LIFE CYCLE ASSESSMENT

WILDPLASTIC

As the first European venture capital fund, Planet A relies on its own scientific team to assess the environmental and climate impact of an innovation. Prior to an investment, a life cycle assessment, like this one, is conducted and integral part of the investment decision. All assessments as well as the methodology is published for maximum transparency.

Terminology and abbreviations

CED_f	Cumulative fossil energy demand
CO_2-eq.	Carbon dioxide equivalents
EOL	End of Life
Functional unit	Quantified performance of a product system for use as a reference unit
GHG	Greenhouse gas
LCA	Life cycle assessment
LDPE	Low density polyethylene
PET	Polyethylene terephthalate
Sb-eq.	Antimony equivalents
WSI	Water Stress Index

About WILDPLASTIC

The demand for plastic and plastic products has been growing in recent decades. Due to the lack of functioning recycling systems the ever-increasing demand for plastics has been accompanied by pollution of natural environments by plastic waste. The Hamburg-based start-up WILDPLASTIC targets this problem by providing plastic bags made of plastic that was collected in the environment. So far, collection systems have mostly focused on the collection of polyethylene terephthalate (PET) bottles and other plastics because they are easier to collect and recycle than foil materials, such as low-density polyethylene (LDPE). WILDPLASTIC uses collected LDPE and converts it into new products. The plastic, which is currently removed from the environment in Haiti, is sorted, granulated and processed into new plastic bags in Europe. WILDPLASTIC's parcel bags and trash bags ('WILDBAGS') are made from recycled LDPE.

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1. About this study

This is a summary report of a detailed life cycle assessment (LCA) study evaluating the potential environmental impact of WILDPLASTIC. The LCA study was conducted in accordance with ISO 14040 and 14044 standards[1] for LCA. A consequential LCA approach was applied to evaluate the change in environmental indicators as a result of WILDPLASTIC's activity. The approach evaluates marginal changes within the overall economy as a consequence of a change in the market structure (e.g. entry of a new market participant such as WILDPLASTIC), production modalities, demands as well as political, consumer or any other decision affecting the former aspects (Ekvall et al. 2016).

1.1. System boundaries

Accordingly, the evaluation comprises the full life-cycle of WILDPLASTIC products as well as other effects arising from WILDPLASTIC's activities (Figure 1). The LCA evaluates potential changes in environmental indicators. Hence, all processes and activities that increase or decrease are considered. All green processes and activities depicted in Figure 1 will increase their output. All orange processes and activities reduce their output due to the business activities of WILDPLASTIC. Grey processes and activities do not change. All energy requirements, waste streams, auxiliary materials etc. are considered in the assessment.

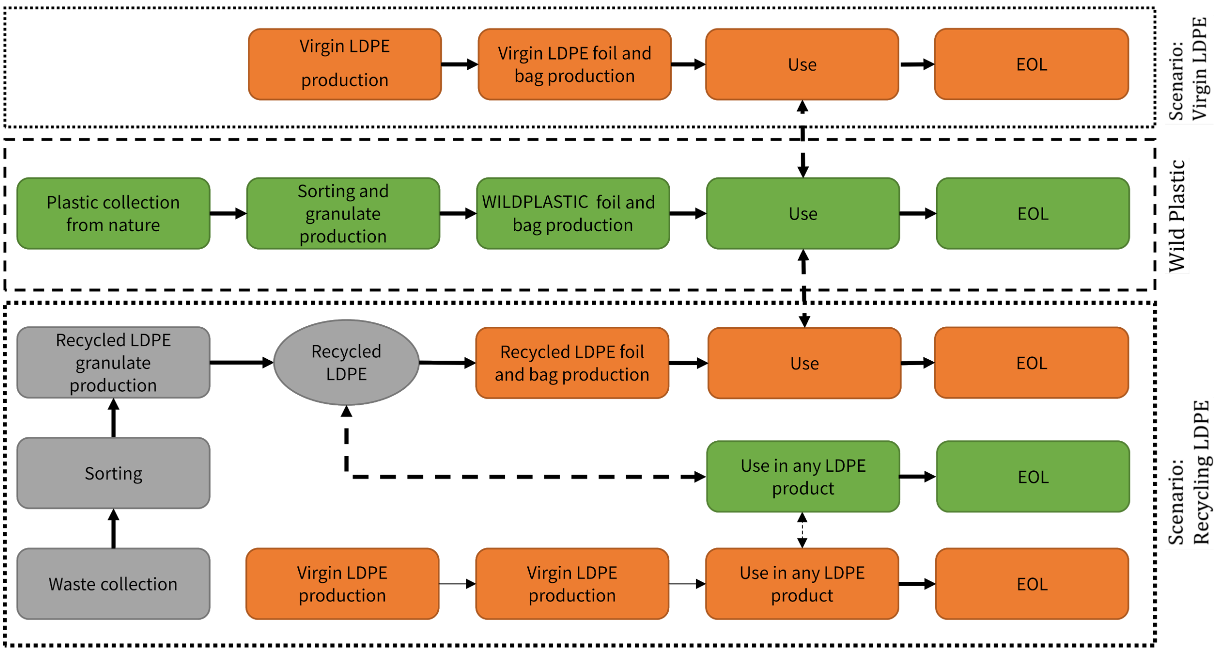

Figure 1 *Depiction of system boundaries. The assessed system comprises the life cycle of WILDPLASTIC bags and potential displacements of other products (recycled or virgin LDPE). Green processes will commence/increase operation due to WILDPLASTIC; orange processes will cease to operate or reduce their production. Abbr.: EOL – End-of-life, LDPE – low density polyethylene.*

Aside from all processes operated by WILDPLASTIC and their partners, other market participants might also be affected by WILDPLASTIC. An example for market effects triggered by WILDPLASTIC is the displacement of existing products and potential changes within the existing waste treatment and recycling system. The sale of WILDPLASTIC parcel bags and WILDBAGS will displace parcel bags

[1] EN 14040:2006 + AMD 1:2021 (Deutsches Institut für Normung e. V. 2021) and ISO EN 14044:2016 + AMD 1:2018 + AMD 2: 2020 (Deutsches Institut für Normung e.V. 2018)

or WILDBAGAS currently sold on the market. Both can either be made of virgin or recycled LDPE. In the former case it is assumed that WILDPLASTIC products substitute the production, use and end-of-life of virgin LDPE products (‘Scenario: Virgin LDPE’ in Figure 1). In the latter case, more recycled LDPE is available on the market because other bags made of recycled material do not need to be produced (and discarded) any longer. This reduces the production of the product substituted by WILDPLASTIC parcel bags or WILDBAGS and also leads to a surplus of recycled LDPE in the market (as previous products are not produced any longer). Based on the current market situation (usually a lower price of recycled LDPE compared to virgin LDPE) and due to higher growth rates of recycled LDPE markets it is assumed that this surplus in recycled LDPE also reduces the demand for virgin LDPE (‘Scenario: Recycling LDPE’ in Figure 1).

