INdIGO

INnovative fIshing Gear for Ocean

DELIVERABLE 3.3.1

LCA ON RECYCLED FISHING GEAR USING SIMAPRO

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EUROPEAN UNION

Interreg France (Channel Manche) England

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ABSTRACT

According to the WWF, fishing gears accounts for the 10%- 15% of the marine debris. This accounts to roughly 1 million ton of fishing gear lost in ocean per year. This not only creates pollution but causes ghost fishing. This report discusses the LCA of the fishing gears and compares to the biodegradable fishing net.

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List of Abbreviation:

AoP: Areas of Protection

ALDFG : Abandoned ,lost ,discarded fishing gear

LCA : Life Cycle Assessment

CO_2 : Carbon dioxide

Mt: Million Metric ton

MP: Microplactics

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Introduction:

Plastics especially Nylon are very durable and take thousands of years to degrade. Considering fishing gears account for 27% of the total lost fishing gear, this generates considerable the issue o of ghost fishing. According to the recent research, (Hahladakis, 2020) on marine litter, plastic account for more than 62% of the marine little. Since the mass production of the plastic 70 years ago, 8300 million metric tons of virgin plastic has been produced, out of which 6300 Mt of plastic waste has been generated till 2015. 79% of this waste goes to landfill and by different means ultimately transported to oceans and sea. (Geyer, et al., 2017)

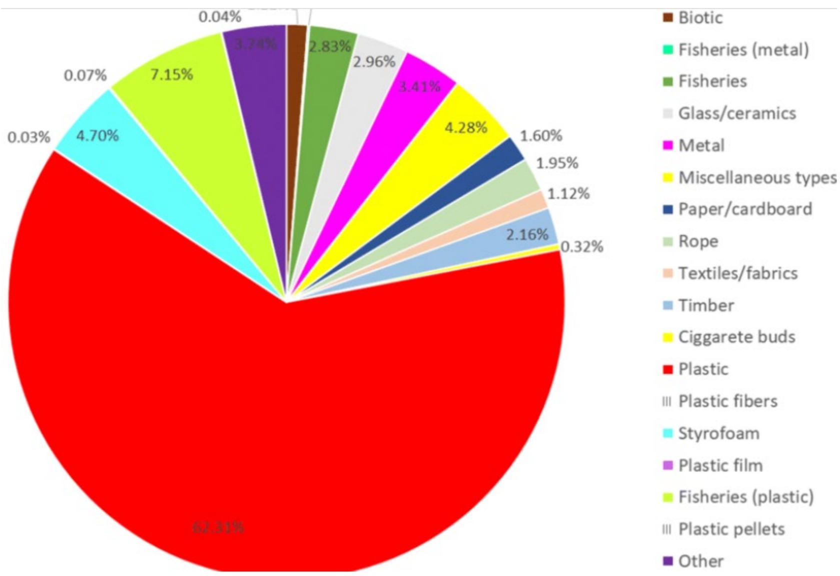

Figure 1 Global Estimate of Marine Little

The global challenge of marine little needs to be address in a logical way. This can be achieved by quantifying the environmental impact of the marine debris not only in term of CO2 emissions but also utilising holistic life cycle assessment methodologies. In recent years the amount of the microplastics in the marine has increase dramatically, but environmental implication of marine these are not yet fully comprehended. Hence the needs for a through LCA is there, thus filling in the literature gap and providing the area of future research. (Kershaw, 2015)

Figure 2 Marine Ocean Pollution

Issues

A comprehensive evaluation of current recycling and waste disposal of the marine litter including the data on the rate of recycling and method was processed using Life Cycle Assessment approach.

Research Aim and Objectives

The aim of the project is to reduce marine litter, hence having the positive impact of the marine environment. This will be achieved by following series of Objectives and utilising SimaPro software package.

Objective:

1. Life Cycle Assessment of the Fishing Gear
2. Environmental impact of new fishing gear

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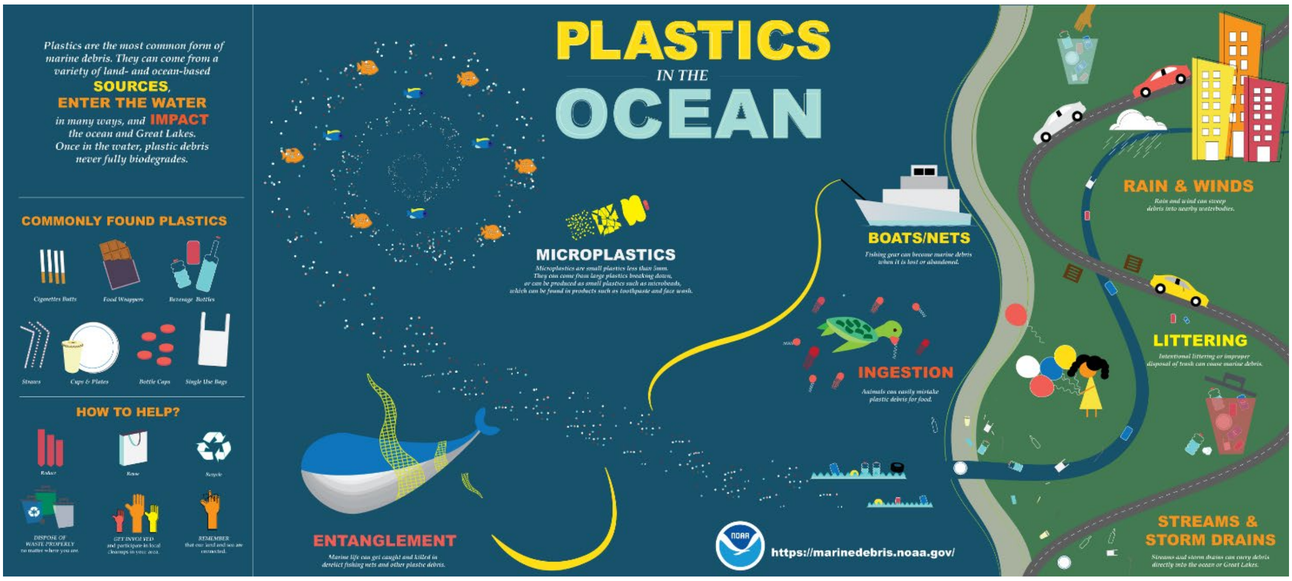


