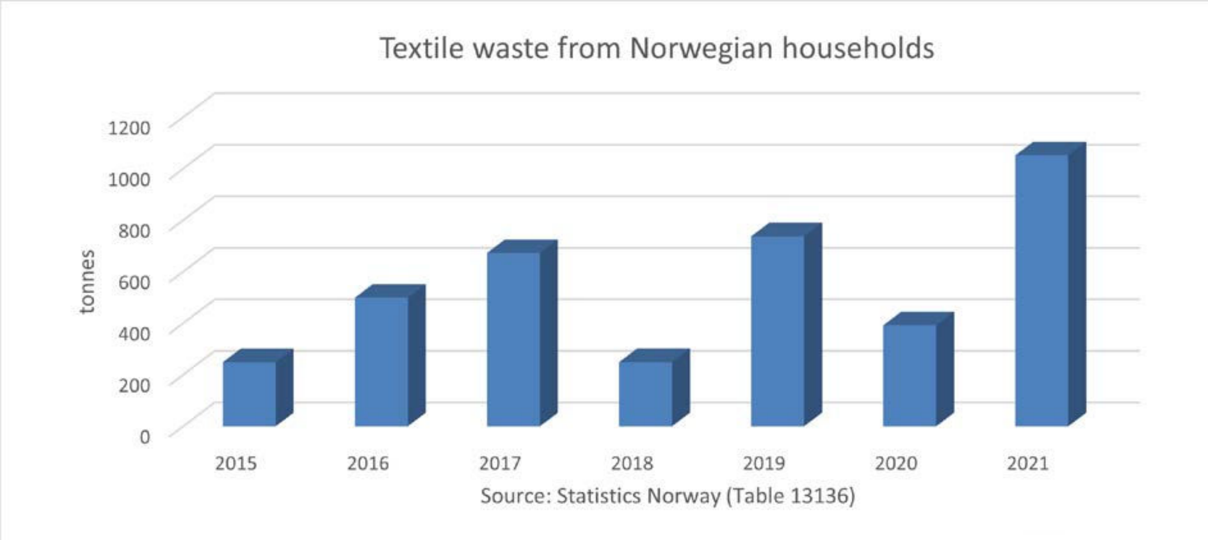

Figure R2.12: Norwegian annual textile wastes from households for the period 2015 -2021 at the country level from SSB (Table 13136).

According to the newly launched EU Strategy for Sustainable and Circular Textiles (European Commission, 2022a), the average textile waste in the EU was 11,2 kg per person in 2017 (Vercalsteren et al., 2019), while in Norway, for the same year, based on the total national waste accounts reported by SSB, the average was of 0,8 kg textiles per person (Figure R2.13). Different tables are currently reporting on waste on SSB. In one table data is presented for the years up until 2011 and another in another one for the period starting with 2012 due to changes in the reporting system both in the method for calculating the waste quantities as well as reorganizing the way information is aggregated by SSB. Up to and including 2011, the amounts of waste in the waste accounts were calculated using a supply/lifetime method. Starting with 2012, the estimates are based on available waste figures and statistics. In addition, up to 2011, the estimates for the category "residual waste" were based on sample analyses which were than distributed to the different categories. The newer SSB table for the textile waste is including now only the quantities sorted, while in the previous version of the report both sorted quantities and waste quantities were included. Thus, the figures reported by SSB after 2012 are not including the textiles collected for re-use anymore.

An example of environmental analysis of Norwegian clothing value chains is presented in (Valente et al., 2015), where Life-Cycle Assessment (LCA) methodology is used. For three case studies, the impacts of specific clothes produced at local boutiques in the Østfold region of Norway are evaluated. The reported results are only for four impact categories, namely: global warming potential (GWP) in kg CO_2-eq., acidification (AP) in SO_2-eq, eutrophication (EP) in kg PO_4-eq and photochemical oxidation potential (POCP) in kg C_2H_4-eq.

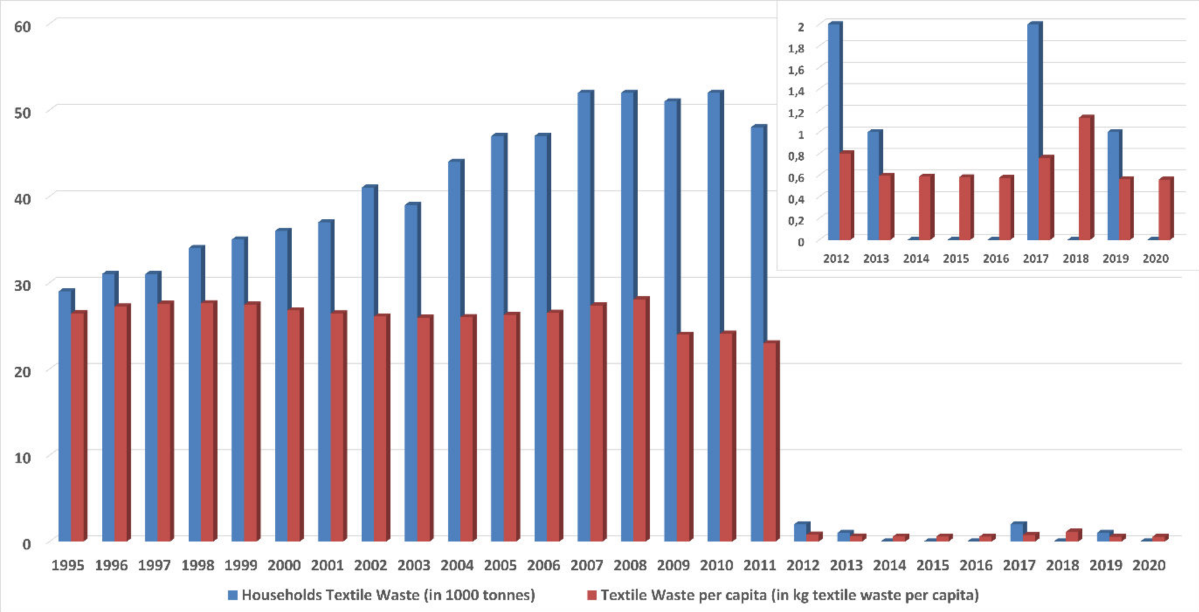

Figure R2.13: Norwegian annual textile waste from households (in 1000 tonnes) and textile waste per capita (in kg per capita) for the period 1995-2020 at the country level based on data from Statistics Norway (Tables 05282, 10514, 05803). In the right corner the graph corresponding to the period 2012 – 2020 which comes from a new report, with different calculating and aggregation method.

Remarks about clothing

1) The annual quantity of imported textiles of all types in Norway has increased by 45%, from 137000 tonnes in 1995 to 198000 tonnes in 2015 according to the Norwegian Statistics (see Table SI.R2.4). When selecting only the clothing and footwear articles from the same national reporting source, the trend is showing a slightly weaker increase of 37%, from 60000 tonnes in 1995 to 82000 tonnes in 2015 (see Table SI.R2.4). A much greater increase is reported in the consumption expenditure of clothing and footwear by the Norwegian households according to the EXIOBASE 3.8.4 database in units of million Euro (see Table SI.R2.1) (not considering the outlier number of 1995).. The biodiversity footprint due to Norwegian consumption of clothing and footwear has for the same period 1995 – 2015 increased from 0,00007 PDF in 1995 to 0,00012 PDF in 2015 (see Table R1.1).
2) Most studies available focus on the fibre production phase overlooking impacts from other stages of the value chain. However, some studies like Quantis (2018) and Östlund et al. (2020) showed that fibre production accounts for only around 15% of climate impacts from clothing, while dyeing and finishing account for the highest impacts (between 23 and 36%), followed by yarn preparation (between 10 and 28%).
3) The LCA study of Wiedemann et al. (2020) of a woollen garments show that the garment use phase is a significant contributor to fossil energy demand (30%), global warming (13%), and water stress (37%), while consumer transport and retail had lower impacts.

