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Digital Product Passport in the textile sector

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Digital Product Passport in the textile sector

This study focuses on the Digital Product Passport (DPP) within the textile industry, framed within the EU's strategy for sustainable and circular textiles. It examines the potential, needs, benefits, and challenges associated with deploying the DPP for all stakeholders throughout the European textile sector's value chain. The DPP offers benefits to all actors in this complex value chain, including producers, supply chain tiers, regulatory authorities, sorters, recyclers, and consumers. It is crucial to identify where added value can be generated, particularly in terms of traceability, sustainability, and business strategy. This research is grounded in a review of regulatory texts, scientific literature, existing initiatives, and proposes a generic model of the DPP for the textile sector. Drawing on a survey of over 80 stakeholders, it gathers essential insights and outlines a three-phase deployment scenario with policy options aimed at fostering a circular economy to minimize the sector's overall footprint.

AUTHORS

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Executive summary

This research aligns with the necessary transition of the textile and fashion sector, aiming to stimulate and accelerate the dynamics of circularity and sustainability. The twin transition (ecological and digital) that the EU encourages can be facilitated by applying new information and communication technologies (NICTs).

The textile and fashion industries are facing a triple crisis that spans ecological, economic, and social realms. To address these challenges and meet consumer demands for transparency, this study discusses about the deployment of Digital Product Passport (DPP) at the European level. The goal is to enhance traceability, circularity, and transparency throughout the entire lifecycle of fashion products. By offering detailed information about each product throughout its lifecycle, DPP can promote sustainability and circular practices.

However, the effective implementation of DPP requires a comprehensive understanding of the complexities within the textile supply chain and the full digitization of industry processes. The garment supply chain operates as a multifaceted network with numerous tiers and a buyer-driven production approach. Retailers focus on marketing and selling apparel, while manufacturing involves a diverse array of entities worldwide, each with unique functional capacities. This diversity in capabilities leads to varying sourcing models, which, in turn, complicates traceability for buyers. Consequently, there is a lack of comprehensive information for consumers to make informed purchasing decisions and for the better sorting of products and optimization of materials at the end of their use life.

To develop a possible generic model of DPP for the textile sector, we employed a methodology based on a bottom-up approach called Grounded Theory. This approach integrates data from various sources, ensuring a comprehensive understanding of the complexities involved in creating an effective DPP for the textile industry. Our aim is to define the concept of DPP and to analyse the information required at each stage of the product lifecycle, identifying the challenges and stakeholders involved.

We integrated data from diverse sources to inform our approach, including transparency initiatives within the fashion sector, insights from testimonials and experiences within the textile industry, and the regulatory and scientific framework surrounding DPP. We define the DPP as following: **DPP is the combination of an identifier, the granularity of which can vary throughout the lifecycle (from a batch to a single product), and data characterising the product, processes and stakeholders, collected and used by all the stakeholders involved in the circularity process.**

We identified **11 categories of possible DPP aims and contributions**: Informing consumers, Informing companies, Managing resource flows, Promoting circularity, Sustainability indicators management, Market surveillance, Track and trace after sales, Compliance with regulations, Product end-of-life management, Commercial competitive edge, Product authentication.

We have identified **8 categories of stakeholders** (people or companies who could be involved or interested by using a DPP): Supply chain companies, Brands, Retailers, Authorities, Certification and assessment companies, Circularity Operators, Media, Consumers.

Once the products have been identified by reference ('unique' or 'batch') and brand, we identified **16 categories of information** and concepts that could be contained in the DPP: Product description, Composition, Supply Chain, Transportation, Documentation, Environmental impact, Social impact, Impact on animals, Circularity, Health impact, Information on the brand, Communication/identification media, Granularity, Quantity, Costs, Tracking and tracing after sales, Customer feedback.

Following our research work, we defined a first version of a **generic model of DPP** based on the lifecycle model representation to include all the information previously mentioned.

We organized a consultation and collected feedback about this model during an online survey composed of 10 questions. The survey involved 81 stakeholders and experts in textile sectors from almost 20 countries in Europe. They validated the interest of most of the information concerning **Supply chain** and **Finished products** with a doubt concerning the identification of transformation and **transportation** companies. Costs are not considered as an information to include for a majority of respondents. Regarding **distribution stage**, there is less consensus about information to be included apart from location and second-hand criteria. Concerning **Usage** stage, customer identification is not to be included as well. For the **end of life,** all information mentioned should be included.

Based on the results of the survey, we propose a step-by-step scenario and policy options for the deployment of the DPP in 3 phases:

Phase 1. **Deployment of a "minimal & simplified DPP" for textile at short-term horizon 2027** This "minimal & simplified DPP" proposal is mainly based on dissemination of mandatory information completed by additional information that will be useful for lifecycle analysis.

Phase 2. **Deployment of an "advanced DPP" for textile at mid-term horizon 2030** This **"advanced DPP"** could progressively be extended to other stakeholders and more information are collected all along the life cycle, based on the learnings of the first phase and return on experimentation.

Phase 3. **Deployment of a "full circular DPP" for textile at long-term horizon 2033** During this last phase, a **"full circular DPP"** can be fully deployed to promote circularity in the textile sector.

The main objectives of the policy options concerning DPP are:

- Enhancing transparency throughout the entire value chain
- Streamlining and reducing the consumption of raw materials.
- Promoting the creation of durable products
- Minimizing waste generation
- Fostering product differentiation based on quality, thereby facilitating competition against the fast-fashion actors.

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1. Introduction

This study focuses on the Digital Product Passport (DPP) in the textile industry in the context of the EU strategy for sustainable and circular textiles.

The fashion and textile industry faces significant environmental, social and economic challenges. This research is in line with the necessary transition of the fashion sector, which aims to stimulate and accelerate the dynamics of circularity and sustainability. The twin transition (ecological and digital) that the EU is encouraging is possible by applying new information and communication technologies (NICT).

This document looks at the development of an ambitious NICT system: **the Digital Product Passport (DPP) for the textile and fashion industry**. This system will not only inform consumers about the environmental impact of their purchases (European Commission, 2022) but also act as a "circularity information system" ("CIRPASS", 2023). The potential of this tool to promote a circular economy is significant, especially if it is applied to all products in the industry. It could support a transition of the textile industry from a linear to a circular economic model. We want to identify **the potential of DPP in the textile industry**.

As the DPP in the fashion and textiles sector is an innovative scheme, to understand it properly we need to explore a method that allows rigorous analysis of the 360° data collected from a wide range of sources, including experiments in the sector and other industries, scientific literature, current regulations and expert interviews.