Figure 3 Plastic in the Ocean

Literature Review and Gaps:

The problem of the anthropogenic littler in marine environment in discussed in detail in various literature, however the there is still significant gap in linking the data to multiple Areas of Protection (AoP). There is requirement to conduct coordinated research into multiple pathways i.e Raw material extraction, manufacturing, utilisation, recycling /end of life etc. of the whole LCA of marine litter. This will help to produce the individual characterisation factors to cover the research gap. Few researchers in the past has discussed the issues of marine litter leeching into the environment but the modelling of multiple pathways for recycling and End of Life (EOL) scenario is not discussed in details.

In 2019 European Commission welcomes the European Parliament adoption of new rules on single use plastic. The commission proposed the tackle the issue of marine litter on European beaches including the abandoned, lost discarded fishing gears (ALDFG). The extended producer responsibility scheme was also extended to the fishing gears. This scheme will help cover the cost if reducing /cleaning marine litter. (Commission, 2019). It is widely acknowledged that marine littler resulting from plastic is a major environmental problem. Current efforts and approaches to reduce the plastic marine litter may reduce the plastic litter in oceans. The engaged strategies usually result in the potential trade-offs with holistic environmental issues. (Wood, et al., 2021). Hence LCA should be used to locate and identify the weightage of these trade-offs between possible EOL routes. As shown in figure (2), the framework of the various EOL scenarios for marine litter detailed along with the exposure, effect and severity on multiple factors such as Human health, ecosystem quality, socio economic assets, natural heritage etc.

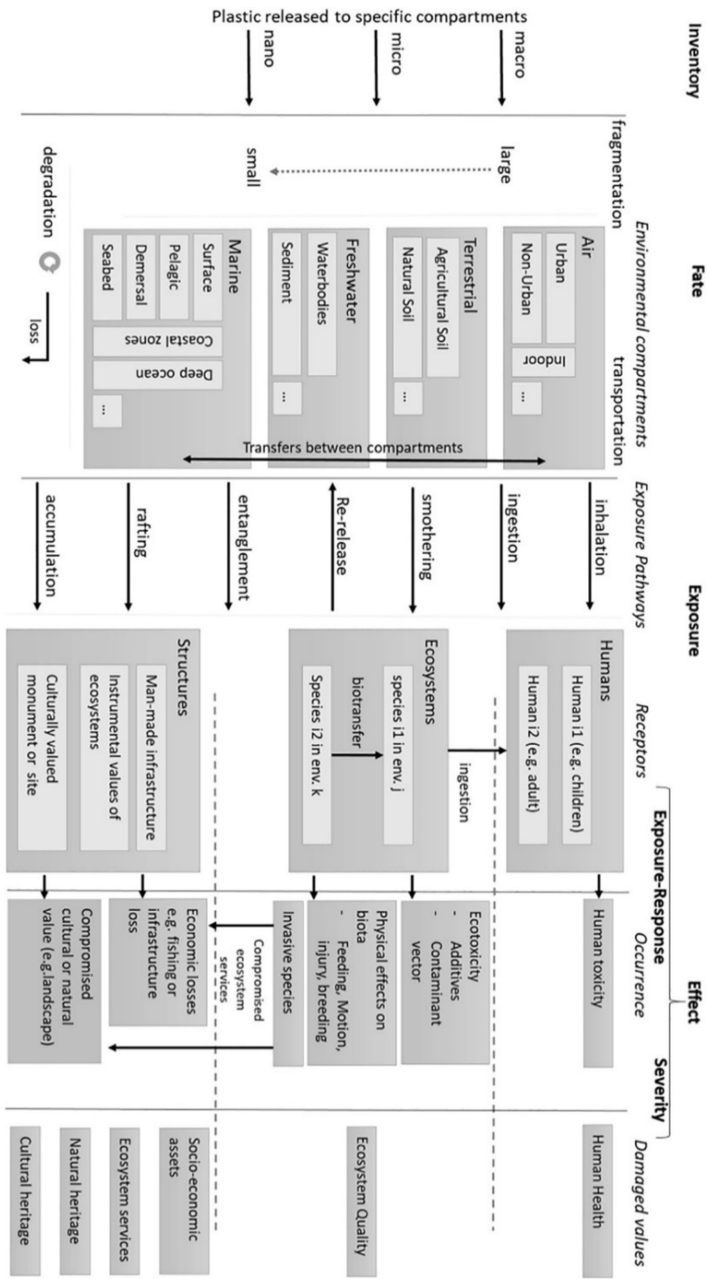


Figure 4 An LCIA modelling framework for marine plastic litter Impact (Wood, et al., 2021)

A recent study carried out in Great Britain's focussing on South West Peninsula, (as shown in figure 3)conclude its finding as ; (Units are standardised per person and per meter of beach cleaned : See Appendix 2 for supplementary Data)

- From 600m of coastline 1004 items of ALDFG were collected from six study sites
- Among ALDFG, ropes make up 17%, net 33% and lines 50% found on beaches.