Impacts from electronics consumption

The electronic articles consumption in the Norwegian society is mapped only in terms of the impacts on the CO_2-eq without biodiversity footprinting, and only for year 2008 in a study by Hertwich and Roux, (2011) (Figure R2.14).

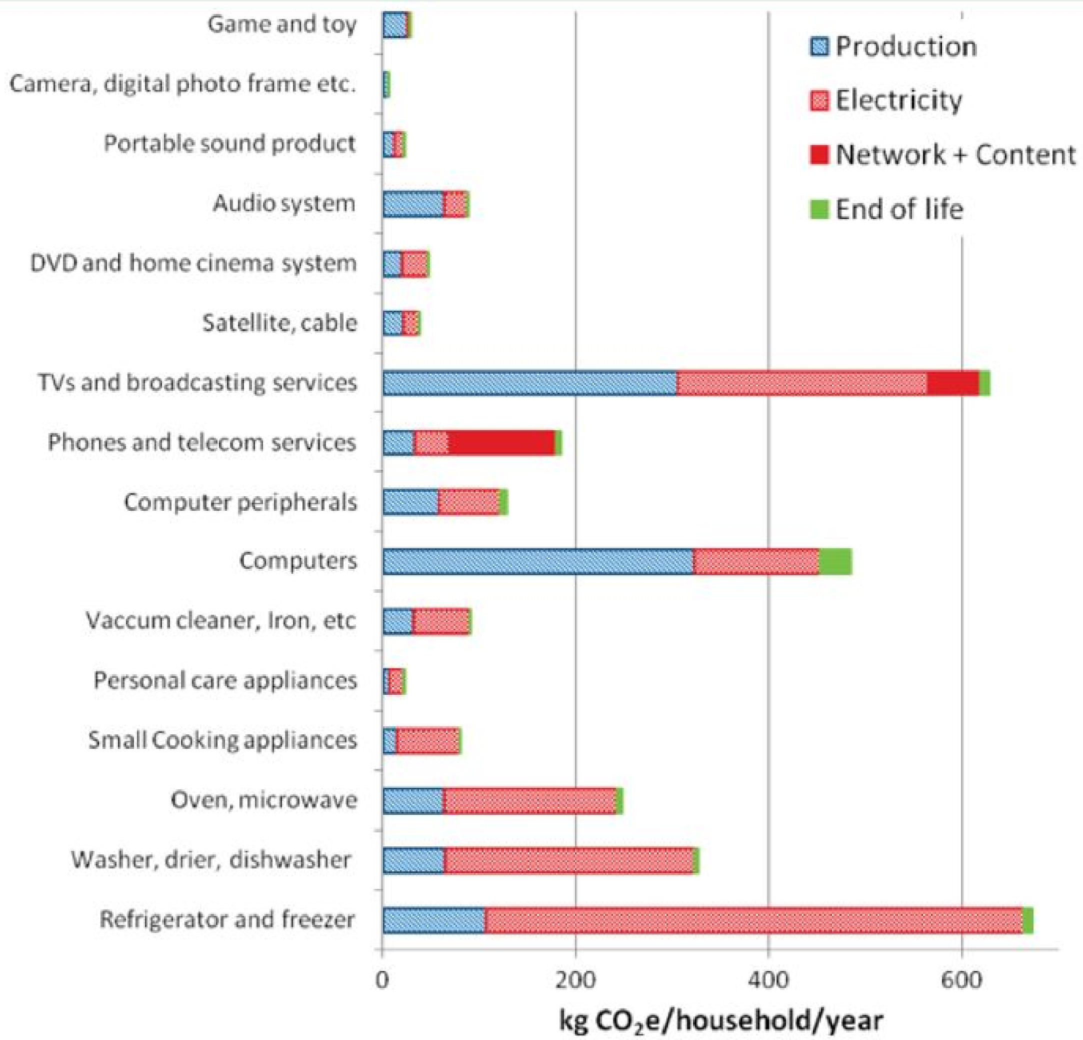

Figure R2.14: Greenhouse gas emissions caused by the consumption of different electric and electronic products by the average Norwegian household in 2008, assuming an EU-average electricity mix. Telecoms services include the Internet, while TV and broadcasting includes TV content. Figure from Hertwich and Roux, (2011).

The Science for Policy report by the Joint Research Centre (JRC), the European Commission's science and knowledge service, used LCA to quantify the contribution of the household appliances consumed within EU in 2010 to 5 different SDGs (Beylot et al., 2019). Their results show that TV screens and laptops have together the largest impacts on SDG 14 and SDG15, mainly due to their inherent properties (i.e., the use of gold in the printed circuited boards of TV screens) (Figure R2.15).