In the first part of this study, we present our methodology based on the *Grounded Theory*. It enables us to understand the DPP better: **to define it, to identify its objectives, the stakeholders involved and the information it gathers,** and to create a universal data model for a DPP that will promote the circularity of products in the fashion sector.

Once this information has been defined, we will compare the results with a sample of potential users. The aim will be to **determine which information should be prioritised according to use, and to give priority to essential data, considering the difficulties involved in collecting it.** This expert survey, conducted using the Delphi-Reignier methodology, will enable us to identify user profiles and categories of information and to prioritise them using a colour code.

In the final section of this paper, we will **develop recommendations for policy options** relating to DPP in the textile sector. These recommendations will help to understand the impact assessment, the advantages, the disadvantages, and the associated risks.

2. Why a DPP for the textile and fashion industry?

2.1. The different challenge for the textile industry

Nowadays as any industry, the textile and fashion sectors are also facing a triple challenge:

- **an ecological challenge:**

The industry is known to be wasteful and polluting using non-renewable resources, intense water, and land uses. With the fast-fashion emergence, the production of clothing is now the twice of amount before the year 2000 (Ellen MacArthur Foundation, 2017). The production of unrecyclable low-quality apparel of fast fashion has a negative impact on natural resources; stresses the importance of supporting the EU textile industry in moving away from fast fashion and towards the promotion of a sustainable manufacturing model (Ehler, C. et al. 2023).

- **an economical challenge:**

The projections for the industry with "business as usual" were a decline due to raw material shortage, energy, water prices and labor costs growth (Global Fashion Agenda and Boston Consulting Group, 2017). This tendency has been accelerated drastically with the Covid 19 supply and retail interruptions (Anner, 2020). In 2023, many French fashion retails like Camaïeu, Go Sport, Pimkie, Kookaï… recently went bankrupt or are undergoing judicial reorganisation.

- **a social challenge:**

The recent industry dramas (Rana Plaza, Uighur cotton forced production…) have been highlighted the worst practises of the textile production. The UN Guiding Principles on Business and Human Rights to respect human rights, including paying a living wage, to workers in supply chains, are not the norms according to the organization Labor behind the label.

2.2. The need of transparency of textile and fashion sector

Since the COVID 19 crisis, some interesting trends and consumers behaviours have been recently observed:

- "**Chosen de-consumption" or lack of money:** 60% of consumers spent less on fashion during crisis and half of them expect to continue (Granskog *et al.*, 2020).

- **Second-hand clothing** will overtake fast fashion market by 2028 (Thred up, 2019)

- **Online purchases** for clothing represent 57% in UK, 26,4% in France 22,7% in Spain, 21% in Italy (Kantar world panel, 2021).

- 52% of millennials always do **research background information before buying textile**, 45% for GenZ and 41% for Baby boomers (The Business of Fashion and McKinsey & Company, 2019).

To understand the need of DPP, we conducted prior to this study a **fieldwork from 2021 to 2023** (Ospital *et al.*, 2023) to analyse the current practices concerning traceability and transparency in the textile sectors. We selected a representative segment of "engaged companies" of the industry composed of the 54 brands that signed the **Fashion Pact**[1]. For each of those brands, and for all of

[1] The Fashion Pact https://www.thefashionpact.org/ began as a call to action to fashion CEOs to rally and build a collective to address the industry's environmental impacts. The pact was then presented to the Heads of State at the G7 Summit in Biarritz in 2019. In 2024, The Fashion Pact is gathering more than 160 brands in 17 countries.

them (example of figure 1), we calculated the percentage of transparency based on the information available and collected from both source in shop and online (website) concerning:

- **product transparency (in shops or on website):** we noted whether the following elements were mentioned for All/Some/None of the products: The origin of raw materials, The country of manufacture, Visibility of the label (yes/no), The name of the supplier or factory, Material certificati+on, Presence of an environmental impact rating (carbon footprint, water consumption or environmental display), If technological support was available in the store (mobile application, blockchain, connected screen, QR code…)
- **Brand's transparency:** we noted whether the following elements were mentioned about the brand: Corporate Sustainability Reporting (CSR) report, extra-financial performance declaration, Publication of the list of suppliers, Environmental and social commitments…
- **the Fashion Revolution Transparency index:** for each of the brand, we noted the Transparency index calculated by the Fashion Revolution initiative (https://www.fashionrevolution.org/)

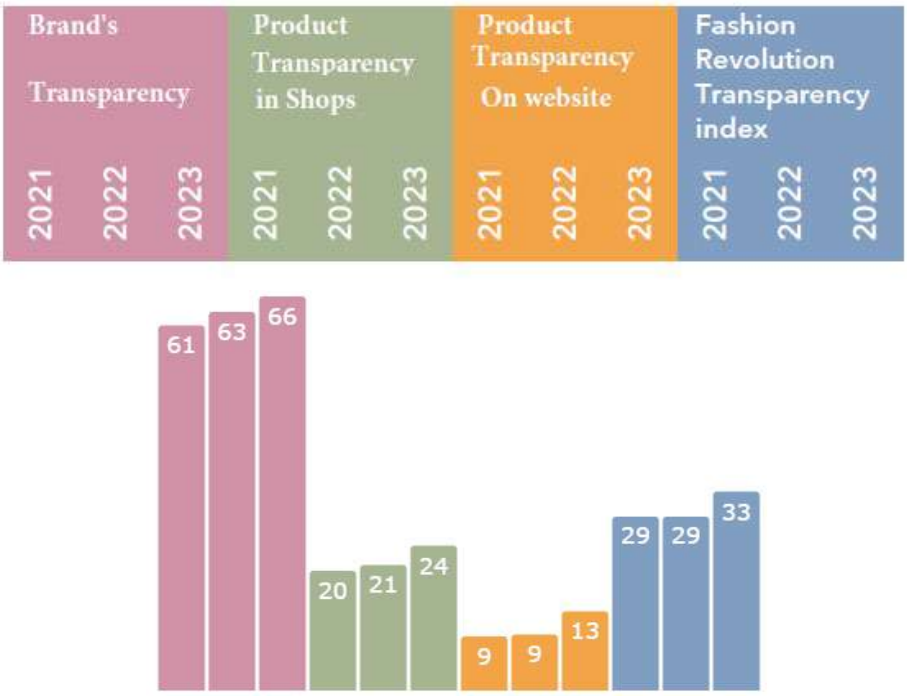


Figure 1 – Percentage of transparency for all the 54 brands of the Fashion Pact (source: Ospital P. et al. 2022)

Overall, the main findings of this fieldwork shows that:

- **Transparency in global** is increasing slowly each year from 2021 to 2023.