- The south coast of the SW Peninsula had 5.33 times more items related to the ALDFG than the north coast.

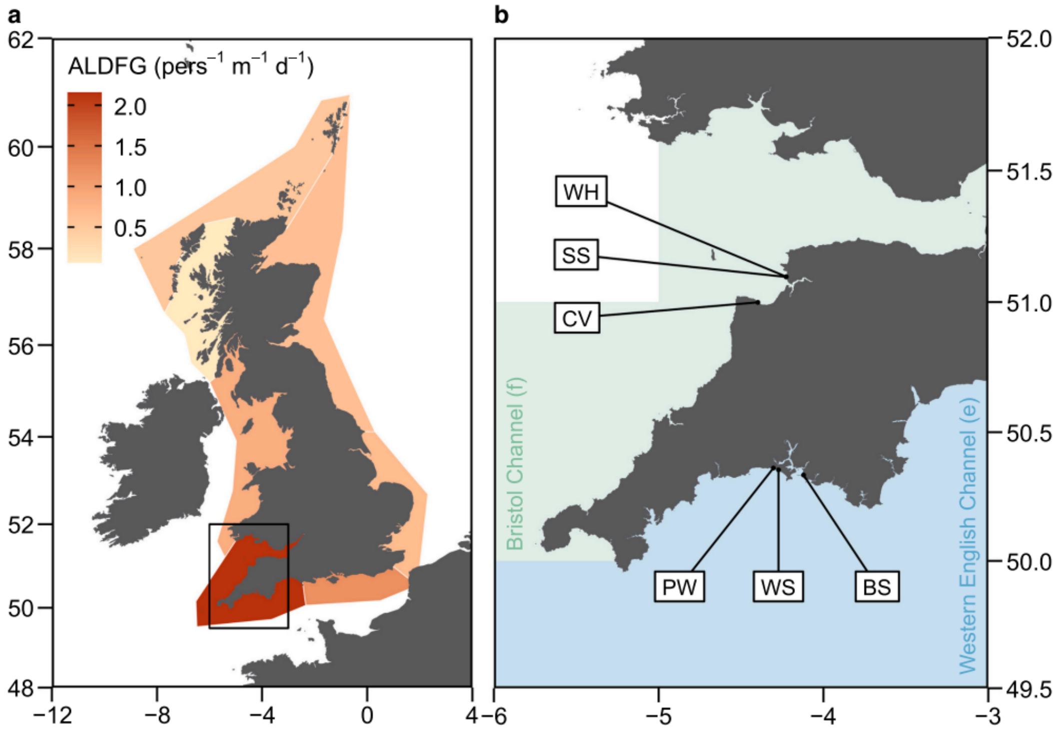


Figure 5: ALDFG distribution around Great Britain. Whitehall (WH) , Saunton Sands(SS), Clovelly (CV), Portwrinkle(PW),Whitsand (WS), Bovisand (BS) (Seamus Wright, et al., 2021)

The study also analysed the filament length, change in filament diameter and potential micro plastics per meter of south coast. All the respective data is justifies based on the fact that south coast is higher fishing activity region as compared to north coast. (Seamus Wright, et al., 2021)

Still there are numerous gaps in the current research on marine litter LCA on recyclability. My focus will be to develop the LCA model on recyclability of the ALDFG for the further research. Hopefully this research will fill in the gap to some extent and further improve iteration of the model can be developed subsequently.

Proposed Methodology

The conduct LCA research following methodology is proposed.

1. Defining System Boundaries

System boundaries will be defined as per the scope of the project. A layout of the system bounders is provided below, and further refinement is required:

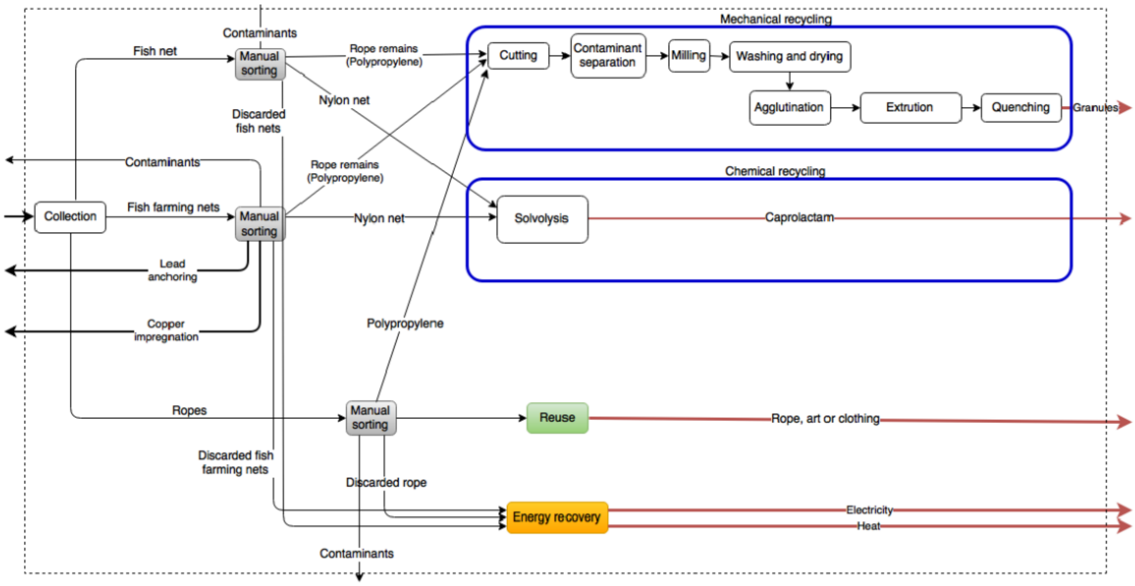
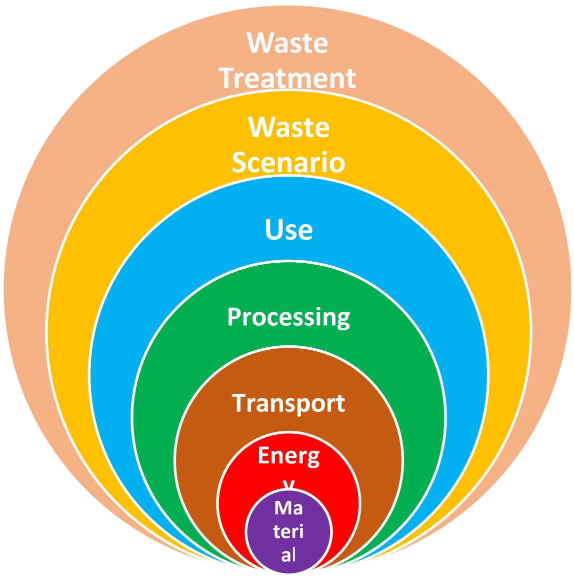