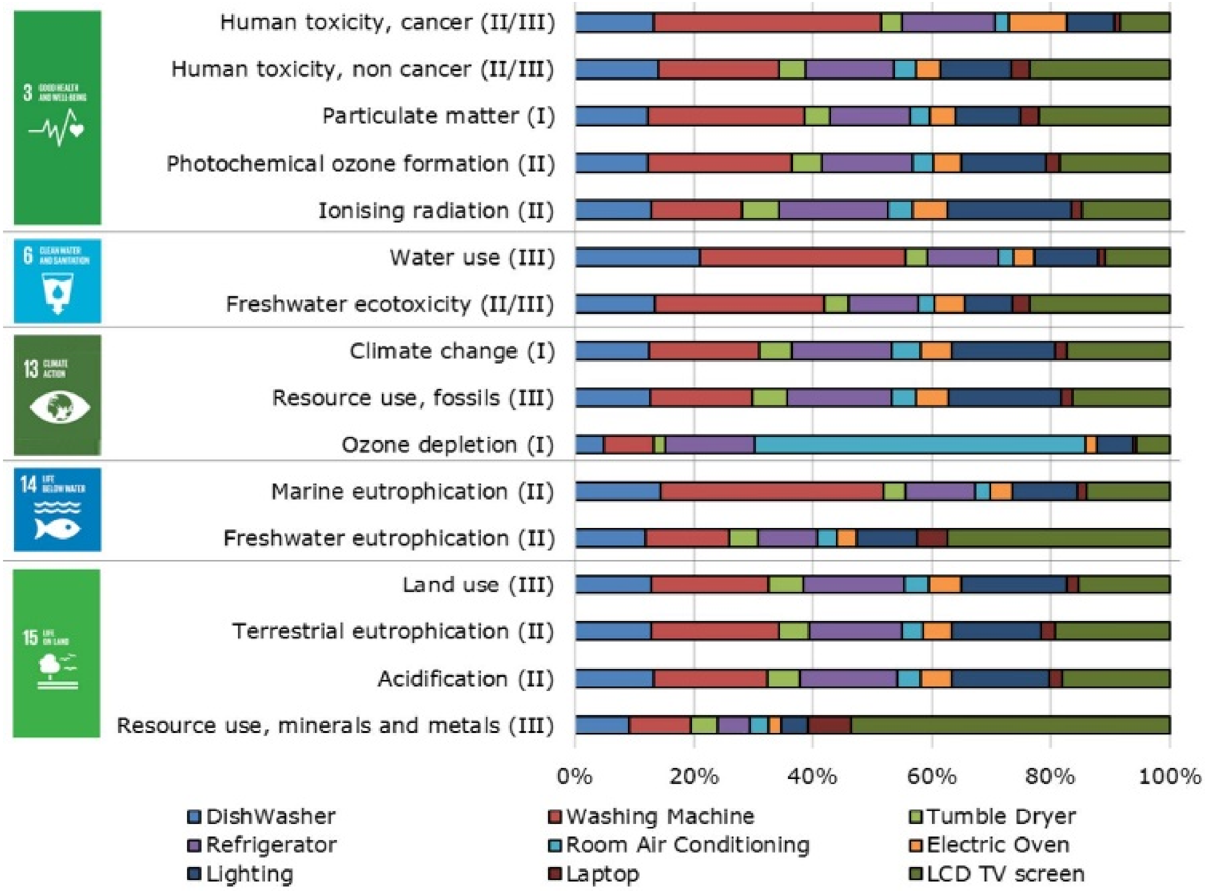

Figure R2.15: Contribution of different products to the impacts of household goods in EU in 2010. The roman numbers in brackets reefer to the robustness of the model used to assess environmental impacts. The lower the number, the higher its robustness. Figure from Beylot et al.(2019).

Moreover, when exploring potential impacts from more than 50 different future eco-innovation scenarios, such as technical improvements of devices (i.e., energy efficiency or recyclability of materials at the end of their life) as well as expected future behaviours of consumers Sala et. al. (2019) report increased forecasted impacts on resource and material use as well as land use (both contributing to SDG 15).

Impacts from food consumption

A more recent study quantified the impacts of food supply chains on biodiversity at the EU-28 level for year 2015 (Crenna et al., 2019). In this study, 32 representative food products of consumption were selected, and their environmental impacts calculated through LCA. The potential contribution of EU food consumption to the current biodiversity decline has been evaluated adopting two sets of indicators (midpoint and endpoint). The results they produce (Figure 16) are meant to be used on a comparative basis, according to the purposes of LCA practice, nevertheless, the authors mention that the absolute values are in line with the estimated magnitude of biodiversity decline (i.e. between 1000 and 10000 times the natural background extinction rate according to Chivian and Bernstein (2008). From the 32 products considered, 8 are responsible for more than 75% of total damage to biodiversity.

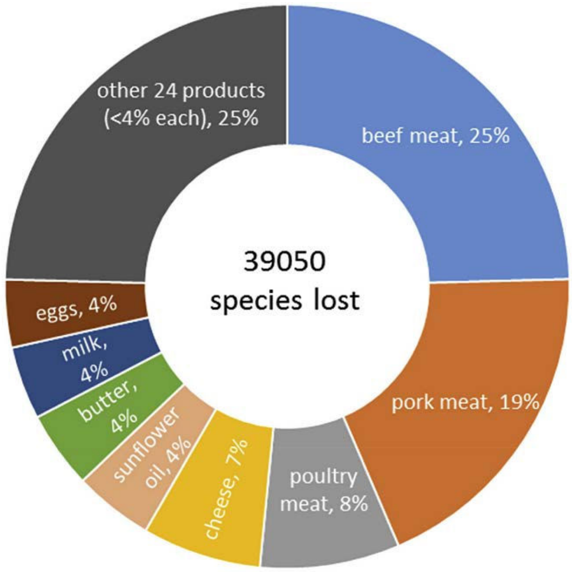

Figure R2.16: Overview of the relative contribution of each food product in the Basket of Products (BoP) to damage on biodiversity in 2015, based on ReCiPe 2016. Note that the number of species lost is to be considered for comparative purposes. Figure from Crenna et al. (2019).

Loss of species is mainly driven by meat, specifically pork and beef (43% of total species loss over a year) (Crenna et al., 2019). The high contribution of meat products in the total biodiversity footprint is due to two main reasons: first, the intensity of the impacts of meat products per kg and second, the amounts of meat consumed at EU-28 level. Consumption of pork meat presents a lower overall environmental burden when compared to beef, despite a higher annual consumption of pork meat (44.9 kg/person) than beef meat (15.2 kg/person) but this was counterbalanced by the lower environmental impact per kg pork meat.

A study, which combined global biogeophysical and economic models, by Marques et al. (2019) on the impacts from agriculture and forestry production confirmed the trend presented in the first report that despite decrease in land-use impacts per gross domestic product (GDP) between 2000 and 2011, the biodiversity loss has increased. In their study the authors use the bird species richness, measured as the impeding bird extinctions (that is, number of species that would become extinct if land-use activities would be maintained in the long run) as a proxy for biodiversity loss. In their results (Supplementary Table 6 of Marques et al.(2019)) the impacts from Norway's agriculture and forestry production slightly decrease by 0,7% in the number of bird species loss from 2000 to 2011 (from 0,00040584916 to 0,00040291248 bird species loss).

Summary of the findings

The current report represents an extended review of the scientific literature on the impacts on biodiversity and land use from consumption with focus on the Norwegian society. This work builds on the findings from the first report where the results from the study by Bjelle et al. (2021) are presented in which the impacts on biodiversity from land use due to consumption for the period 1995 -2015 are quantified.

Main findings from the current review are:

1. There are currently *few scientific efforts* in assessing the impacts on biodiversity from consumption in Norway. Usually, results are reported in studies which focus on the consumption at the EU level. Most of the studies are quantifying impacts for one single year (i.e., 2010, 2015) but no time series are offered.
2. Norwegian consumption: We report data for the period 1995-2021 from two sources, EXIOBASE 3.8.2 (which is a multi-regional input-output database used frequently for the assessment of environmental impacts at national, regional, and global levels) and Statistics Norway.
3. Clothing: few studies assessing the impacts on the environment from clothing consumption are reporting results for the entire value chain, including processes like usage and disposal in addition to the fabric production. Clothing is the second most land-intensive of consumption categories though it is associated with only 4,3% of the land use by EU households.
4. Electronics: Publications Office of the EU published an assessment of the impacts on the SDGs from appliances consumed in the region for one year (2010) where scenarios are developed with focus on eco-innovation.
5. Food: Different regional and global studies evaluate the impact on biodiversity loss from food production and consumption, often only for one year. The land footprint from the consumption of food has the highest intensity, namely 7,2 m^2/Euro and accounts for about half of the total land footprint of the EU households.

Limitations and method description

For the consumption data we used the latest EXIOBASE 3.8.2 database, which describes the global economy in 163 industries and 200 different products (Stadler et al., 2019). EXIOBASE 3 is a publicly free database, which provides a time series of EE-MRIO tables ranging from 1995 to 2021 for 44 countries (28 EU member plus 16 major economies) and five rest of the world regions in current prices. EXIOBASE was developed by harmonizing supply-use tables for many countries, estimating emissions and resource extractions by industry. The country specific supply-use tables are linked via international trade data and the database can be used for the analysis of the environmental impacts associated with the final consumption of product groups.

For this report we aggregated the original data into 12 different categories based on the COICOP 1 system (United Nations Classification of Individual Consumption by Purpose) for an easier reporting.

Supplementary Tables

Table SI.R2.1: Annual consumption of Norwegian households in units of million Euro based on the EXIOBASE 3.8.2 database from Stadler et al. (2019) with a breakdown on 12 different categories following COICOP 1 system.