- **Regarding Brand's transparency,** our study reveals that 83% of the companies produced a CSR report (Extra-Financial Performance Statement) and 98% communicated their social and environmental commitments. For 30%, the list of their

first-tier suppliers was published, however without linking this information to the products.

- **Regarding product transparency,** very few traceability information is available online or in shops concerning textile products. For 93% of brands, the most accurate traceability information attached on product (in store) is the country of manufacture (only 17% online).

- The most transparent brands are **generally using information and communication technology (mobile application, QR Code…) to disclose product information.**

This fieldwork shows that the current brand practises could be more stimulated, and the use of **Digital Product Passport** could enable **more transparency** and encourage **more sustainable uses and circularity** (repair, maintenance, rental, resale, return, recycling…).

The results of this previous work highlights that the challenge with the DPP is to fill the gap and **go beyond from "Brand Transparency" to "Product Transparency"** by information disclosure related to a specific product and its manufacturing process and not only at the company level. But this challenge needs to understand the complexity of the textile supply chain.

2.3. The complexity of the traceability of the textile products supply chain

The textile garment supply chain is a very complex multi-actors buyer-driven production chain (see figure 2). The stakeholders are grouped vertically by level from raw material production (Level 4) to sales (Level 0).

- **At Level 4,** manufacturers (tiers 4) produce raw materials: e.g. farms grow fibers such as cotton or wool, petrochemical industries produce synthetic fibers, or recycled fibers.
- **At Level 3,** factories (tiers 3) process raw materials into yarn. This level includes cleaning steps such as ginning cotton or washing wool and spinning mills.
- **At Level 2,** factories (tiers 2) transform yarn into fabric by weaving or knitting.
- **At Level 1,** manufacturers (tiers 1) cut, sew, and assemble garments.
- **At Level 0,** the brands orders production and are in charge of retail.

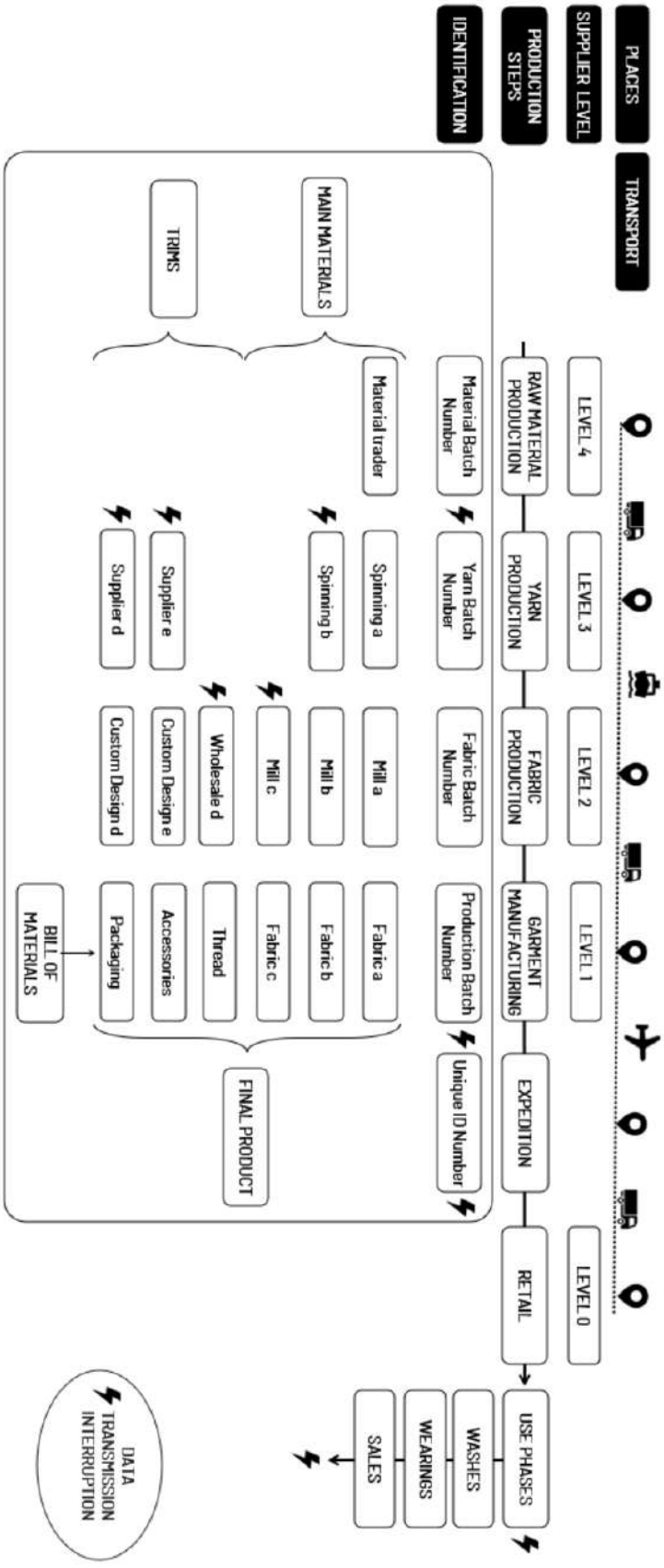


Figure 2 – Generic product traceability process (proposed by authors)

As consequences, this is complex to track and trace the total lifecycle of textile products and simple product identification (like a barcode) is not enough to differentiate same products but with different processes of production (see example in figure 3).

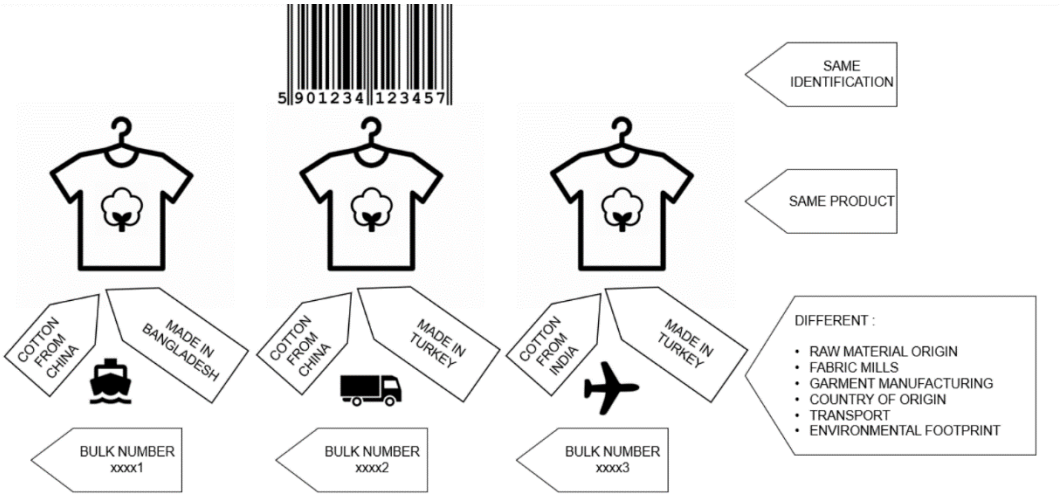


Figure 3 – example of information on similar T-shirts with different origins (proposed by authors)