Figure 6 System Boundaries for the LCA

The system boundaries include the energy consumption in collection, sorting, bailing process, transportation and chemical recycling of the fishing net.

2. Designing the Matrix

Matrix will be designed based on the available scenarios and the each stage will have input based on the qualified functional unit. An unrefined matrix is provided below



3. Data Collection

Primary Data will be collected and refined form multiple sites in Southwest. Data collected will be refined and homogenised. Data will be mostly quantitative.

Homogenisation of the data set will be done based on tkm (tonne per kilometre) and this will be subsequently used as input functional unit. Table 1 is the first set of data , that has been analysed and used into the SimaPro LCA .

As shown below the material and data was collected from the 9 sites and transported to Exeter Material Recovery Centre.

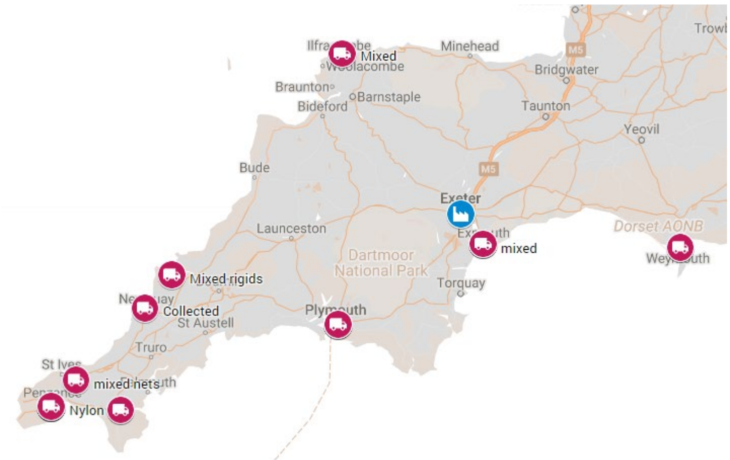


Figure 7 Google Map showing the Marine Litter Collection points in red and Exeter Material Recovery Centre in Blue colour.

After performing certain primary separation functions and separating the nylon fishing net from the other marine litter , the material is converted into bales of nylon to reduce the volume and make it more economical to transport. The bales are then transported to lorry and shipped to Aquafil Solovenia where the material is recycled.

Figure 8 Route Taken by 14 tonne lorry from Exeter to Slovenia

In UK the fishing activities produced substantial amount of the marine litter. According to a research by Marine Conservation Society (2007), fishing lines, buoys, floats were one of the biggest source of marine litter. The real issue is the management of the ALDFG and requires as suitable and sustainable route for recycling,

Table 1 Data Set of ALDFG fishing gear (Data Collected from MRF Exeter Site):

Ticket Number	Transfer Date	Registration	Waste Weight	Source	Material type	Post Code
BW00035207	06/10/2021 10:19	WA58BLV	1600	Plymouth Harbour	Mixed	PL1 2LR
BW00035264	08/10/2021 9:26	MJ05YMZ	100	Exmouth net guy	Mixed nets & ropes	EX8 1 DU
BW00035277	08/10/2021 14:22	HG53OXC	20	Kayak guy	Rigids (Kayaks)	
BW00035382	14/10/2021 09:45	MJ05YMZ	120	Environment agency	Mixed nets	
BW00035471	19/10/2021 11:46	CV69GLF	340	Ilfracombe harbour	Mixed	EX 34 9EQ
BW00035697	29/10/2021 08:53	WA58BLV	3680	Trevisker GC	Mixed rigids	PL28 8LD
BW00035711	29/10/2021 12:06	WG17OYM	40	West Country moorings	Mixed	
BW00035828	04/11/2021 13:23	DT70HRX	200	Net guy	Mixed nets	
BW00035872	08/11/2021 9:51	GN03OGG	1200	Clean Ocean Sailing	Mixed	TR12 6UG
BW00035873	08/11/2021 9:55	GN03OGG	1000	Clean Ocean Sailing	Mixed	TR12 6UG
BW00035965	10/11/2021 13:51	CV69GLF	1320	Newquay, GhostNB, Heligan, Par	Collected	TR7 1HR
BW00036503	01/12/2021 10:56	WA20ZPC	60	Hayle	mixed nets	TR27 4BL
BW00036638	07/12/2021 14:30	WA58BLV	2900	Newlyn	Nylon	TR18 5HW
BW00036689	09/12/2021 10:01	CV69GLF	1320	Turn the tide	mixed	
BW00036761	14/12/2021 08:33	WA58BLV	1080	Meva	mixed nets	
BW00036833	16/12/2021 09:48	CV69GLF	360	Exmouth	mixed	EX8 1DU
BW00036888	20/12/2021 11:30	WU62OYK	2780	Dorset	mixed	DT4 8BG
BW00036929	21/12/2021 11:36	GV06XJL	80	Supplier delivered	rigids	
BW00037046	29/12/2021 09:15	CV69GLF	340	Exmouth	mixed	EX8 1DU
BW00037092	31/12/2021 07:57	CV69GLF	100	Turn the tide	mixed	
BW00037218	07/01/2022 7:14	WA58BLV	2820	Newlyn	Nylon	TR18 5HW
BW00037477	17/01/2022 14:46	WA58BLV	2740	Newlyn	Nylon	TR18 5HW
BW00037623	24/01/2022 10:36	WA58BLV	2000	Plymouth	Mixed	PL1 2LR
BW00038070	16/02/2022 07:31	WA58BLV	3480	Newlyn	Nylon	TR18 5HW
BW00038133	17/02/2022 14:51	WA58BLV	2340	Dorset	Mixed	DT4 8BG
BW00038478	09/03/2022 7:53	WA58BLV	2720	Newlyn	Mixed	TR18 5HW
BW00038658	17/03/2022 00:00	WA58BLV	700	Plymouth	Mixed	PL1 2LR
BW00038906	29/03/2022 14:56	WA58BLV	3160	Newlyn	Mixed	TR18 5HW