	Food and non-alcoholic beverages	Alcoholic drinks and tobacco	Clothing and footwear	Housing, light and fuel	Furniture and household items	Health care	Transport-ation	Post and telecomm unications services	Culture and leisure	Education	Restaurant and hotel services	Other goods and services	Total
1995	7076	821	29	13225	3098	2221	12036	179	1618	317	8910	4582	54113
1996	5954	818	839	15644	3798	2458	11308	2093	1951	371	6241	7406	58882
1997	5944	839	1053	15964	4360	2707	13764	2189	2137	410	6710	7233	63311
1998	6309	855	1166	13797	4152	2717	15147	2483	2266	420	7092	6674	63079
1999	5962	868	1151	19506	3366	2998	12642	2766	2454	474	7279	8252	67717
2000	7003	1081	1264	18258	3981	2899	16839	2808	2579	469	8033	9226	74440
2001	7798	1067	1137	20038	3786	2996	15924	3001	1216	548	8129	9723	75364
2002	7520	1127	1362	21737	5016	3315	20728	3131	3028	511	9242	10315	87033
2003	7240	1035	1213	22778	5406	3566	18408	3962	3197	553	9298	12058	88714
2004	7643	1101	1339	21130	6344	3338	19036	4007	3068	595	10182	11273	89055
2005	8923	1239	1431	24715	5488	4343	21410	4402	3518	9	11730	12837	100046
2006	9328	1496	1473	23660	4472	2408	21478	4059	3332	9	12644	11352	95712
2007	10363	1830	1558	9236	5870	6361	30057	5698	1914	9	15059	17697	105652
2008	10618	1700	1403	24319	3071	3737	29303	5430	1561	680	13536	11336	106695
2009	8851	1557	1251	27364	3035	3422	25174	5577	1542	666	13131	11493	103063
2010	11087	1723	1921	31181	6328	4909	31781	6513	4445	1087	14034	15150	130160
2011	12588	2041	2330	34641	4815	5669	31273	7049	4846	1336	14840	16459	137887
2012	13619	2216	2277	37279	5596	5284	31875	7485	2140	1279	15723	16673	141445
2013	13890	2272	2428	30411	5629	6814	34826	7790	2287	1681	15370	17375	140772
2014	13143	2135	2196	26300	5791	6232	35188	7769	2120	1565	15463	19261	137163
2015	12658	2002	2057	34263	4301	4592	33448	7651	1877	1174	15553	16620	136196
2016	13111	1984	2239	30363	4991	5034	33954	7552	1897	1309	16157	17563	136156
2017	12990	1980	2225	37514	4978	4669	33157	7487	1646	1200	16926	16896	141667
2018	14205	2143	2355	35527	6563	101	38455	8784	4389	932	17764	17207	148426
2019	13586	2068	2595	35257	6513	5035	35198	8066	1731	1358	18352	14890	144650
2020	15728	2510	2584	3421	7511	8816	45258	10079	2211	2408	21000	21399	142926
2021	14110	2251	2012	3063	6430	8274	43112	10168	2203	2221	22864	28419	145127

Table SI.R2.2: Annual consumption from Norwegian households for 12 categories in units of million NOK from Norwegian Statistics (based on table 09172).

	Food and non-alcoholic beverages	Alcoholic drinks and tobacco	Clothing and footwear	Housing, light and fuel	Furniture and household items	Health care	Transport-ation	Post and tele-communications services	Culture and leisure	Education	Restaurant and hotel services	Other goods and services
1995	71135	20780	27319	97406	27455	11309	62890	8176	50764	1926	28092	39346
1996	73022	22264	28211	102365	29286	12349	74333	9101	56494	2252	30459	40723
1997	76521	24718	30020	105721	31765	13239	77655	9478	60935	2401	33262	41686
1998	80746	25519	31145	107666	33316	14165	81079	11250	65723	2464	35657	44827
1999	84709	27389	32794	111214	34159	15063	83445	14332	71846	2746	38152	48943
2000	88763	28544	34045	119041	37965	16441	92423	15910	76761	2881	39406	52936
2001	90541	29166	36113	131341	39550	17650	92293	17208	81389	3588	39271	54077
2002	92695	29863	36995	139820	41353	18850	95300	18208	84803	3784	40486	57956
2003	97001	31811	38021	152051	42071	20305	97057	19673	90082	2717	41003	64053
2004	99702	33893	40380	155558	43826	21570	107862	23827	95489	2737	41752	70635
2005	100588	34597	42874	162728	46404	23041	116782	24817	99840	2870	43497	76434
2006	101628	35703	45567	175588	49761	23517	127926	25794	106681	3093	48342	81749
2007	106719	37568	50106	180196	52636	24565	145122	25843	111620	3651	52378	92358
2008	113514	40695	50921	194532	54468	26258	146813	26373	113532	3657	57015	97293
2009	120252	42394	52912	203916	54174	27930	142469	26801	114842	4070	56835	100258
2010	123004	42232	54854	224546	58561	29380	158061	27902	117173	4449	59333	104632
2011	126978	43066	54975	225092	61551	30793	168405	27864	120125	4943	63009	105950
2012	133829	43496	55958	227834	69317	31674	175170	27115	120525	5328	67268	118805
2013	138749	45907	56862	246001	70409	33033	177377	26020	124271	5813	71352	124460
2014	144690	47619	58238	253915	73987	34987	181546	25499	130355	6142	75402	129387
2015	148215	49302	60542	271858	76647	37010	189042	26147	136395	5176	81612	133061
2016	154319	51128	63044	285176	79735	38982	195022	27388	145788	5472	86599	137076
2017	154418	52569	64642	296071	81792	41357	207077	28691	151846	5749	93287	143724
2018	159369	54073	68014	313926	83380	41455	213490	32377	162943	6090	94077	143846
2019	162197	54687	67313	326121	86737	43610	220963	32581	166416	6444	100347	153246
2020	187800	63910	67896	320656	98076	44660	200403	34636	148597	6306	79178	157107

Table SI.R2.3: Annual Norwegian consumption-based biodiversity footprints for the categories food and clothing and footwear from Bjelle et al. (2021) in units of potentially disappeared fraction of species (PDF)

	Food	**Clothing and footwear**
1995	0,00085	0,00007
1996	0,00114	0,00006
1997	0,00121	0,00007
1998	0,00083	0,00007
1999	0,00110	0,00008
2000	0,00084	0,00006
2001	0,00195	0,00013
2002	0,00224	0,00017
2003	0,00191	0,00015
2004	0,00177	0,00014
2005	0,00220	0,00015
2006	0,00242	0,00015
2007	0,00222	0,00016
2008	0,00285	0,00014
2009	0,00178	0,00012
2010	0,00240	0,00013
2011	0,00341	0,00014
2012	0,00412	0,00014
2013	0,00376	0,00014
2014	0,00347	0,00013
2015	0,00320	0,00012

Table SI.R2.4: Imports of textile articles in Norway in 1000 tonnes from Statistics Norway, SSB (Table 11009: External trade in goods, by contents, commodity number, imports/exports, country and year) from (Statistics Norway, 2022a)

Year	Imports of all textile articles	Imports of only clothing and footwear articles
1988	122	44
1989	116	43
1990	120	46
1991	119	49
1992	122	52
1993	124	54
1994	137	60
1995	137	60
1996	138	58
1997	148	63
1998	152	64
1999	148	64
2000	154	67
2001	149	64
2002	154	69
2003	159	74
2004	171	77
2005	180	81
2006	193	85
2007	207	90
2008	204	91
2009	179	83
2010	200	92
2011	211	95
2012	194	82
2013	196	85
2014	199	84
2015	198	82
2016	195	81
2017	203	79
2018	206	79
2019	204	76
2020	199	68
2021	218	77

Table SI.R2.5: Annual direct imports of clothing and footwear by Norwegian households from EXIOBASE 3.8.4 in million Euro from Stadler et al.(2019) with a breakdown on the most important trade partners and the rest of the world.