1.2. Functional unit and assessed indicators

The functional unit of this study is the production, use and disposal of WILDPLASTIC parcel bags and WILDBAGS with a volume of 25 L, 35 L, 60 L and 120 L. Thus, the reference flow is defined as one parcel bag, one WILDBAG with a volume of 25 L, 35 L, 60 L and 120 L.

In total five indicators are evaluated:

1. climate change/GHG emissions (Intergovernmental Panel on Climate Change (IPCC) 2014),
2. abiotic resource depletion (CML 2001 v. 4.7 2016 (CML - Department of Industrial Ecology 2016),
3. cumulative fossil energy demand (CED_f) (Verein Deutscher Ingenieure (VDI) (ed.) 2012),
4. water demand (WSI) (Pfister, Koehler, and Hellweg 2009),
5. plastic waste removed from the environment.

The latter category is strictly speaking no standardized LCA category. However, WILDPLASTIC collects plastic from the environment and returns it to the economic cycle. The quantification of the impact of removing plastic from the environment exceeds the current state of the art of LCA impact assessment methods. Therefore, only absolute numbers of removed plastic waste are reported.

1.3. Assumptions, data and data quality

The most important assumption that is made is that the sales of WILDPLASTIC Products will affect the existing market. It is assumed that WILDPLASTIC products replace other products. This is considered a reasonable assumption because parcel bags and trash bags are considered inflexible demands: customers are unlikely to buy more trash bags in case of an additional supplier in the market. The demand for parcel bags is also considered inflexible. As the demand is unlikely to change due to changes in the supply, a displacement of existing market participants is likely. A detailed sensitivity analysis evaluates different substitution scenarios and the influence of basic assumptions regarding the weight and materials of displaced products.

Primary data was collected by WILDPLASTIC from their suppliers. Data was cross-checked by experts for plausibility and consistency. All other processes and all background processes were modelled using the ecoinvent 3.7 database (consequential system model)(Wernet et al. 2016).

Data quality and its influence on results was evaluated based on the pedigree matrix approach (Ciroth et al. 2016; Muller et al. 2016). This approach allows data providers to select several qualitative statements on data quality referring to spatial, temporal and technological correlations as well as reliability and completeness. Based on these selected statements, standard deviations for log-normal distributions are derived. These probability distributions are then used for a Monte-Carlo Simulation. For each model, 1000 model runs were conducted. For additional information, the reader is referred to (Ciroth et al. 2016; Muller et al. 2016). The results of the Monte-Carlo simulation is provided in the Annex.

2. Life cycle stages and reference products

The life-cycle of a WILDPLASTIC product comprises the following stages (see all green processes depicted in the frame labelled 'WILDPLASTIC' in Figure 1). Wherever possible data was gathered directly from partners involved in the supply chain in order to depict a precise picture of the life cycle.

- **Collection.** The collection of film waste is accomplished by the Plastic Bank[2] in Haiti. Collection is done manually. Collected material is transported by truck to a central facility. Subsequent washing of the material to remove coarse contaminants is done with cold water. It is assumed that all trips in Haiti are made by truck and that the average distance from collection to washing is 50km.

- **Transport Haiti to Portugal.** Before shipping, waste is densified. The route to the next processing step is covered by cargo ship, assuming a distance of 7768 km on average. The loading of the 40" freight container is 25 t on average. The transport of the collected waste from the container port to the recycler is 80 km and is done by truck with a loading of 25 t per truck.

- **Granulation.** For the production of the granulate, 350 kWh of electricity is required per ton of granulate.[3] Furthermore, 45 kg of auxiliary materials are required for the granulation. It is assumed that 60 kg of sludge waste and 600 L of water are required. The same volume of water is treated as wastewater.

- **Transport Portugal to Germany.** Transportation to Germany is accomplished by a logistics company by truck.

- **Film production.** The modelling of the film production includes the energy demand (1300 kWh/t of foil), other production inputs and cutting losses of 10%.[4] The latter are reintroduced into the recyclable material cycle. Color accounts for 10% of the bag weight and that a non-water-based, black color is used.

- **End-of-life (EOL).** Based on waste volumes it is assumed that two-thirds of the bags are collected separately (e.g. in separate collection systems such as the German "Gelber Sack"). The rest ends up in municipal solid waste and is treated according to the municipal solid waste treatment in Germany and the EU. Of separately collected plastic waste in Germany,

[2] https://plasticbank.com/

[3] All data on granulation are directly obtained from the partner company.

[4] The film production data was provided by the primary producer.

73% is treated (other treatment than recycling, e.g. incineration or (in certain countries) landfilling), 17% is recycled and 10% is exported to third countries. Of exported waste, 76% is recycled, 14% is landfilled, 7% incinerated and 3% is lost to the environment due to inadequate handling (Bishop, Styles, and Lens 2020). Caveat: There is a high degree of uncertainty in waste statistics. Studies reveal that the share of plastics recycled into recycled material is much lower than claimed in official statistics (Wecker 2018). For example, Eurostat reports a recycling rate of 69.9% for packaging waste in Germany in 2017 (Eurostat 2020). However, this number is calculated as the share of plastic that is separately collected from total plastic waste. The number does not give an indication of the production of recycled plastic. Another studies estimates that in 2017, the actual recycling share (defined as recyclate produced per plastic waste arising) were 30 and 17% of the total and post-consumer plastic waste in Germany, respectively(Conversio Market & Strategy GmbH 2018) . A similar share is reported in (Plastic Recyclers Europe 2019). Others report even lower numbers: 11% of plastic waste arising within the EU is recycled to replace virgin material is reported in (Hsu, Domenech, and McDowall 2021). In order to account for these uncertainties, different scenarios are evaluated in a sensitivity analysis.