3. How to design a generic DPP for the textile sector?

3.1. The proposed methodology

The aim of this part is to:

- **Define the methodology to design a generic DPP for the fashion and textile industry and identify its challenges and the stakeholders involved**
- **Define the source of data concerning DPP**

To do this, we use a qualitative research methodology based on the Grounded Theory method[2] (Glaser and Strauss, 1967) that enables us to analyse multiple data sources.

Based on a bottom-up approach, this methodology enables a theory to be developed through the systematic collection and methodical analysis of information. This approach adopts an inductive approach, unlike the hypothetico-deductive method. It involves the collection of qualitative data and the analysis of repetitions with a view to coding. The progressive definition of a model is achieved **through successive and simultaneous coding.**

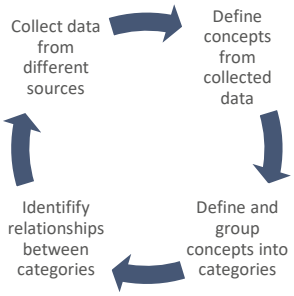


Figure 4 – Grounded Theory steps (proposed by authors)

Through the various stages of analysis and coding, we aim to determine 4 types of information:

- **Definition:** We want to define the concept of DPP for the textile sector.
- **Aims of the DPP:** We analyse the aims and objectives of implementing a DPP in the fashion sector in relation to the different stakeholders involved.
- **Categories of information contained in the DPP:** We examine the types of information that will be included in a Digital Product Passport for optimal use.
- **DPP stakeholders:** At each stage of the analysis, we define which people or companies have an interest in the use of a DPP.

3.2. The sources of data

Our method for the definition of the DPP through with a GT methodology includes data from multiple sources.

3.2.1. Transparency initiatives in the fashion sector:

Prior to this study, we analysed the **product information of committed brands**: Loom, Asphalte, Asket, Nudie Jeans... and we studied 13 **information solutions** deployed by brands and/or technology provider in 2022: H&M, Etam, Made in Green by Oeko-tex , Sorga, TBS & Fairly Made, Residus & Trust Trace, Eram & e-SCM, Gabriela Hearst & EON Circular.ID, Myrka Studios & Circularity

[2] Grounded theory is a qualitative method that enables to study a particular phenomenon or process and discover new theories that are based on the collection and analysis of real-world data. The process of data collection, data analysis, and theory development happen in an iterative process. Iterative data collection and analysis occurs until theoretical saturation is reached, the point at which additional data adds no additional insight into the new theory.

ID, Hopaal & Clear Fashion, Reformation & Fibertrace, Saint James & Crystalchain, Aigle & Tilkal Footbridge.

Technology Provider	Brand	Description	Composition	Supply Chain	Transport	Brand	Documentation	Env Impact	Circularity	Data carrier
Fairly Made	TBS	x	x	x	x		x	x	x	x
Made in Green by Oeko-tex	Demo	x	x	x	x	x	x			x
Trust Trace	Residus	x	x	x	x	x	x	x	x	x
Sorga	Demo	x	x	x	x	x				x
e-SCM	Eram	x	x	x	x	x		x		x
EON Circular.ID	Gabriela Hearst	x	x	x	x			x	x	x
Circularity ID	Myrka Studios	x	x	x	x	x	x	x	x	x
Clear Fashion	Hopaal	x	x	x	x	x		x		x
Fibertrace	Reformation	x	x	x	x	x		x		x
	H&M	x	x	x	x	x				x
	Etam	x	x	x	x	x	x			x
Crystalchain	Saint James	x	x	x	x	x	x			x
Tilkal Footbridge	Aigle	x	x	x	x	x	x	x		x

Table 1 – Analysis of transparency initiatives (proposed by authors)

3.2.2. Testimonies and experiences from the textile sector

Prior to this study, we organised a **DPP workshop** during the BALI Chair's annual event in October 2022. It brought together 20 people from a wide range of backgrounds: product developers, CSR directors, textile quality experts, R&D directors, purchasing managers, marketing and communications leaders, directors of companies specialised in CSR and traceability, sustainable fashion consultants, etc.

We gathered the **testimonies of expert interviews**: Potential users of the DPP (companies in the textile sector: design, quality, customs, CSR, certification, trusted third parties, after-sales, second-hand, collector-sorter). These 13 semi-directed interviews addressed 3 points: a presentation of the professional and his activity, an identification of the information currently available and a projection of the information that could be relevant in the DPP.

3.2.3. The regulatory context of the DPP

We analysed the information **in the regulatory context in Europe** concerning product transparency. We studied 16 texts from the European institutions and the current regulations.