For the first Data set the tkm will be calculated shown in figure 5. Few data set has been excluded based on the multiple factors such as unknown location, unknown material, and unknown mode of transportation:

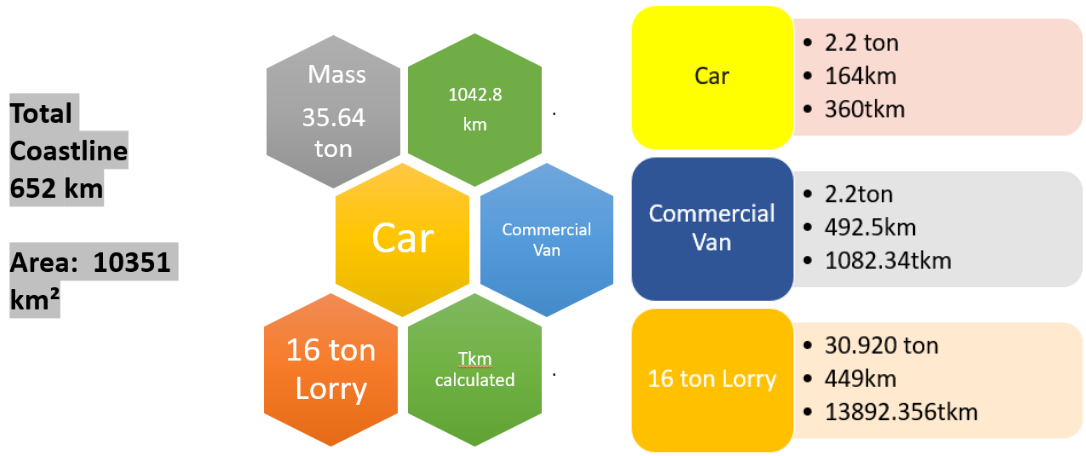


Figure 9: Data refinement and calculating the tkm with respect to different modes of transportation

Data was normalised based on multiple factors i.e. Geography, time, completeness, technology. Verification etc.. After the first iteration the baseline will be created and will be input in to the SimaPro for iteration II.

4. Database and Software Utilisation

Initially the software used was SimaPro with updated version of the Ecoinvent database. Data used will be in the system form as it will link with the stages of the process. Even though it slow the processing down on SimaPro. Also Chemical Abstract Service (CAS) registry will be used

5. LCA Flowchart

A LCA flowchart will be produced and the hotspot will be analysed based on further research. Below the SimaPro flowchart is attached in figure6. The LCA is conducted on the material collected from multiple sites, sorted, speared in the PA66. Out of 35.64 tonne of material collected, 54 bales of combine mass of 13.88 tonne was transported to 1797 km further to Aquafil site in Slovenia for processing.

Simapro Methodology

Life Cycle Assessment was conducted using the Eco invent 3.8 database. The ReCipe 2016 midpoint analytical method was employed for the obtaining the end results for the Life Cycle Assessment . This method was selected due to following reasons.

- Total environmental load expressed as a single score.
- In that score, characterization, damage assessment, normalization and weighting are combined.

The LCI results and midpoint impact categories are linked though the damage pathways to provide three endpoint areas as shown in figure below :