Reference products are modelled analogously as depicted in Figure 1. For all these stages of the life-cycles, the LCA considers energy consumption, energy sources, water use, wastewater, auxiliary materials, losses due to insufficient quality of incoming film waste and other waste. The data for WILDPLASTIC processes is primary data obtained from companies providing services to WILDPLASTIC (i.e. waste collection, waste sorting, granulation as well as foil and bag production). All other processes are modelled with the Ecoinvent 3.7 database (Wernet et al. 2016).

The functional unit of this study is defined as one WILDPLASTIC parcel bag or one WILDBAG. The weight of WILPLASTIC products assessed in this study and corresponding reference products is presented in Table 1.

Table 1 *Weight of WILDPLASTIC products and corresponding reference products.*

	Parcel bag	WILDBAG 25 L	WILDBAG 35 L	WILDBAG 60L	WILDBAG 120L
WILDPLASTIC	30 g	13.5 g	16.3 g	30.4 g	85 g
Reference	30 g	8.9 g (5.1 to 19.2 g)	14.7 g (6.3 to 19.8 g)	16.3 g (8.7 to 27.6 g)	64 g (37 to 85 g)

The reference parcel bag is made of 80% recycled LDPE and 20% virgin LDPE. In the base case scenario, the reference trash bag is made of virgin LDPE. Alternative scenarios were evaluated in a sensitivity analysis. The displacement of recycled LDPE products eventually leads to a reduction in the demand of virgin LDPE (Figure 1). The evaluation is based on primary data from waste collection, granulation and bag production and considers market data from Germany (the key market for WILDPLASTIC).

A number of **sensitivity analyses** were conducted:

- **Alternative substitution scenario:** the substitution of recycled LDPE. In case of the trash bags two alternative scenarios are considered: the reduction in virgin LDPE demand due to surplus recycled LDPE reducing the demand for virgin LDPE and a reduction in LDPE recycling and an increase in other treatment (i.e. waste incineration). The latter case was also evaluated for the share of recycling material contained in the reference parcel bag (80% of bag weight).

- **Alternative EOL scenarios:** 100% recycling and 100% treatment with MSW treatment (i.e. incineration).

- **Weight of reference bags:** Based on minimum and maximum weights of reference bags found in a market analysis.

In total, 25 alternative scenarios were analyzed in addition to the base cases. They comprise a combination of a substitution scenario, EOL scenario and reference product weight scenario. In addition, an uncertainty analysis was conducted for the base case by a Monte-Carlo simulation (1000 model runs).

3. WILDPLASTIC's environmental impact

3.1. Carbon footprint

The LCA calculation shows that WILDPLASTIC products potentially reduce GHG emissions by 57, 98, 10, 21 and 10 g CO_2-eq. per parcel bag, 120, 60, 35 and 25 L WILDBAG, respectively (Figures 2 to 6). In comparison to virgin LDPE bags, WILDPLASTIC bags emit 55, 44, 17, 43 and 32 % less GHG emissions in case of the WILDPLASTIC parcel bag, 120, 60, 35 and 25 L WILDBAG, respectively (Table 2).

***Table 2** Comparison of WILDPLASTIC bags with other reference bags available on the market. The minimum and maximum values correspond to the results if minimum and maximum weights of reference products available on the market are displaced by WILDBAGs.*

		Parcel bag	WILDBAGS			
	unit		120 L	60 L	35 L	25 L
WILDPLASTIC	g CO2-eq./bag	46.08	123.41	46.7	29.45	20.74
Reference bags	g CO2-eq./bag	103.24	221.25 (127.90 to 304.18)	56.33 (29.90 to 95.42)	50.97 (21.71 to 68.28)	30.65 (17.63 to 66.38)
Absolute improvement	g CO2-eq./bag	-57.16	-97.84 (-180.81 to -4.5)	-9.63 (-48.72 to 16.8)	-21.52 (-38.83 to 7.74)	-9.91 (-45.64 to 3.10)
Relative improvement[a]	%	55%	44% (4 to 59%)	17% (-56% to 51%)	42% (-36% to 57%)	32% (-18% to 69%)

[a] Positive values represent a net reduction in GHG emissions. Negative values represent a net increase in emissions

The most important results regarding GHG emissions caused within the life cycle of WILDPLASTIC parcel bags and WILDBAGS are:

- EOL is the most important contributor to GHG emissions accounting for 49% of the GHG emissions emitted within the life cycle of WILDPLASTIC products. This is affected by consumers' behavior and access to separate collection systems for plastic wastes as well as by the share of material that is really recycled once it is collected. Studies indicate that recycling rates are low, even of separately collected consumer plastic wastes (see 'EOL' above). This results in high direct emissions in the EOL phase.

- All production processes together (granulation, foil production, bag production) account for about 32% of the GHG emissions emitted within the life cycle of WILDPLASTIC products.

- Shipping and transportation by truck of sorted waste from Haiti to Portugal and of granulate from Portugal to Germany account for around 17% of WILDPLASTICs GHG emissions. Data from the sorting and granulation facility in Portugal indicates that about 10% of delivered is unsuitable for granulation. If granulation took place in Haiti instead, only about 0.6% of WILDPLASTIC's GHG emissions could be reduced due to less material that is transported. The transportation from Portugal to Germany by truck accounts for about two-thirds of the GHG emissions of transportation. This could be reduced by choosing other means of transport (e.g. shipping or freight train).

- Collection in Haiti only accounts for about 2% of the GHG emissions emitted within the life cycle of WILDPLASTIC products.

WILDPLASTIC products are likely to displace other products on the market. This potentially results in a decrease in GHG emissions:

- Wild Parcel bag (Figure 2):
  - It is assumed that each parcel bag displaces a parcel bag made of 80% recycled LDPE and 20% virgin LDPE. This share has a considerable influence on overall results: The production of virgin LDPE parcel bags entails 2.8 times more GHG emissions than recycled material. Eventually, displacing recycled LDPE parcel bags results in about the same quantity of GHG emissions saved. This is due to the fact that the surplus recycled LDPE is available to the market. It can therefore be used to displace virgin LDPE (or reduce the increase in demand for virgin LDPE).
  - The EOL of substituted recycled material accounts for two-thirds of the (displaced) GHG emissions related to the life cycle of displaced recycled LDPE parcel bag material. The highest share of net reductions in GHG emissions related to substitution of virgin material contained in displaced parcel bags is the provision of virgin LDPE and its processing accounting for 78%.