Year	Total	Germany	Danmark	Italy	Sweden	China	India	Eastern Asia	Rest of the world
1995	29	0	0	0	0	0	0	3	26
1996	839	64	69	94	105	71	19	22	394
1997	1053	71	67	105	99	111	23	16	561
1998	1166	78	81	116	110	123	26	14	619
1999	1151	73	86	101	113	140	25	13	599
2000	1264	78	89	100	125	176	32	13	650
2001	1137	80	93	109	113	197	27	17	501
2002	1362	82	97	111	116	209	30	17	699
2003	1213	68	83	83	112	228	30	14	594
2004	1339	74	84	95	126	272	38	18	631
2005	1431	73	87	83	129	272	44	23	720
2006	1473	84	82	83	133	339	46	27	679
2007	1558	109	94	97	157	458	46	32	566
2008	1403	112	88	91	128	403	45	35	502
2009	1251	100	72	75	97	381	52	34	441
2010	1921	138	110	98	154	625	83	56	659
2011	2330	172	120	117	182	796	100	77	766
2012	2277	182	129	115	187	748	92	70	755
2013	2428	186	139	123	199	800	104	84	793
2014	2196	167	126	111	172	716	91	79	735
2015	2057	156	108	94	154	697	86	79	682
2016	2239	188	124	100	193	706	95	97	736
2017	2225	273	113	93	179	637	99	93	736
2018	2355	295	128	99	196	614	101	110	813
2019	2595	314	141	106	202	703	102	123	903
2020	2584	305	142	105	203	684	105	131	909
2021	2012	247	110	86	159	497	80	112	721

Table SI.R2.6: Textile waste statistics for Norway. Data compiled from the waste accounts for Norway (in 1 000 tonnes) as a combination of the Table 05282 (for the period 1995 – 2011) from SSB (2022b) and Table 10514 (for period 2012 – 2020) from SSB (2022c) in addition to the national population statistics published in Table 05803 from SSB (2022d).

	Total	**Households**	**Norwegian population**	**Textile Waste per capita**
Units	**1000 tonnes**	**1000 tonnes**	**Number of citizens**	**kg/cap**
1995	115	29	4348410	26,4
1996	119	31	4369957	27,2
1997	121	31	4392714	27,5
1998	122	34	4417599	27,6
1999	122	35	4445329	27,4
2000	120	36	4478497	26,8
2001	119	37	4503436	26,4
2002	118	41	4524066	26,1
2003	118	39	4552252	25,9
2004	119	44	4577457	26,0
2005	121	47	4606363	26,3
2006	123	47	4640219	26,5
2007	128	52	4681134	27,3
2008	133	52	4737171	28,1
2009	115	51	4799252	24,0
2010	117	52	4858199	24,1
2011	113	48	4920305	23,0
2012	4	2	4985870	0,8
2013	3	1	5051275	0,6
2014	3	0	5109056	0,6
2015	3	0	5165802	0,6
2016	3	0	5213985	0,6
2017	4	2	5258317	0,8
2018	6	0	5295619	1,1
2019	3	1	5328212	0,6
2020	3	0	5367580	0,6

Table SI.R2.7: Classification of Individual Consumption According to Purpose (ECOICOP) for the food and non-alcoholic beverages category used in this report according to Classification of Individual Consumption According to Purpose (ECOICOP) - Statistics Norway (ssb.no):

Food	Bread and cereals	Flours and other cereals
		Rice
		Bread
		Other bakery products
		Pizza and quiche
		Pasta products and couscous
		Breakfast cereals
		Other cereal products
	Meat	Beef and veal
		Pork
		Lamb and goat
		Poultry
		Other meats
		Edible offal
		Dried, salted or smoked meat
		Other meat preparations
	Fish and seafood	Fresh or chilled fish
		Frozen fish
		Fresh or chilled seafood
		Frozen seafood
		Dried, smoked or salted fish and seafood
		Other preserved or processed fish and seafood-based preparations
	Milk, cheese and eggs	Fresh whole milk
		Fresh low fat milk
		Preserved milk
		Yoghurt
		Cheese and curd
		Other milk products
		Eggs
	Oils and fats	Butter
		Margarine and other vegetable fats
		Olive oil
		Other edible oils
		Other edible animal fats
	Fruit	Fresh or chilled fruit
		Frozen fruit
		Dried fruit and nuts

		Preserved fruit and fruit-based products
	Vegetables	Fresh or chilled vegetables other than potatoes and other tubers
		Frozen vegetables other than potatoes and other tubers
		Dried vegetables, other preserved or processed vegetables
		Potatoes
		Crisps
		Other tubers and products of tuber vegetables
	Sugar, jam, honey, chocolate and confectionery	Sugar
		Jams, marmalades and honey
		Chocolate
		Confectionery products
		Edible ices and ice cream
		Artificial sugar substitutes
	Food products n.e.c.	Sauces, condiments
		Salt, spices and culinary herbs
		Baby food
		Ready-made meals
		Other food products n.e.c.
Non-alcoholic beverages	Coffee, tea and cocoa	Coffee
		Tea
		Cocoa and powdered chocolate
	Mineral waters, soft drinks, fruit and vegetable juices	Mineral or spring waters
		Soft drinks
		Fruit and vegetable juices

Table SI.R2.8: Classification of Individual Consumption According to Purpose (ECOICOP) for the housing and fuel category used in this report according to Classification of Individual Consumption According to Purpose (ECOICOP) - Statistics Norway (ssb.no):

Housing, water, electricity, gas and other fuels	Actual rentals for housing	Actual rentals paid by tenants	Actual rentals paid by tenants
		Other actual rentals	Actual rentals paid by tenants for secondary residences
			Garage rentals and other rentals paid by tenants
	Imputed rentals for housing	Imputed rentals of owner-occupiers	Imputed rentals of owner-occupiers
		Other imputed rentals	Other imputed rentals
	Maintenance and repair of the dwelling	Materials for the maintenance and repair of the dwelling	Materials for the maintenance and repair of the dwelling
		Services for the maintenance and repair of the dwelling	Services of plumbers
			Services of electricians
			Maintenance services for heating systems
			Services of painters
			Services of carpenters
			Other services for maintenance and repair of the dwelling
	Water supply and miscellaneous services relating to the dwelling	Water supply	Water supply
		Refuse collection	Refuse collection
		Sewage collection	Sewage collection
		Other services relating to the dwelling n.e.c.	Maintenance charges in multi-occupied buildings
			Security services
			Other services related to dwelling
	Electricity, gas and other fuels	Electricity	Electricity
		Gas	Natural gas and town gas
			Liquefied hydrocarbons (butane, propane, etc.)
		Liquid fuels	Liquid fuels
		Solid fuels	Coal
			Other solid fuels
		Heat energy	Heat energy

References Report 2

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Report 3: Methodology, limitations, and further work

This is the third from a series commisioned by Naturvernforbundet where the overall goal was to gather the available scientific results of how Norwegian consumption is impacting biodiversity loss and land use. In this report we explain the main methods that are currently used to assess such impacts from consumption and discuss the limitations and uncertainties of these methods and the results. We also recommend possible follow-ups of this work.