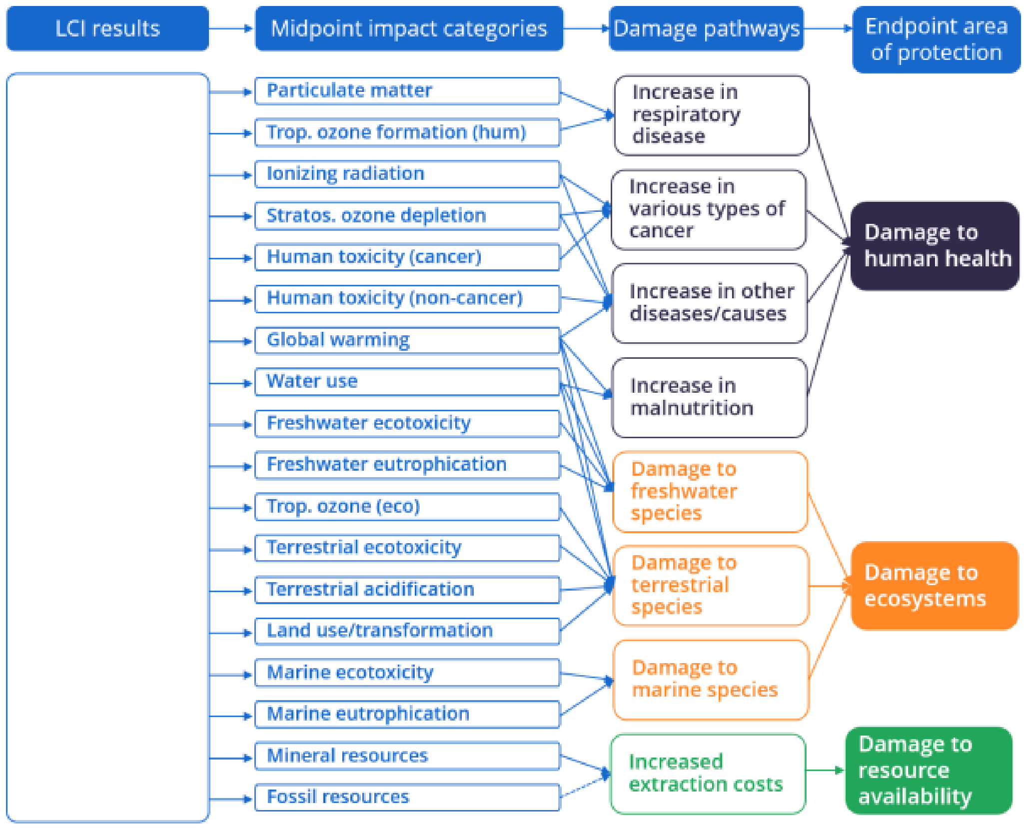


Figure 10 LCI results linked to 18 Midpoint categories, 8 Damage pathways and 3 Endpoint areas of protection . (Simapro, 2022)

ReCiPe Characterization

In the ReCiPe midpoint characterization , the indicator results of the midpoint impact were linked to the intervention and the magnitude of the intervention by equation provided below :

$$I_m = \sum_{i=0}^{n} Q_{mi} mi$$

$m_i = Magnitude\ of\ intervention\ i$

$Q_{mi} = Factor\ that\ connects\ intervention\ i\ with\ midpoint\ catagory\ m$

$I_m = Indicator\ result\ of\ the\ midpoint\ impact$

The exergy (amount of the work/ entropy) characterization factor for the 112 different resources were included in the calculation.

$$CExD = \sum_i m_i * Ex_{(ch),i} + \sum_j \eta_j * r_{ex-e(k,p,n.r.t),j}$$

Where

$CExD = cumulative\ exergy\ demand\ per\ unit\ of\ product\ pr\ process\ (MJ - eq)$

$m_i = mass\ of\ material\ resource\ i\ (kg)$

$Ex_{(ch),i} = Exergy\ per\ kg\ of\ substance\ i\ (MJ - eq/kg)$

$\eta_j = amount\ of\ enrgy\ from\ energy\ carrier\ j (MJ)$

$r_{ex-e(k,p,n.r.t),j} = exergy\ to\ energy\ ratio\ of\ energy\ carrier\ j \left(MJ - \frac{eq}{MJ}\right)$

$ch = chemical$

$k = kinetic$

$p = potential$

$n = nuclear$

$r = radiative$

$t = thermal$

6. Stages of LCA

While conducting the LCA following stages will be included

Stage 1: The goal and scope definition – aims and objectives of the study

Stage 2: Life Cycle Inventory analysis (LCI) – compilation and quantification of inputs and outputs for a product through its life cycle.

Stage 3) Life Cycle Impact Assessment (LCIA) - understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product,

Stage 4) Life Cycle Interpretation – the findings of the LCI or LCIA or both are evaluated in relation to the defined goal and scope in order to reach conclusions and recommendations.

Results:

Initial simulation was carried out on the Simapro software to produce 1 kg of virgin Nylon for InDiGo project. The results of the simulation are shown below in figure 11: According to the data obtained by utilising the ReCiPe Mid-Point characterization method, the production of the 1 kg virgin nylon resulted in 9.79 kg CO2 equivalent of global warming, 4.08 kg equivalent of terrestrial Eco toxicity along with the fresh water consumption of 96 litres of water

Se	Impact category	Unit	Production of 1 kg of Virgin
☑	Global warming	kg CO2 eq	9.79
☑	Stratospheric ozone depletion	kg CFC11 eq	-1.78E-7
☑	Ionizing radiation	kBq Co-60 eq	0.0142
☑	Ozone formation, Human health	kg NOx eq	0.016
☑	Fine particulate matter formation	kg PM2.5 eq	-0.0373
☑	Ozone formation, Terrestrial ecosy	kg NOx eq	0.0166
☑	Terrestrial acidification	kg SO2 eq	-0.132
☑	Freshwater eutrophication	kg P eq	-0.000574
☑	Marine eutrophication	kg N eq	0.000314
☑	Terrestrial ecotoxicity	kg 1,4-DCB	4.08
☑	Freshwater ecotoxicity	kg 1,4-DCB	-0.82
☑	Marine ecotoxicity	kg 1,4-DCB	-1.02
☑	Human carcinogenic toxicity	kg 1,4-DCB	-0.0564
☑	Human non-carcinogenic toxicity	kg 1,4-DCB	-8.5
☑	Land use	m2a crop eq	0.0844
☑	Mineral resource scarcity	kg Cu eq	-0.423
☑	Fossil resource scarcity	kg oil eq	1.91
☑	Water consumption	m3	0.096