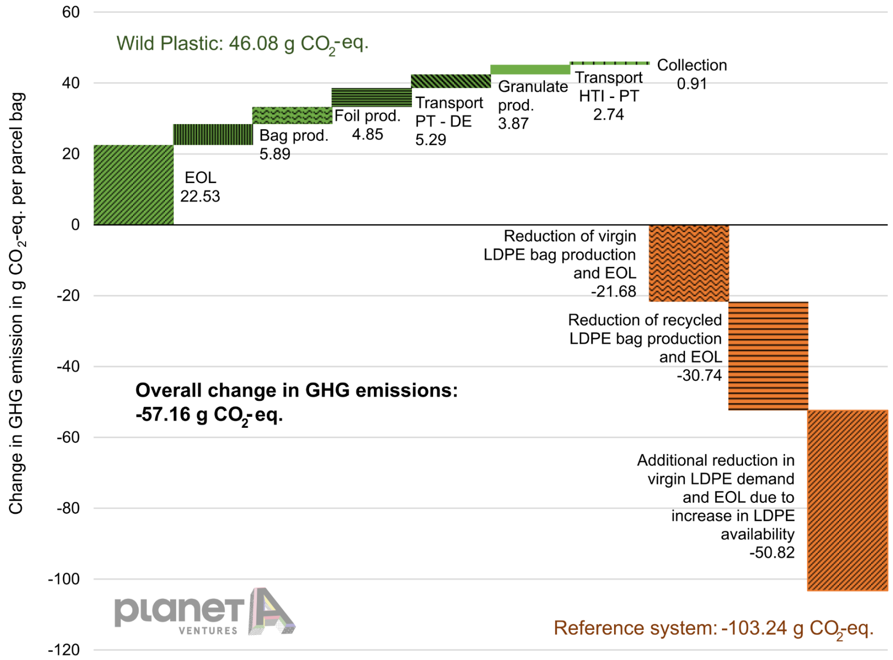

Figure 2 *Change in GHG emissions of WILDPLASTIC Parcel bags in kg CO_2-eq, per parcel bag. Abbreviations: EOL – end-of-life, GHG – greenhouse gas LDPE – low density polyethylene, prod. – production; countries abbreviated in ISO 3166 country codes: DE – Germany, HTI – Haiti and Pt – Portugal.*

- WILDBAGS (Figure 3 to 6):
  - A substitution of virgin LDPE bags was assumed. An alternative scenario (substitution of trash bags made of recycled material was evaluated in the sensitivity analysis (see below).

- The weight difference between the WILBAGs and the average bag weight differs between the different WILDBAGS. The 35 L WILBAGS displaces more virgin LDPE per bag (in relative terms) as the other bags. This results in a higher net reduction in environmental indicators of the 35 L bag in comparison to the other WILDBAGs.

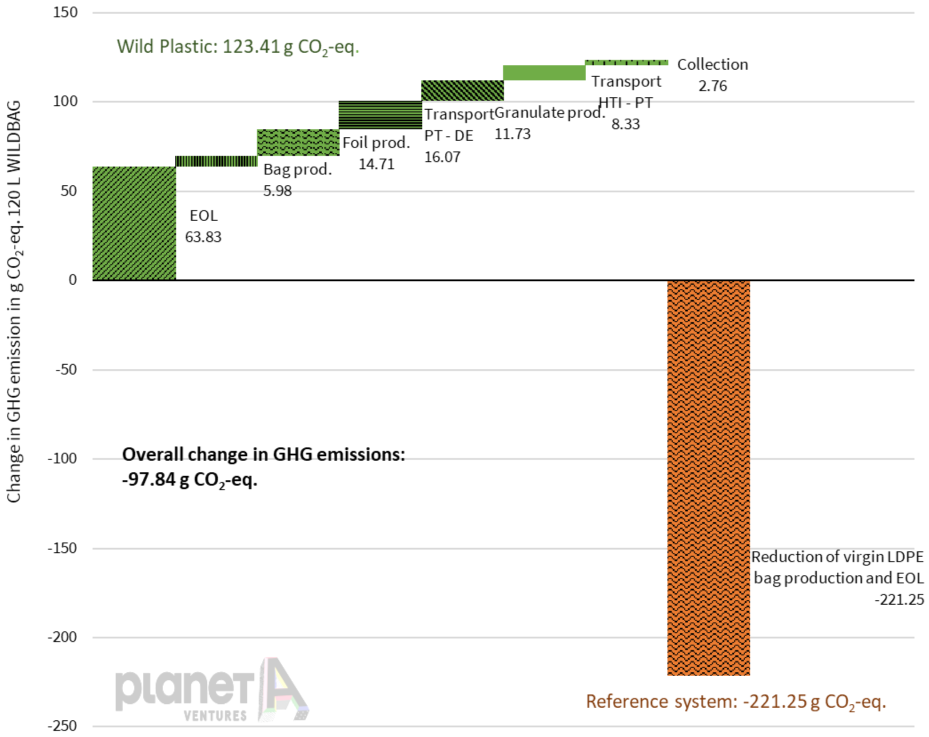

Figure 3 *Change in GHG emissions of 120 L WILDBAGs in kg CO_2-eq, per bag. Abbr.: EOL – end-of-life, GHG – greenhouse gas LDPE – low density polyethylene, prod. – production; countries abbreviated in ISO 3166 country codes: DE – Germany, HTI – Haiti and Pt – Portugal.*