Methods and models used in assessment of footprints

Input-Output analysis and consumption-accounting

Input–output (IO) models are systems of linear equations which describe the yearly economic flows between all sectors of a country. Individual countries IO-data can be combined with trade data to create multi-regional input–output (MRIO) databases, which then also describe international trade relations. These MRIO databases can then in turn be extended with environmental accounts, such as emission data, land use, materials, etc. There are about a handful of environmentally-extended (EE) MRIO databases with global coverage and time-series data available, including EORA (Lenzen et al., 2012), GLORIA (Lenzen et al., 2022) , EXIOBASE (Stadler et al., 2019) and EXIOBASE 3rx (Bjelle et al., 2019; Lenzen et al., 2022). An environmental extension translates the effects from the production activity of each sector into direct environmental impacts and thus allow estimating indirect environmental impacts by linking the consumption with the production across distant value chains (Marques et al 2017). With MRIO analysis it is hence possible to link final demand (of a product, a country, or a region) to the corresponding impacts occurring down the supply chain, creating a footprint of the consumption studied.

Results from input-output analysis always must be interpreted with care, keeping in mind the uncertainties that inevitably accompany such data-intensive descriptions of the global economy and difficult to measure and or quantify impacts.

EXIOBASE

For the consumption data presented in report 2, the latest available version (v3.8.2) of the EXIOBASE database, which describes the global economy with 163 industries and 200 different products (Stadler et al., 2019), was used. EXIOBASE 3 is a publicly available and free database that provides a time series of environmentally extended multi-region input-output (EE-MRIO) tables ranging from 1995 to 2021 for 44 countries (28 EU member plus 16 major economies) and five rest of the world (RoW) regions (RoW Asia, RoW Europe, RoW Africa, RoW America, RoW Middle East.

EXIOBASE was developed by harmonizing and detailing supply-use tables (from national accounts) for a large number of countries, estimating emissions and resource extractions by industry. The country supply-use tables are linked via trade and thus the database can be used for the analysis of the environmental impacts associated with the final consumption of product groups, both those consumed domestically and imported from other countries. For more details about the database, we refer to their website: https://www.exiobase.eu/.

For report 2 we aggregated the original data from EXIOBASE v.3.8.2 on 12 different consumption categories based on the COICOP level 1 system (United Nations Classification of Individual Consumption by Purpose) for an easier reporting. The description of these categories can be found in full on the webpage https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Glossary:COICOP_HICP or alternatively in the Statistics Norway website: https://www.ssb.no/en/klass/klassifikasjoner/134.

Regarding the data reported within the EXIOBASE database, the original EXIOBASE 3 data series end in 2011. This translates into the fact that this is the last year where actual data from national statistics were gathered. In addition, the database offers estimates up until 2022 based on auxiliary data, mainly trade and macro-economic data considering IMF expectations. The end years of real data points used for different categories are: 2015 energy, 2019 all GHG (nonfuel, non-CO_2 are nowcasted from 2018), 2013 material, 2011 most others, land, water.

For Report 1, the two data sources used for biodiversity impact calculations are EXIOBASE 3rx, which provide the economic and land use data, and the life cycle impact method LC-IMPACT providing characterization factors of biodiversity impacts from land use with results at the extinction level (potential species loss). The EE-MRIO database EXIOBASE 3rx is detailed into 200 sectors and 214 countries describing production requirements and demand in national economies. Whilst official input-output tables are not available for many of these countries, in EXIOBASE 3rx these tables were estimated based on multiple sources of data on technology, estimated outputs and bilateral trade (for more information see Bjelle et al. (2021)). The database contains extensions for six land use types: urban, annual and permanent crops, internsive and extensive forestry and pasture.

LCA and LC-Impact

Life-cycle assessment (LCA) evaluates the environmental impacts throughout a product's entire lifespan, from raw material extraction through materials processing, manufacturing, distribution, use, repair and maintenance, and disposal or recyclying (Guyne et al 2002). In contrast to the IO model, the focus for LCA is product or service specific.

Characterization factors (CF) in LCA are the indicators of impact and describe the amount of impact per amount of resources consumed or pollutants emitted in one year for production of a functional unit of the product/service analysed (e.g. number of species lost per year per km^2 of land used for production of 1 kg of cotton) (Marques et al 2017).

Thus, when conducting an LCA, CFs are used to translate the inventory results into indicators of potential environmental impacts. These sets of CFs are gathered in LCIA methods (Verones et al., 2020) which are constantly under methodological developments thus improvements are constantly published by different research institutes and universities but usualy they are published independently from each other and not necessarly consolidated within a consistent LCIA method. One such exemption though is LC-Impact (Verones et al., 2020).

Impacts from land use are modelled in LC-IMPACT for land occupation (use) and land transformation, but only land use was applied in Bjelle et al. (2021) The model is based on the countryside species-area relationship (SAR), taking into account that species may be able to survive in the absence of natural habitat, i.e. live in human-modified land only (see also Figure R3.1).

Following the LC-Impact methodology, biodiversity impacts are calculated by multiplying the CFs (which are in units of PDF/m2) with land use data (m2/year) and indicate the footprint at a certain point in time (PDF/year) relative to a hypothetical natural state without any human land use. The biodiversity indicators thus can be regarded as "snapshots" of the biodiversity impacts due to global land use in a certain year relative to the natural state. These indicators do not account for the cumulative biodiversity impacts of land use over several years. As pointed out in the scientific literarure (Verones et al., 2020), these indicators are rather reflecting an increase in the risk of extinction than an instantaneous loss.

Land use impacts are modelled for mammals, birds, amphibians, reptiles and plants individually for local losses and then adapted with a “vulnerability score” to transform local losses to global species extinction. Thus, land use impact factors estimating the potentially dissapeared fraction (PDF) per area occupied by specific land use types are using these species (birds, mammals, amphibians, reptiles, and plants) as a proxy for the entire “biodiversity”.

Both EE-MRIO and LCA methodologies are mainly using species diversity as a proxy for biodiversity, but other aspects like species traits, ecosystem structure and function are also identified in the scientific literature as very important factors when assessing the status of biodiversity (Pereira et al., 2013).

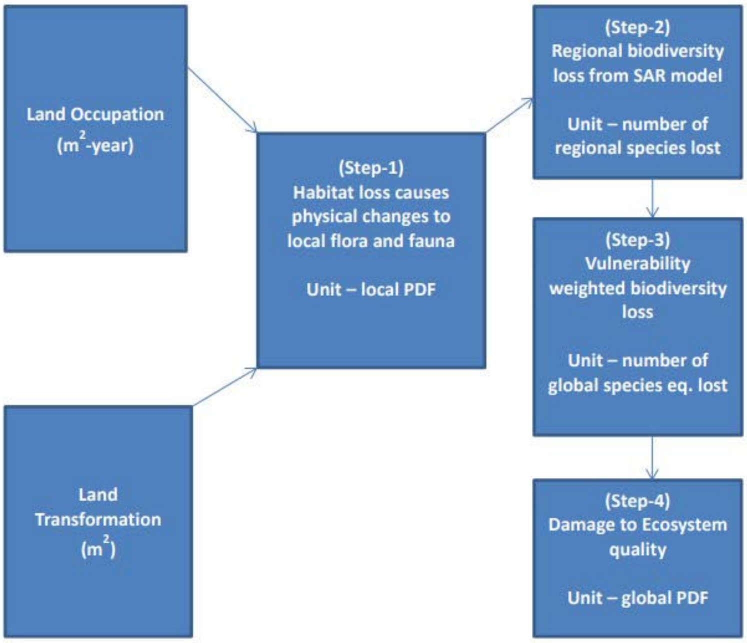

Figure R3.1: Cause-effect chain for impacts caused by land use and the modelled impact pathway. Land transformation and land occupation causes physical changes to flora and fauna locally, which leads to an altered species composition and species richness on the occupied land itself. If too much suitable habitat is lost, this leads to species extinction on regional or global scales. The unit of corresponding biodiversity damage at each step is also shown. Figure from Chaudhary et al.(2016).