Figure 11 Impact of Gill Net on Global warming

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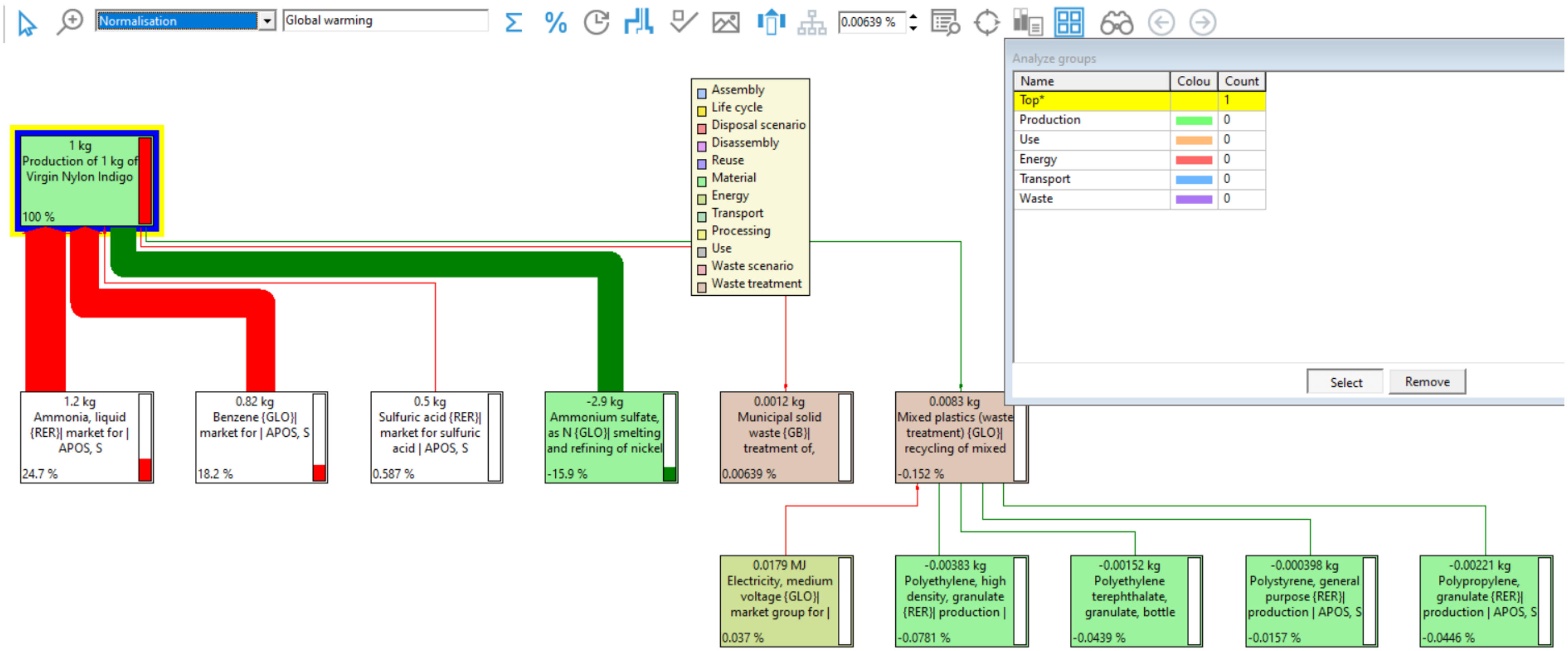

Figure 12 Environmental Impact: Production of 1kg Virgin Nylon

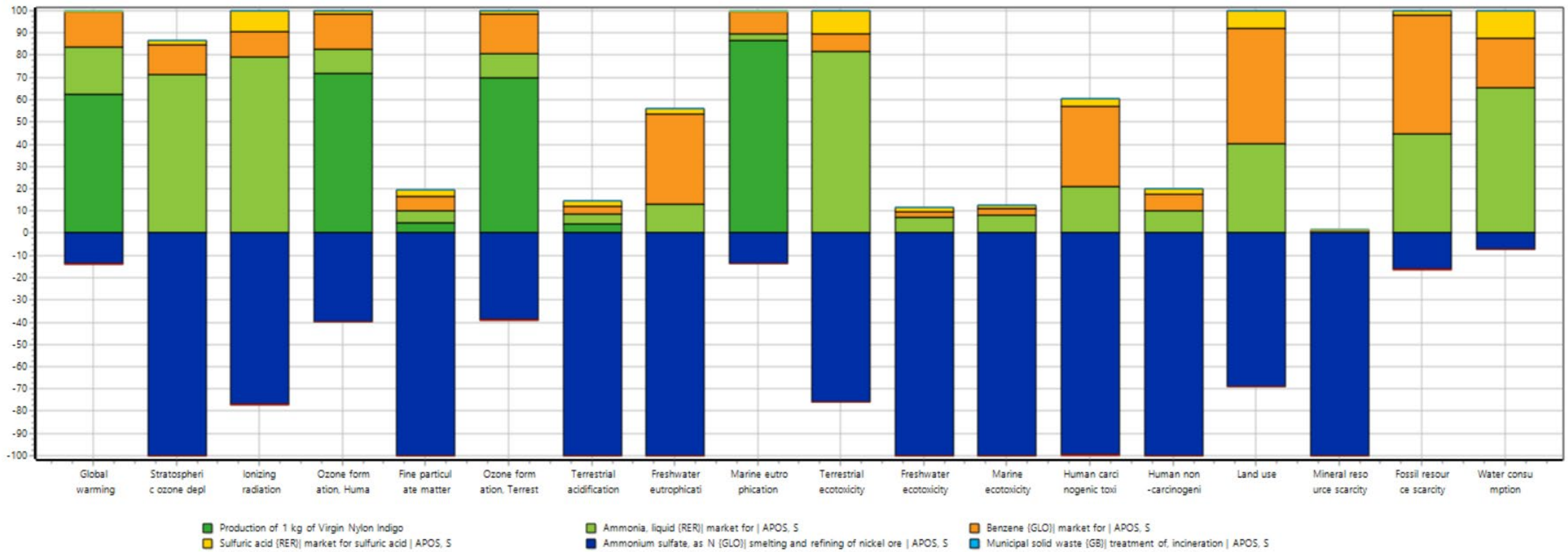

Figure 13 Impact Assessment: 1kg of Virgin Nylon Using ReCiPe 2016 Midpoint Method