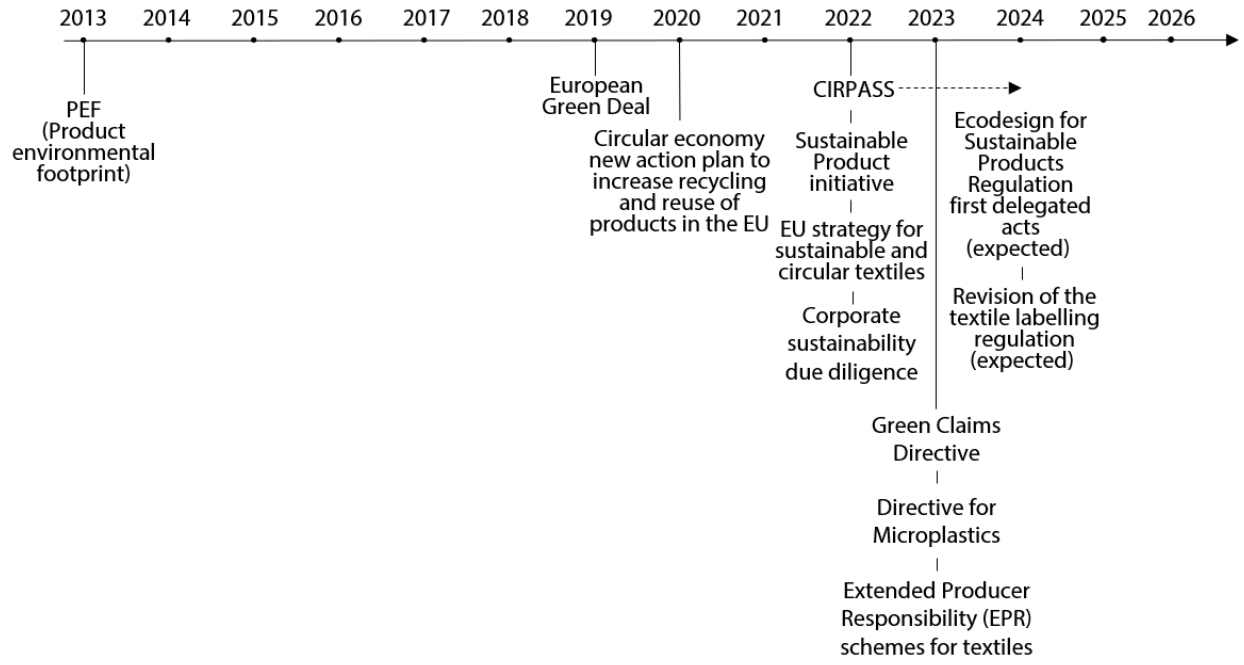


Figure 5 – Evolution of regulation in Europe (proposed by authors)

The requirement to disclose more information about products is becoming clearer due to the implementation of European regulations, with the Digital Product Passport (DPP) providing information about products' environmental sustainability. The European Green Deal, presented in 2019, is a roadmap outlining a series of actions to guide the European Union towards ecological transition, with the goal of achieving climate neutrality by 2050. Its strategy aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient, and competitive economy.

One of its policy frameworks, the Circular Economy Action Plan, was adopted in 2020 to increase the recycling and reuse of products in the EU. It includes significant actions such as a proposal for a new Ecodesign for Sustainable Products Regulation (ESPR), with the first delegated acts expected in 2024. In 2022, the European Commission adopted an EU strategy for sustainable and circular textiles, and a revision of the textile labelling regulation is expected in 2024. This revision will introduce specifications for the physical and digital labelling of textiles, including sustainability and circularity parameters based on requirements under the ESPR.

Other projects not directly linked to the DPP involve measuring the impact of products to design more sustainable products. The Product Environmental Footprint (PEF), started in 2013, aims to create a European science-based, standardized framework for measuring the environmental impact of products and services, based on 16 impact indicators.

As the impact of value chains extends beyond European borders, European companies that order products from abroad also bear responsibility. In 2022, the Commission proposed a Directive on Corporate Sustainability Due Diligence to promote sustainable and responsible corporate conduct. The directive integrates human rights and environmental concerns into companies' operations and corporate governance.

In 2022, CIRPASS (Collaborative Initiative for a Standards-based Digital Product Passport for Stakeholder-Specific Sharing of Product Data for a Circular Economy) began its first 18-month phase following the ESPR proposal. The aim of this initiative is to create a clear concept of the DPP by defining a cross-sector product data model that promotes the circular economy. Initially targeting three sectors: electronics, batteries, and textiles, the consortium comprises 30 partners, including industrial, digital, international standardization, regulatory organizations, and NGOs from across

Europe. Its objective is to standardize data exchanges, develop use cases, and create roadmaps for piloting and deploying the DPP for circularity and sustainability.

3.2.4. Scientific approach with a systematic literature review concerning DPP

To complete this previous work, we made a **Systematic literature review** that have been updated during this study. A search for the expression "digital product passport" OR "product passport" OR "electronic product passport" OR "passeport numérique des produits" on Google scholar, Scopus, Web of science, Science Direct, on 30 January 2024. (Figure 6). With a first selection, we identified 128 articles from international peer-reviewed journals that mention the DPP. We then analysed 41 of these articles that developed the concept of the DPP for a more in-depth study. Additionally, we added a cited article that is dedicated to DPP (Stratmann et al., 2023). We have seen a growing interest in the concept of the DPP year on year, with articles dedicated to the DPP that go into more detail.

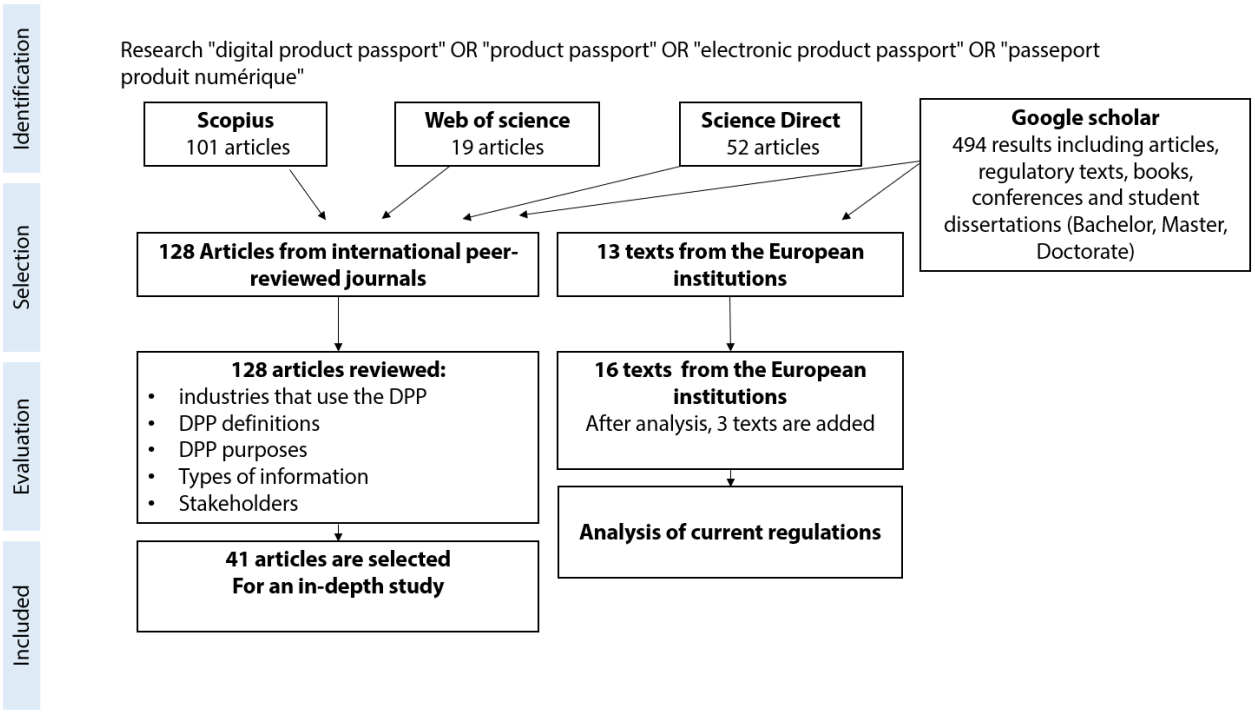


Figure 6 – Systematic review of the literature (proposed by authors)

4. What could be a generic DPP for the textile sector?

4.1. The DPP definition

During our analysis of sources, we searched for a definition of DPP in all different sources. Only the texts from the selection of European institutions and the scientific literature mention a definition of DPP. During the different stages of our study, we noted that the texts referring to a definition of DPP cited that of the German Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection. (Götz et al., 2022; Jansen et al., 2022; The Policy Hub, 2021)

DPP is defined as:
A set of data summarising a product's components, materials, chemical substances and/or information on reparability, replacement parts and proper disposal.