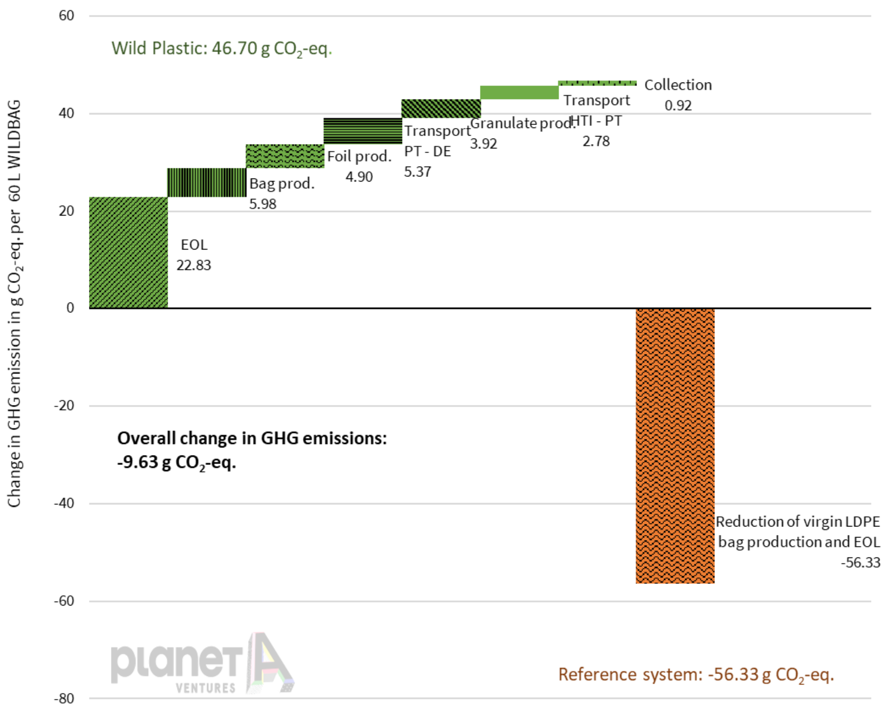

Figure 4 *Change in GHG emissions of 60 L WILDBAGs in kg CO_2-eq, per bag. Abbr.: EOL – end-of-life, GHG – greenhouse gas LDPE – low density polyethylene, prod. – production; countries abbreviated in ISO 3166 country codes: DE – Germany, HTI – Haiti and Pt – Portugal.*

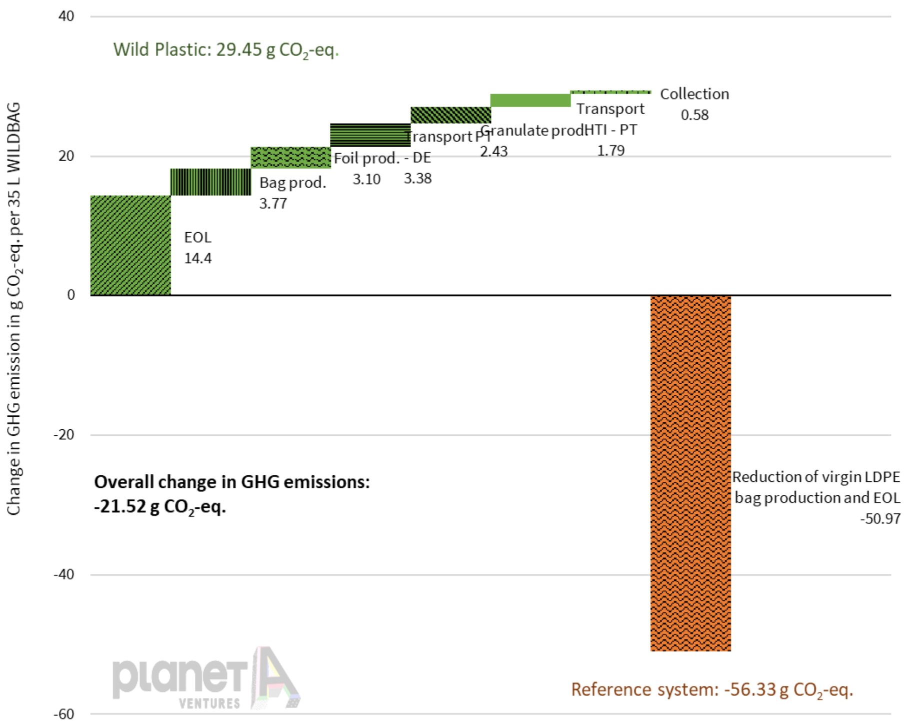

Figure 5 *Change in GHG emissions of 35 L WILDBAGs in kg CO_2-eq, per bag. Abbr.: EOL – end-of-life, GHG – greenhouse gas LDPE – low density polyethylene, prod. – production; countries abbreviated in ISO 3166 country codes: DE – Germany, HTI – Haiti and Pt – Portugal.*

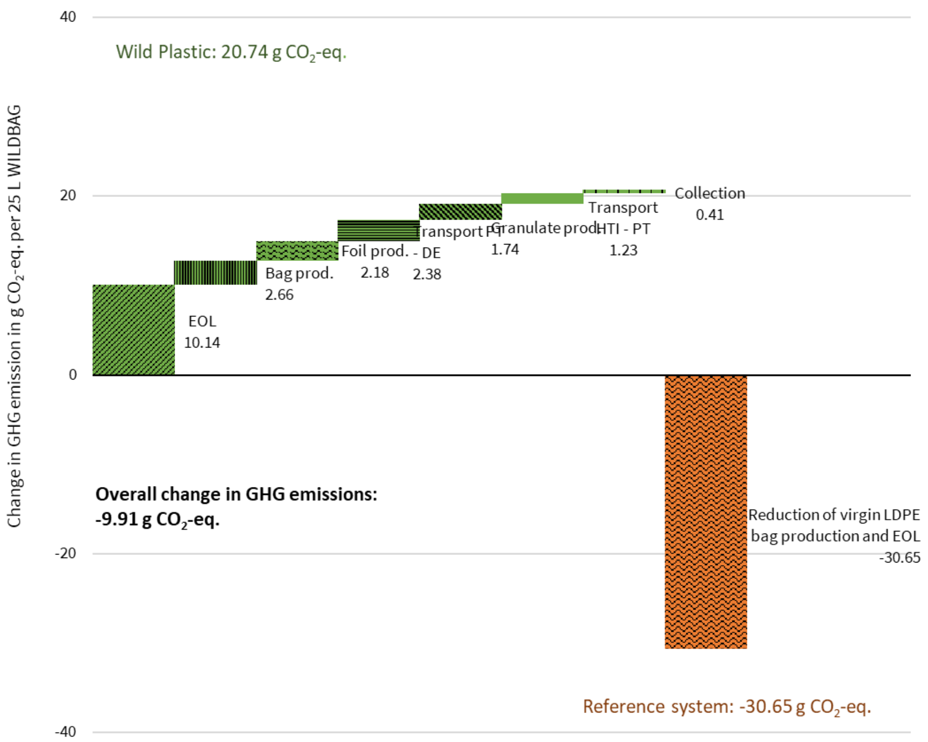

Figure 6 *Change in GHG emissions of 25 L WILDBAGs in kg CO_2-eq, per bag. Abbr.: EOL – end-of-life, GHG – greenhouse gas LDPE – low density polyethylene, prod. – production; countries abbreviated in ISO 3166 country codes: DE – Germany, HTI – Haiti and Pt – Portugal.*

3.2. Other environmental footprints

Aside from GHG emissions, other impact categories were evaluated. Table 3 depicts the result of all indicator values. In all impact categories, WILDPLASTIC products result in a net improvement.