Looking at the figure 10 for impact categories, production of 1 kg of Nylon causes 625 of global warming impact , impact on ozone formation terrestrial is 70%, terrestrial acidification impact id 2%, and marine Eutrophication impact is 88%.

Iteration 2

The Simulation was conducted again by utilising and imputing the available data from table 1 . The results were very promising and shows CO2 saving of 91.5 %.

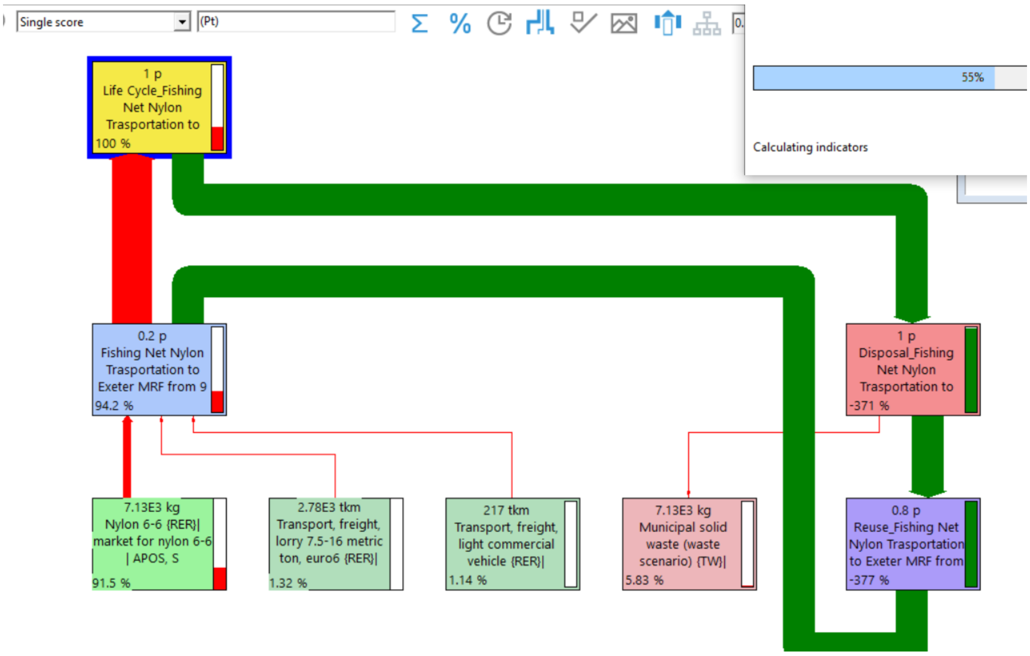

Figure 14 Scenario showing the 91.5% reduction in CO2 emissions.

The result were further refined by considering the assembly scenario of 95% i.e.5% of the waste collected in the scenario is not recycled or reused . The refined results show the

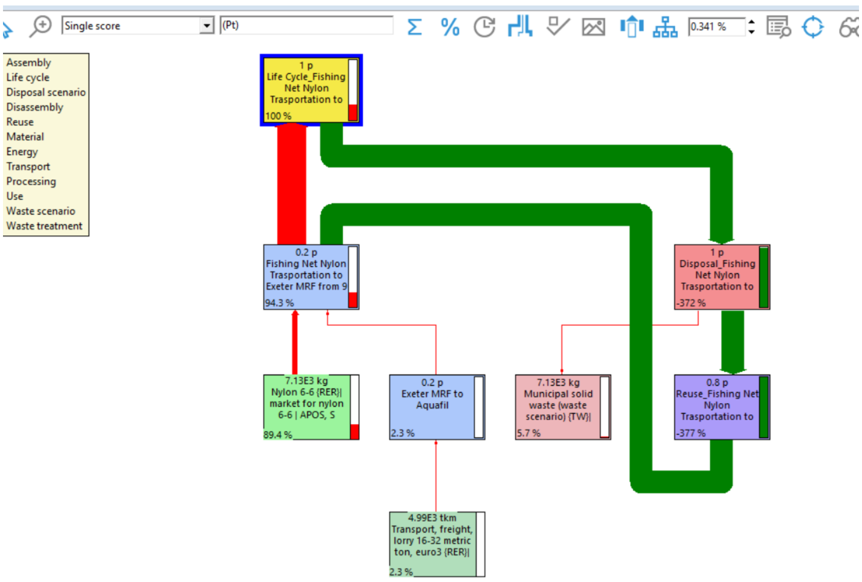

Figure 15 Scenario 5% waste: Simulation Showing 89.4% saving in CO2 emission

When looking at the Impact assessment, it was found that Reuse fishing net has -19.5kpt effect on Human health, ecosystem quality was improved by 7.19kpt and resource utilisation was down by 11.8 kpt on a single pint

Limitation of the project:

The new material chosen for the manufacturing of the biodegradable net was a combination of the PBAT. Though the material was biodegradable, not enough data was available to carry out the viable LCA of the new fishing gear .

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