Completed by:
The data originates from all phases of the product life cycle and can be used for various purposes in all these phases (design, manufacture, use, disposal)"
(Berg et al., 2021; Jansen et al., 2022)

We also add the technical description (Marchesi *et al.*, 2022):
A DPP is a combination of (1) a unique product identifier; (2) data collected by different value chain actors related to this unique identifier; and (3) a physical link (tagging) between the product and the data. Note that a final industrial product will often be an assembly of complex parts, each in turn having its DPP.

The definition by Götz et al., inspired by "The proposal for a new Ecodesign for Sustainable Products Regulation (European Commission, 2022)" mentions:

A product-specific data set, which can be electronically accessed through a data carrier to "electronically register, process and share product-related information amongst supply chain businesses, authorities and consumers".

We propose to define the Digital Product Passport as:

DPP is the combination of an identifier, the granularity of which can vary throughout the lifecycle (from a batch to a single product), and data characterising the product, processes and stakeholders, collected and used by all stakeholders involved in the circularity process.

We introduced the nuance of unique or batch identification because we believe the use of unique identification is appropriate mainly for luxury products that are individually manufactured. However, if we are to extend the use of the DPP, it should also be used for lower value products manufactured in larger quantities. The product could be uniquely identified after manufacture or purchase by adding an additional identifier.

On the articles that are dedicated to DPP, we noticed that the reflexions are gaining maturity going into further details and considering **DPP as an improved product lifecycle management (PLM) system** (Portillo-Barco and Charnley, 2015). Koppelaar et al. (2023) defined the conceptual design of a Digital Product Passport based on a circular supply management system. DPP can be summarized as a system that takes product-related data and information (D&I) as input to deliver necessary D&I as output (Ducuing and Reich, 2022).

Considering a more technical scope, (Jansen *et al.*, 2023) build the basis for DPP systems requirements (digital infrastructure for the creation and handling of the DPP).

A universal definition of a **Digital Product Passport Ecosystem (DPPE)** for international policy, industrial and technical communities is elaborated through the systems thinking approach, coupled with systems engineering (King *et al.*, 2023). It synthesises: a definition, goals, limits, and stakeholders of the DPP Ecosystem:

A Digital Product Passport Ecosystem (DPPE) is a socio-technical System of Systems, which is collaboratively owned by the producers, users, and disposers of products.

"A DPPE evidences sustainable business practice and product design values, encourages change in consumer and disposer behaviour, and enables greater collective efforts towards a circular economy by all product stakeholders (resource, producer, user, disposers) and economic stakeholders. It does this by defining the metrics for sustainability and circularity for a given product and across product lifecycles, which requires a whole-life assessment against social and environmental impact performance metrics, then translates these into a comparable set of attributes for uniquely identifiable product designs. The DPPE provides a mechanism for uniquely identifying, describing, and exchanging product and actor data between actors. It also requires evidence to support the claims made by actors and evidence of a clear chain of custody of the product, its parts, and associated events. The DPPE provides the information necessary to identify hazardous, problematic, and valuable materials, maintain the useful life of the product, and how to dispose of it optimally. The DPPE operates within acknowledged constraints (such as commercial interests, data quality and data ownership, a variety of sustainability metrics, privacy concerns, legacy systems, cost, skills, and current capacity) to achieve the sustainability values and goals of societal stakeholders." (King et al., 2023).

The diversity of the different types of Product passports is also considered with a distinction between single-component product and complex product assembly of different components: *each component possesses its own DPP, and all the data contained within these individual DPPs is passed on to the assembled product* (Psarommatis and May, 2024)

In the industries where DPP is experimented, **various terms** exist without a definition: *product passport, material passport, resource passport, recycling passport, cradle-to-cradle passport, etc. Built a definition based on the similarities and conceptual boundaries identified: "a digital interface composing a certified identity of a single identifiable product by accessing the set of life cycle registrations linked to this object in order to yield insight into the sustainability and circularity characteristics, the circular value estimation, and the circular opportunities for both that product and its underlying components and materials."* (Van Capelleveen et al., 2023)
Another article presents a **distinction between material and product passports**: *the aggregation of different material passports will form the digital passport of the final product* (Panza *et al.*, 2022).

4.2. Examples of DPP in other industrial sectors

We observed a variety of industries mentioning the DPP in the literature (see Figure 7). During our literature review, we noticed that most of the articles concerning DPP are generic and not apply to a specific sector (56), and 17 are dedicated to the most advanced sector concerning building with the term *Material or Building passport*. The textile industry is mentioned for 8 references and is detailed only in 3 references (Alves et al., 2023; Ospital et al., 2023; Riemens et al., 2023).