Table 3 *Change in environmental indicators per WILDPLASTIC parcel bag, 25, 35 and 60 L WILDBAGS. Minimum and maximum values in parentheses refer to minimum and maximum weights potentially displaced on the market.*

			Parcel bag	**WILDBAGS**			
Indicator		unit		**120 L**	**60 L**	**35 L**	**25 L**
Climate change	Global Warming Potential	g CO_2-eq.	-57.16	-97.84 (-180.81 to -4.5)	-9.63 (-48.72 to 16.79)	-21.52 (-38.83 - 7.74)	-9.91 (-45.64 to 3.11)
	Abiotic depletion	10^{-6} kg Sb-eq.	-1.38	-2.52 (-4.09 to -0.76)	-0.42 (-1.16 to 0.08)	-0.56 (-0.88 to 0.00)	-0.29 (-0.97 to -0.05)
Resources	Non-renewable, fossil energy	MJ	-2.12	-4.89 (-6.30 to - 3.31)	-1.22 (-1.88 to -0.77)	-1.03 (-1.33 to -0.53)	-0.64 (-1.24 to -0.42)
	Water demand (WSI)	L	-7.97	-31.58 (--41.96 to -22.33)	-13.77 (-16.71 to -9.41)	-6.96 (-10.22 to -5.03)	-5.49 (-6.94 to -1.5)
Waste	Plastic waste removed from the environment	g	30	94	33.78	21	15

4. Conclusion

The evaluation shows that the potential displacement of products existing on the market and the EOL of used WILDPLASTIC bags and displaced bags are the most important with regards to the environmental impact of WILDPLASTIC. At present as long as WILDPLASTIC contributes to the increase in production and use of alternatives to virgin LDPE, a positive impact with regard to the evaluated indicators can be expected. WILDPLASTIC can lower its environmental impact by using renewable energies and by lowering the impact of transportation, e.g. by increasing the density of transported material (e.g. shipping granulate instead of bags), reducing transportation distances in general or switching to more environmentally friendly alternatives, such as railways instead of road transportation. Existing EOL systems are insufficient with regards to environmental impacts and the unsustainable use of finite resources. WILDPLASTIC alleviates certain negative externalities of these dysfunctional EOL systems. At the same time, WILDPLASTIC is likely to result in a net improvement of the evaluated environmental indicators. Therefore, WILDPLASTIC can complement efforts to reduce the use of virgin plastics and the urgently needed establishment of closed recycling systems.

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Annex

A1 Monte-Carlo simulation histograms

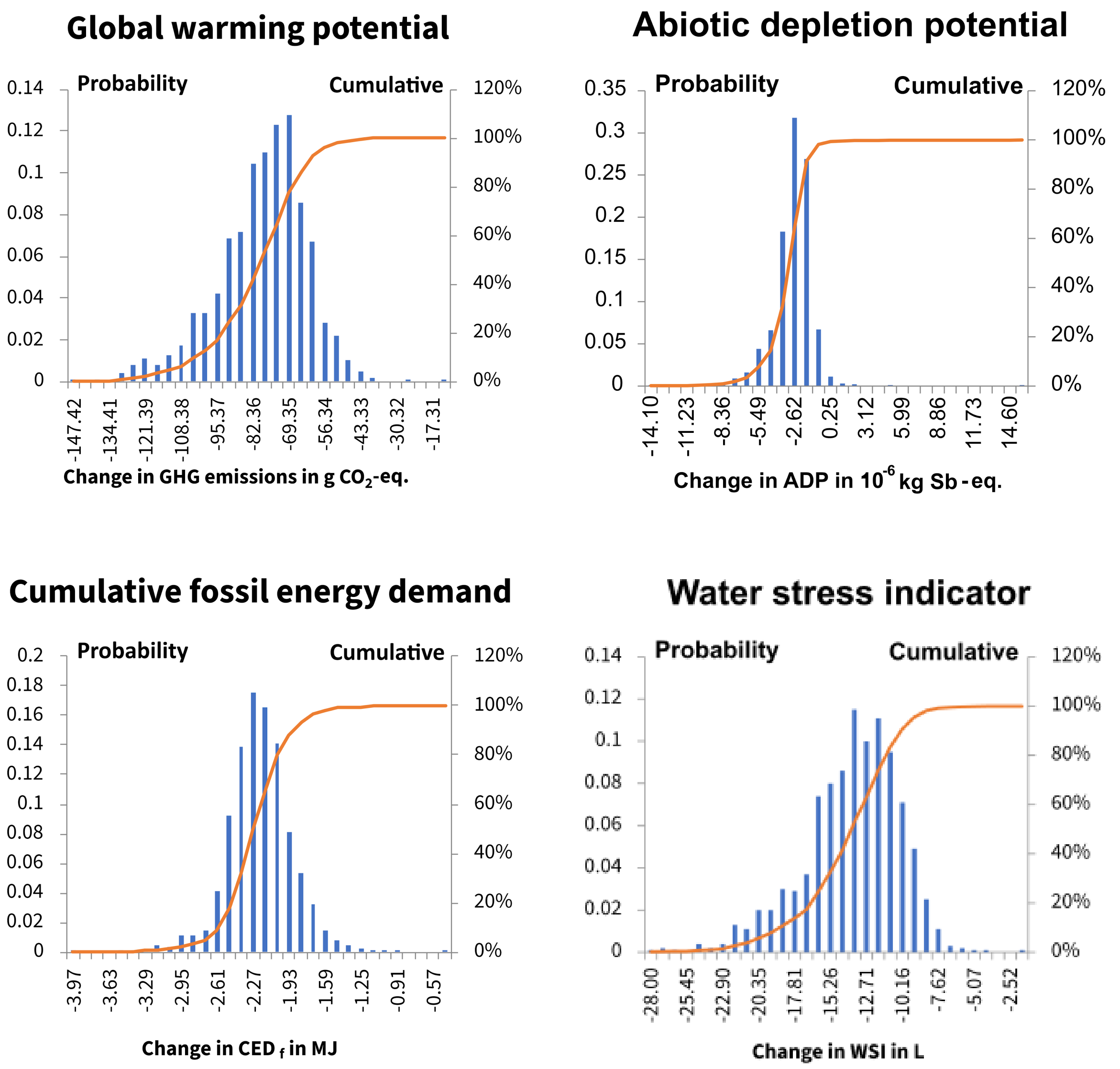

Figure A1 *Results of the Monte Carlo Analysis of the WILDPLASTIC parcel bag. Abbr.: ADP – Abiotic depletion potential, CED_f – Cumulative fossil energy demand, WSI – Water stress index.*