Differences between SSB and EXIOBASE consumption results

The main difference between SSB and EXIOBASE consumption data is the difference in pricing. While SSB data is in purchaser's pricing, EXIOBASE data is in basic pricing. The difference between these pricing schemes is summarized in Figure 2.

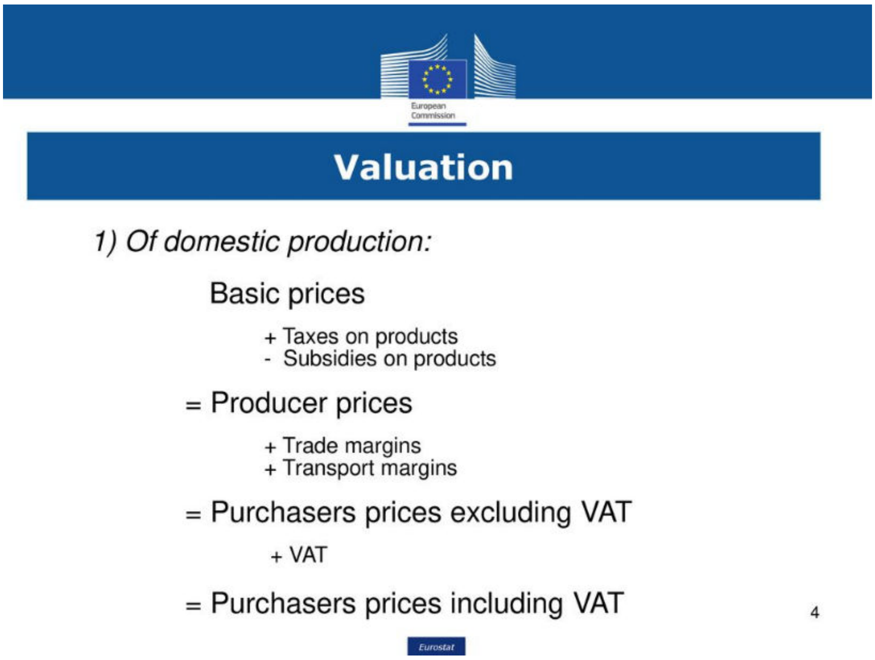

Figure R3.2: Difference between basic, producer and purchaser's prices from https://slideplayer.com/slide/16058398/.

The difference comes down to adding taxes, less subsidies and trade and transport margins when converting from basic to purchaser's price. In addition, currency is different as EXIOBASE data is given in million Euro and SSB data in million NOK.

A third source of differences is the balancing routines applied in EXIOBASE that ensures that all data in the database are balanced towards each other. This balancing mainly consists of ensuring the input matches the output for each sector and country in the database. The routine can involve shifting consumption between the 200 products in EXIOBASE, but the total on an aggregate product level remains unchanged.

Current prices and constant prices

Data in current (or nominal) prices refer to prices that are in the value of the current year. Data series in current prices are hence influenced by inflation. Data in constant (or real) prices show the data in the value of a chosen base year, which can therefore provide a measure of growth without the effects of inflation.

Almost all major global (EE-)MRIO databases are currently provided in current prices, with ongoing efforts to develop versions that capture the effects of inflation, for instance by creating tables in constant or previous year prices, or by adopting hybrid tables (physical and monetary). It is important to understand that the **total** environmental impacts for the entire world economy are identical, regardless of if they are calculated using constant prices, current prices, or hybrid units. What differs is the allocation of impacts across subparts of the economy since inflation varies across industries and products.

This implies that calculating consumption-based impacts (footprints) over multiple years in current or constant prices will give the same total (over all consumption), as if it was calculated with constant prices. For example, given a single country environmentally extended input output system for Norway as a time-series, the total environmental footprint for each year will be the same, no matter if it is calculated with data given in current prices or inflation adjusted, in constant prices. This is inherent to how footprints are calculated in IO analysis; inter-industry transactions as well as sector impacts are normalized by output. Hence, if inter-industry flows and output are in current prices, impact intensities will be normalized by output in current prices.

However, tables in current prices cannot adjust for different inflation levels across industry and product types. This entails that when comparing footprints of specific sectors over several years, inflation effects cannot be captured and might affect sector-specific footprint calculations. These differences are expected to become more pronounced the higher the level of detail of the analysis.

Potentially Dissapeared Fraction of Species (PDF) for reporting biodiversy loss

In the life cycle impact assessment (LCIA) methodology, the unit used to assess the impacts on biodiversity is the Potentially Disappeared Fraction of Species (PDF), which accounts for a fraction of species richness that may be potentially lost due to an environmental pressure (land use, ecotoxicity, climate change, eutrophication, etc). Thus, PDF compares the original species richness from the natural undisturbed by human activity state (which represents the reference) to the fraction left after a human intervention. In our reports, the biodiversity footprint due to Norwegian household consumption in 1995 represents the species richesness loss in 1995 relative to the species richness without any human disturbance. Similarly, the footprint for year 2015 is relative to the same natural refence state without human intervention, thus the two biodiversity footprints can be directly compared. PDF for a certain year represents the fraction of species expected to go extinct if the current pressures prevail and do not represent actual extinctions that have occurred already (Kuipers et al., 2019).

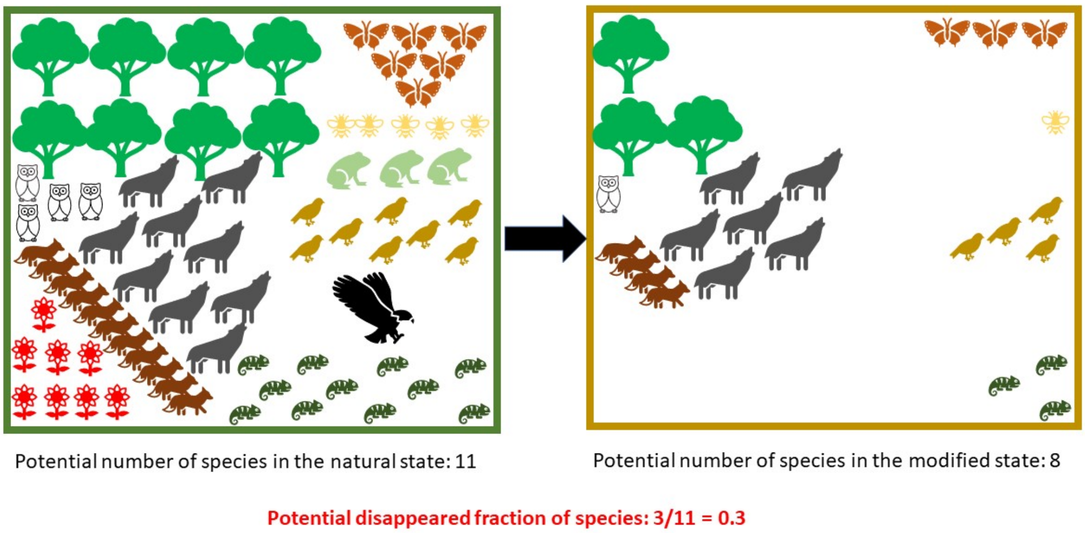

Figure R3.3: Hypothetical case for describing the concept of PDF

For example, in Figure R3.3 we present an hypotetical study case where the ecosystem on the left, in the green sqaure, in natural state has 11 number of species. On the right side, in the blue square, the hypotetical ecosystem was altered (for example due to land-use change to produce crops), and now the number of species in this modified state is 8. This leads to an PDF of 0,3.