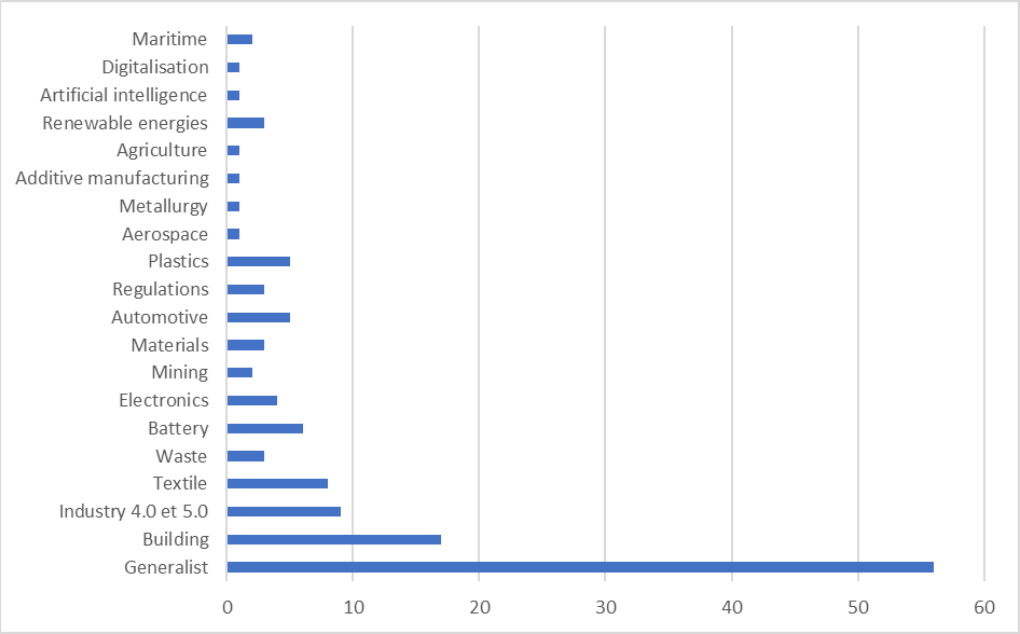


Figure 7 – Number of articles concerning DPP initiatives by different sectors

Relating to the **building sector** some alternatives have been developed since 2012 like Concular[3], Madaster[4] with the purpose of proposing a digital registry for materials and product in a circular perspective. We can also mention the work carried out by the Global Alliance for Buildings and Construction and the United Nations Environment Program[5] about the building passport. This report provides a whole guidelines analysis and implementation process of a digital passport in the construction and real estate domains. Promoted by CUES Foundation[6] and other partners, the CAPSA platform[7] is a digital building passport data platform. The data of building can be extracted from the BIM (Building Information Modelling) and Digital twins' models.

In the **food sector**, Yuka[8] and open-source initiative OpenFoodFacts[9] are used by many customers in different countries in Europe. In this sector, another type of passport emerged like Combinable Crops DGP (Digital Grain Passport). Farmer Connect[10], Koltiva[11] are solutions to track and trace supply chain in this sector. Additional traceability actions have been carried out, in the Agri-food such as molecular markers-based, isothermal amplification-based and DNA metabarcoding. FoodChain ID[12] recently made a partnership to develop an AI-powered platform and launched a Regenerative Agriculture Certification. Within the European Union, the project FishEUTrust[13] mentions the objective of developing a product passport for fisheries. This initiative aims to create instruments that enhance trust through the assurance of quality, safety, and traceability in seafood

[3] https://concular.de/

[4] https://madaster.com/

[5] https://globalabc.org/

[6] https://cuesanalytics.eu/

[7] http://capsa-building.com/

[8] https://yuka.io/

[9] https://fr-en.openfoodfacts.org/

[10] https://www.farmerconnect.com/

[11] https://www.koltiva.com/

[12] https://www.foodchainid.com/

[13] https://fisheutrust.org/

products. This will be achieved through the implementation of intelligent control systems (sensors), metagenomics, genetic biomarkers, isotopic techniques, labelling, product passport, blockchain. All these tools will be consolidated into a unified digital platform.

There are also initiatives in **transport** concerning "battery passport" like Spherity[14], Circulor[15] as the EU Battery Regulation requires proof of sustainable, responsible, and circular sourcing for batteries to access the European market, and mandates that all batteries have a digital battery passport by February 2027.

For a more global and detailed benchmark, the CIRPASS project have done a classification of DDP initiatives[16] with data available for research purposes.

4.3. The different aims and objectives of DPP for textile sector

During our analyse of the different sources in the textile sector, we identified 11 categories of possible DPP aims and contributions:

- **Informing consumers:**

It is one of the main objectives of DPP to provide information about a particular product to the consumers during an online or in-store purchase. This information should enable consumers to make an informed purchase and to explain how to manage the product at its end of life.

- **Informing companies**

Brands and all companies involved in the supply chain, but also customer service, evaluation, investment, media, etc. can access useful information thanks to the DPP by centralising available data from different information systems. The DPP interoperability brings together information from the supply chain that can be used to inform the brand's departments, such as quality, sales teams and also the companies that repair or service the products. Better-informed employees are a source of confidence and can demonstrate their company's transparency.

- **Managing resource flows**

Companies need to know where their supplies come from in order to manage their resources effectively and assess the challenges they face. Transitioning to sustainable sourcing may involve substituting sources of supply, for example switching from conventional cotton to more sustainable alternatives such as organic or recycled cotton. This approach can be encouraged and allow companies to benefit from eco-modulation as part of their extended producer responsibility declaration in France. Measuring the quantities of materials processed is the first step in improving a company's sourcing strategy by being able to assess the progress made. Tracing the origin of raw materials throughout their transformation allows companies to be audited and to justify their declarations.

- **Promoting circularity:**

The main advantage of the DPP is that it goes beyond a simple label. Thanks to the information it contains, this tool has the power to overcome the lack of data associated with a product, an obstacle that has so far hampered the repair, recycling and reuse processes. Thanks to the data contained in the DPP, it will be easier to repair products by identifying them and accessing specific maintenance or repair services to order spare parts. This service would be available to consumers and circularity

[14] https://www.spherity.com/

[15] https://www.circulor.com/

[16] https://cirpassproject.eu/dpp-related-initiatives-dataset/

actors: repairers, second-hand dealers, renters, collectors, sorters and recyclers. In addition, the new functionality-related circular economy models can use the DPP to collect information during the use phase of the product, such as a history of maintenance, repairs, rentals and resales, right up to the end of the product's life.

- **Sustainability indicators management:**

Companies that place products on the market (manufacturers, brands, principals, importers, distributors, marketplaces) can use the data collected for their products to generate performance indicators such as life cycle analysis. As well, they can assess the risks of companies in their supply chain according to geographical, social and environmental criteria. This information can cover the entire life cycle of products if they are tracked after purchase. For example, if they find that products wear out prematurely in the same place, designers can improve the design of the product to make it last longer. On the other hand, if the brand finds that the product is being resold several times, it may want to offer resale or rental services to change the mission of its business by selling fewer products and offering more services, as is the case with companies that distribute household electrical appliances.

- **Market surveillance**

In order to clear the relevant taxes, products manufactured outside the European Union must be declared to customs, which requires an understanding of the nature of the products and their identification. Other countries, such as France, impose more stringent legal requirements. In particular, Article 13 of the AGEC law requires companies to provide customers with information on the environmental impact of the products, also in aggregated form. Penalties are provided for companies that do not systematically make this information available to the authorities.