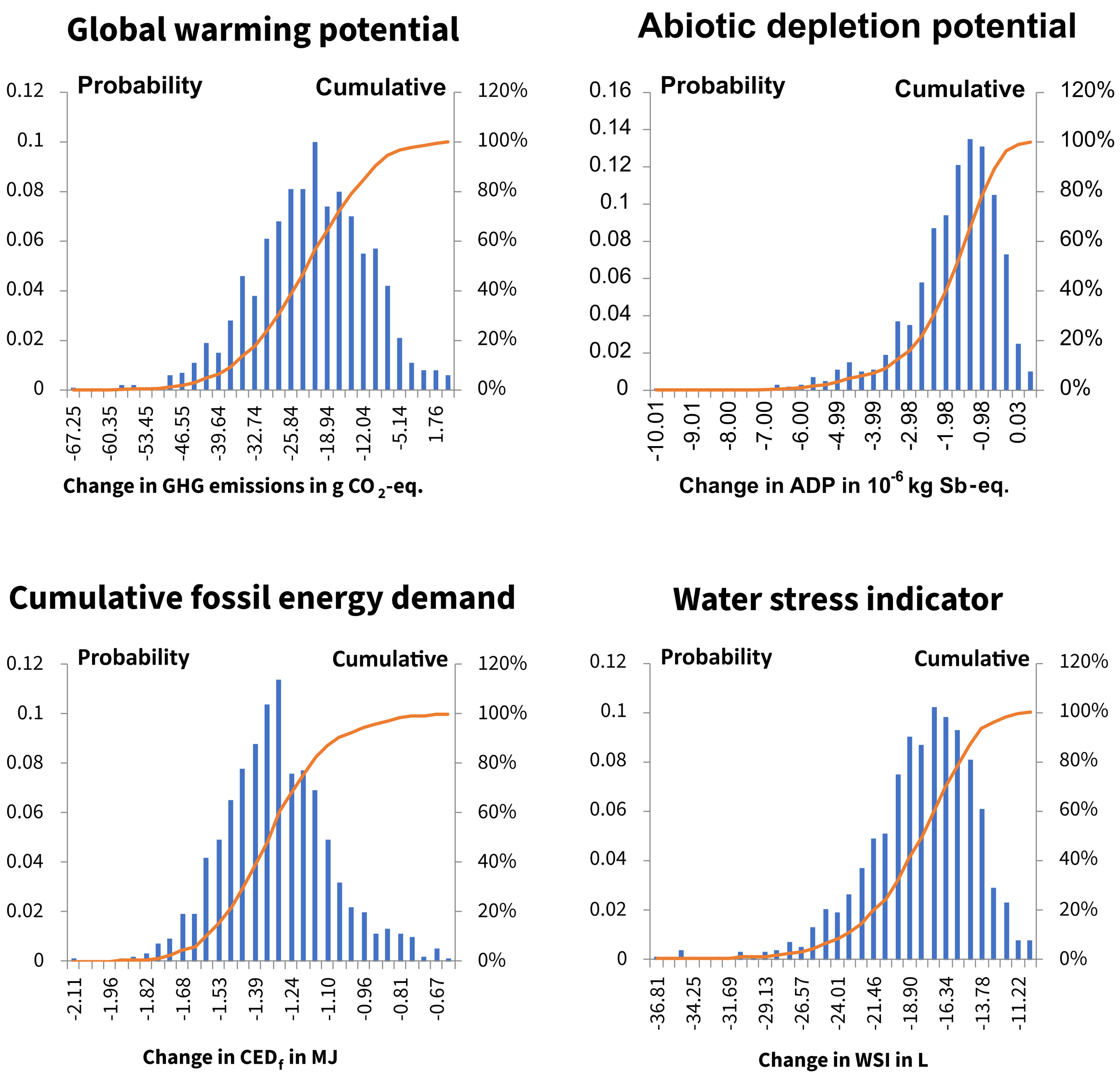

Figure A2 *Results of the Monte Carlo Analysis of the 60 L WILDBAG. Abbr.: ADP – Abiotic depletion potential, CED_f – Cumulative fossil energy demand, WSI – Water stress index.*