Norsk versjon av beskrivelse av PDF

I Life cycle impact assessment (LCIA)-metodikken er det enheten "potensielt tapte andel av arter" (Potentially disappeared fraction of species – PDF) som brukes til å vurdere påvirkningene på biologisk mangfold. Dette måler altså andelen av artsrikdommen som potensielt kan gå tapt på grunn av en ytre miljøpåvirkning (arealbruk, økotoksisitet/miljøgifter, klimaendringer eutrofiering osv.). Dermed sammenligner PDF den opprinnelige artsrikdommen fra den naturlige tilstanden uforstyrret av menneskelig aktivitet (som representerer referansen) med andelen som er igjen etter et menneskelig inngrep (De Baan et al., 2013). PDF brukes til å sammenligne den opprinnelige artsrikdommen (slik artsrikdommen var i en tilstand før menneskelig interaksjon) med delen som er igjen etter menneskelige inngrep. I våre rapporter representerer det biologiske mangfoldet som følge av norske husholdningers forbruk i 1995 tapet av artsrikdom i 1995 i forhold til artsrikdommen uten menneskelig forstyrrelse. Tilsvarende er fotavtrykket for år 2021 relativt til den samme naturlige referansetilstanden uten menneskelig innblanding, og dermed kan de to fotavtrykkene for biologisk mangfold direkte sammenlignes. PDF for et visst år representerer kdelen av arter som forventes å utryddes hvis det nåværende presset råder og representerer ikke faktiske utryddelser som allerede har skjedd.
Vi viser dette som et eksempel i det tenkte scenarioet i figur 2 der vi til venstre, i den grønne firkanten, har økosystemet i naturlig tilstand der 11 arter hører til. Høyre side, den blå firkanten, viser samme økosystem etter den ytre menneskelige påvirkningen (for eksempel på grunn av arealbruksendring for å produsere avlinger). Nå er antallet arter redusert til 8. Dette fører til en PDF på 0,3.

Policy relevance of the methods used

Scientific models and methodologies are a simplification of reality and each of them presents distinct limitations in understanding historical trends and predicting future outcomes. On the other hand, political decision-making processes require flexible models and tools with holistic perspective and simultaneously sufficient detail to allow for the evaluation and comparison of specific policy options (Wiedmann and Barrett, 2013). EE-MRIO analysis and LCA are two established methods, that function as a tool to help understand the impacts of our consumption on biodiversity, taking the whole value chain into consideration (Marques et al., 2017). Today, consumption and production are often spatially disconnected, with the first taking place for example in Norway while the second in the country where production takes place, and an important part of the impact occurs (for example China). This leads to the current situation where consumers may not be aware of the impact that they cause elsewhere in the world.

These methodologies can already provide different types of biodiversity footprint indicators to measure progress towards sustainable patterns of consumption (Barrett et al., 2018; Marques et al., 2017). In addition, both methods, EE-MRIO and LCA, have previously been used to calculate indicators for measuring progress towards sustainable development, with the aim to help designing better policies and gain policy-relevant information (Guinée et al., 2006). For example, in the Organization for Economic Co-operation and Development (OECD) report evaluating strategies to achieve greener growth, they propose the IO method for evaluating the environmental and resources productivity (OECD Indicators, 2011).

Further long-term potential research

Extending impact calculations of biodiversity footprints from consumption per category to the most recent years

One potential suggestion for continuing this work would be to assess the potential impact on biodiversity loss from Norwegian consumption for the period 2016 – 2021. This could be achieved by extending the database used in the work of Bjelle et al. (2021) to cover the more recent years and the subsequent calculation of the biodiversity footprints over these years. Also, the compilation of the database to constant prices would be highly valuable to improve the level of insights that can be drown from time series comparisons.

In addition, a new scientific paper by Brucker et al. (2023) has recently been published in which the authors estimate biodiversity impacts due to consumption at the EU-27 level, and report results for Norway. Nevertheless, the annual biodiversity footprints due to Norwegian consumption estimated by Brucker et al. (2023) are considerably different from the ones reported by Bjelle et al. (2020). Two important differences between the reports are a) the different versions of the database EXIOBASE used, and b) differences in the method used to translate land use to biodiversity loss. Nevertheless, the general trends reported by the two articles are similar. An in-depth analysis of observed differences and their reasons would be an important next step.

Impacts on biodiversity from GHG emissions

Currently, the impacts on biodiversity loss from consumption are estimated based on the amount and type of land-use required to satisfy the consumption. In the LC-Impact methodology are nevertheless available CFs for translating the emissions of GHG from the value chain into biodiversity impacts. Thus, another possible suggestion to continue and expand the current work in a long-term project is to link the consumption data (from for example EXIOBASE) with the intensity of GHG emissions on biodiversity loss (from LC-Impact) to obtain impacts on biodiversity due to GHG emissions from Norwegian consumption.

Impacts from local Norwegian clothing production, usage, and disposal

Another suggestion for a long-term research project is to evaluate the impacts on biodiversity from the full value chain of clothing articles production and consumption in Norway. This work would require estimating the environmental impacts of consumption of Norwegian specific clothing articles (i.e., wool, or waterproof articles produced in Norway) with LCA methodology. The work would potentially involve workshops and/or survey for mapping habits and life-style choices representatives for the Norwegian society with regards to choices of clothing articles, usage (frequency of wearing and washing) as well as disposal. All these details would be included in the environmental assessment to better capture the specifics of the Norwegian market. In addition, these results could be combined with national consumption data from EXIOBASE and some Norwegian-specific scenarios for consumption could be assessed.

For this type of project, we would need collaboration with at least one of the Norwegian producers like: Dale of Norway, which is a knitting factory producing sweaters and cardigans, Oleana which is a knitting factory with some sewing facilities producing patterned knitted garments, Fjellrypa products which is a dressmaker's workshop specialized in outdoor clothing and bunads, Helly Hansen for outdoor and sport clothing or Moods of Norway.

In Table R3.1 we present potential funding opportunities.

Table R3.1. Funding opportunities

Call title	Scope	Thematic areas	Target group	Duration	Funding	Deadline
Support for Events	Norwegian	Democracy, administration and renewalEnergy, transport and low emissions, Oceans Health, Industry and services, Internationalisation, Climate and polar research, Land-based food, the environment and bioresources, Enabling technologies, Education and competence	Public sector, Industry, Research organisations		25000 NOK	Open-ended
Collaborative Project to Meet Societal and Industry-related Challenges	Norwegian	Cross-cutting topics: Energy, transport and low emissions, Oceans, Health, Land-based food, the environment and bioresources, Enabling technologies, Education and competence, Welfare, culture and society	Research organisations + at least two Norwegian partners that are not research organisations	24-48 months	Min NOK 4 000 000	February
Pre-projects to Mobilise Trade and Industry for Research	Norwegian	Trade and industry	Public sector, Industry	4-12 months	NOK 100 000-320 000	Open-ended
Innovation Project	Norwegian	Energy, transport and low emissions, Oceans, Industry and service industries, Land-based food, environment and bioresources, Enabling technologies, Petroleum	Business	24-48 months	TBD for 2023	Open-ended

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