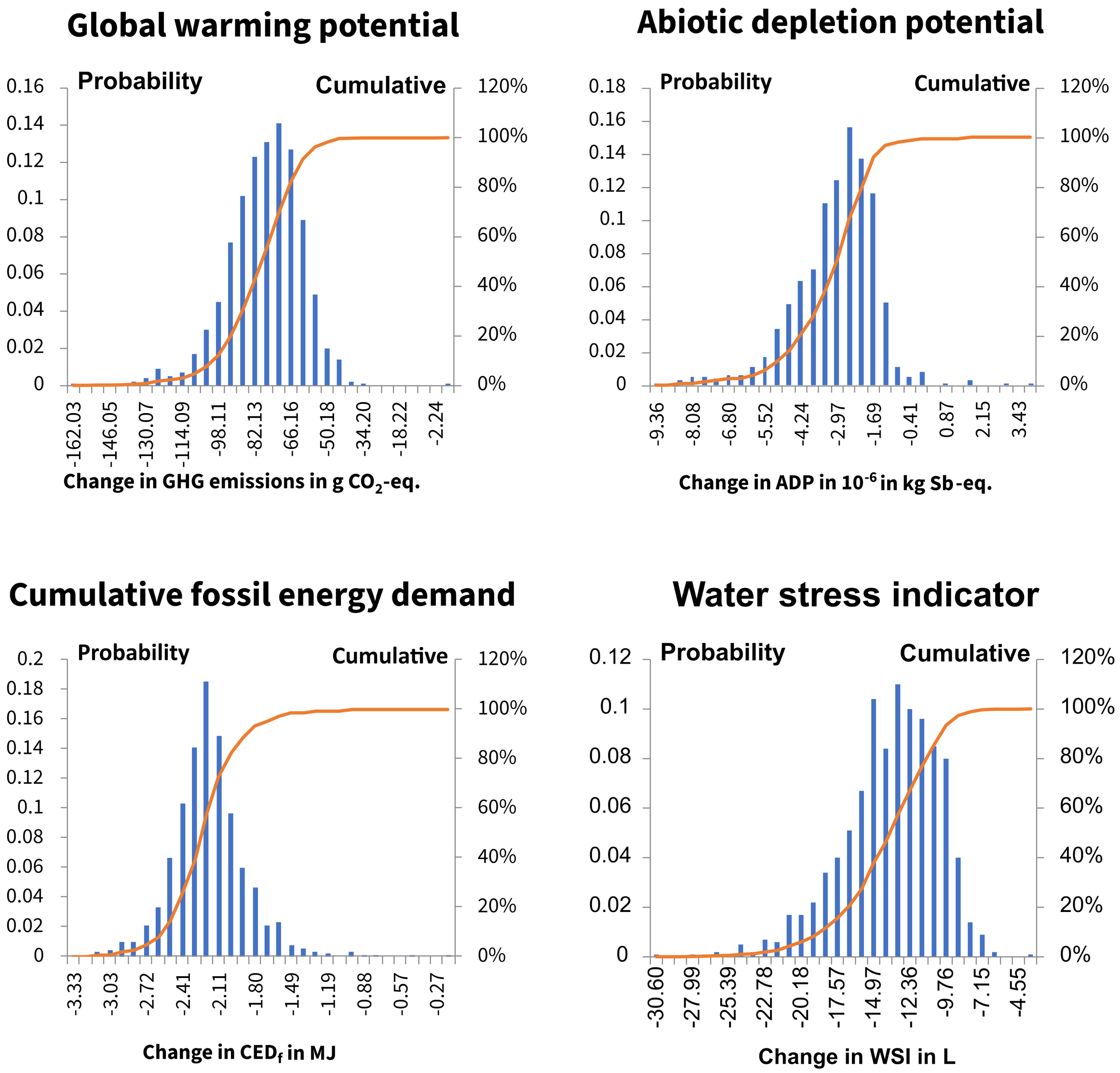

Figure A4 *Results of the Monte Carlo Analysis of the 35 L WILDBAG. Abbr.: ADP – Abiotic depletion potential, CED_f – Cumulative fossil energy demand, WSI – Water stress index.*

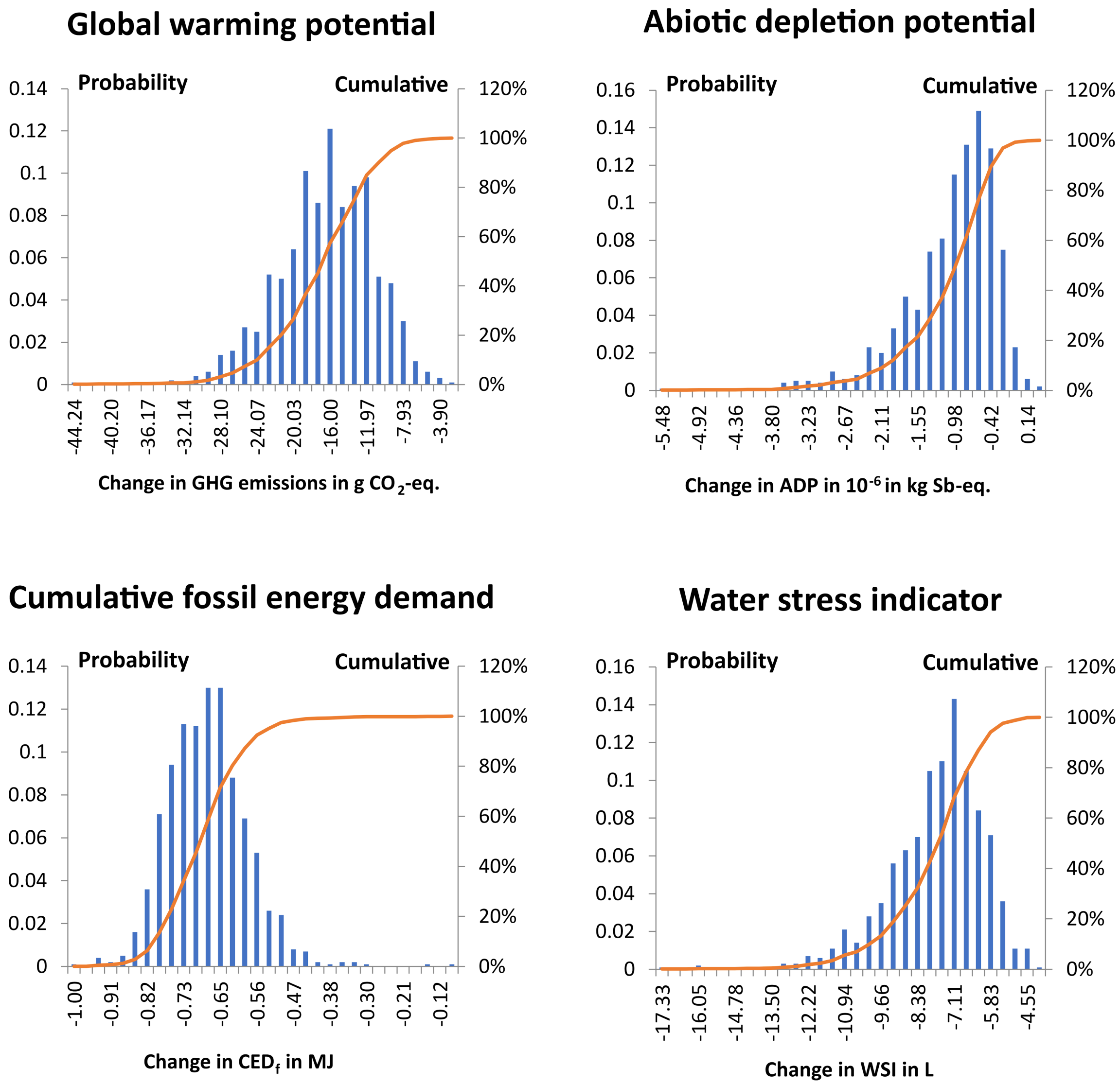

Figure A3 *Results of the Monte Carlo Analysis of the 25 L WILDBAG. Abbr.: ADP – Abiotic depletion potential, CED_f – Cumulative fossil energy demand, WSI – Water stress index.*

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