- **Track and trace after sales**

To date, product traceability has generally been limited to the supply chain up to the point of sale to the consumer. The DPP opens up new horizons by recording events that occur after the initial sale of the product, opening up new sources of data collection. This opens up marketing opportunities such as building customer loyalty through personalised offers and individualised product tracking, providing a better understanding of customer behaviour and usage. This information can be used to improve existing products and create new services, extending the useful life of products.

- **Compliance with regulations**

This aspect is the mirror image of market surveillance on the part of the brands, which must comply with the regulations. In France, Article 13 of the AGEC law requires brands to make certain information available to customers and the authorities in a dematerialised form, which may correspond to a limited DPP. In the future, other regulations may require brands to complete this electronic label with other information.

- **Product end-of-life management**

Producers of waste-generating products have a responsibility to anticipate what will happen to their products at the end of their life. This is the purpose of Extended Producer Responsibility (EPR), which introduces a bonus-malus system based on anticipating product end-of-life through eco-design, through a declaration to the eco-organisation. This information could be included in the DPP together with other information. The DPP could also inform marketers and provide them with indicators of the effective recycling rate of their products and their lifetime if the products can be scanned at the sorting centre.

- **Commercial competitive edge**

One of the challenges of the DPP is to differentiate itself from the competition by offering something different. It provides a superior level of information that can appeal to demanding customers and create a unique customer experience. These brands strive to promote transparency to create a special bond with their customers and to share their values as part of a commercial strategy.

- **Product authentication**

Digital tools that allow consumers to authenticate their products to ensure they are not counterfeit are being developed by companies selling products in the premium and luxury categories. Uniquely identified products can then be authenticated by brands, reducing the risk of fraud, and this marking ensures that their value is retained when they are resold.

4.4. DPP stakeholders

We have identified 8 categories of stakeholders (people or companies who could be involved or interested by using a DPP).

- **Supply chain companies:** including tier 1 to 4 manufacturers, suppliers and processors, their intermediaries such as factory agents and transporters and the manufacturers' local communities.
- **Brands:** these are concerned by the DPP according to their different departments: design, production, finance, sales, marketing, quality, logistics, CSR, legal, public affairs, customer service, etc.
- **Authorities:** these may include authorities that monitor the conformity of products entering the country, such as customs authorities. And, more broadly, the actors involved in product regulation such as policy makers.
- **Certification and assessment companies:** these allow products to be assessed and controlled at different stages of their life cycle: samples, materials, and finished products.
- **The media:** Fashion companies communicate and promote their products Consumers can be represented by organizations through the media and claims can be substantiated using DPP information.
- **Retailers:** physical or online points of sale are where products meet their customers. DPP can be used to inform sales team.
- **Consumers:** DPP gives consumers access to specific information about the products they wish to buy, enabling them to make an informed purchase by supplementing the information provided on labels and giving them access to a higher level of information. Additionally, educational initiatives in schools can further equip younger generations with the necessary knowledge for making informed choices. Consumers can be represented by organizations.
- **Circularity Operators:** The DPP is designed to address the lack of information available to companies that repair, maintain, sort and recycle products. This information will help extend the life of products and ensure that the quality of materials is maintained for longer.

4.5. Categories of information contained in the DPP

Once the products have been identified by reference ('unique' or 'batch') and brand, we identify 16 categories of information and concepts that could be contained in the DPP:

- **Product description**

The product description helps to characterise the product. It can be textual or multimedia, as is the case on e-commerce sites. The description considers detailed information about the product, such as its size, the category of person it is aimed at (woman, man, mixed, child, baby), its colour, its weight and other more marketing-related data. More technical data can also be described, such as performance information according to use. The notion of temporality can complete this description with the season and the marketing year: spring-summer 2023.

With the integration of after-sales data in the DPP, the customer or user will be able to record information on the condition of the product for maintenance, repair or resale purposes, such as: as new, in working order or satisfactory. The DPP will also be able to record alterations if a garment has been shortened or personalised.

- **Composition**

This information, which is mandatory for products sold within the European Community, is printed on the labels attached to the product in a regulated manner, for any product made up of more than 80% textile fibres (by mass). The percentage composition of the materials making up the product must be indicated. The standard is strict and includes polyester or cotton, but not recycled polyester or organic cotton. The presence of components of animal origin must also be indicated. All this in the official languages of the countries where the product is sold.

To supplement this legal information, the DPP can include further details on the origin of the materials, their treatment, and their qualities. This is to inform consumers, but also to enable better maintenance and automated processing at the end of the product's life, with more precise information on dyeing processes and fibre length.

- **Supply Chain**

At EU level, this information is not mandatory in its simplest form, although most brands indicate the country of manufacture or "made in". In France, for textile products subject to the AGEC law, the country of manufacture must be indicated for the first stage of production, but also for the second stage: weaving or knitting and printing or dyeing.

We have noticed that some initiatives go much further: some brands go right back to the origin of the raw materials (tier 4), for example by giving the address of the sheep farms that supply the wool used in the products. This remains the exception. There are large retailers who systematically provide the address of the garment factory as well as information on the social conditions of this company (number of employees, proportion of men and women, standards in force, audit). The identification of actors in the supply chain can be described with varying degrees of precision.

- **Transportation**

To complete the supply chain information and better understand how products and their components travel from one stage to another, some companies describe the transport and distances covered. We saw several examples in the study: some describe the assembly stage (tier 1) right up to delivery to the warehouse, and other initiatives go further by describing the types of transport used for materials between each transformation. This information enables the environmental impact of a product to be calculated more accurately. Other companies will simply

talk about their transport policy and in particular their desire to limit their environmental impact by avoiding air transport, which has a high impact on the environment.

- **Documentation**

The documentation attached to the DPP supports the brand claims by providing evidence. This may include company compliance certificates, audit reports, transaction certificates, quality control, label and performance tests. These documents ensure that the claims can be verified. The planned revision of the **Textiles Labelling Regulation** and the **Eco-Label Regulation** as an opportunity to avoid greenwashing practices through labelling and to harmonise the criterion for the mandatory labelling of textile products across the EU.

- **Environmental impact**

Calculating the environmental impact of products can provide useful information for several stakeholders. Product development teams can eco-design by forecasting the product's impact on natural resources, the product's end-of-life and its potential for circularity. This information can then be used by fashion brands to calculate the impact of their company's products.

Communicating the environmental impact of products is at the heart of forthcoming regulations at national level with environmental labelling **Climate and Resilience Act** and at European level with the **Product Environmental Footprint (PEF)** and the **Green Claims Directive**, which aims to better inform consumers. Consumers who know the environmental qualities of a product can make informed purchasing decisions. This standardised information will make it possible to compare the results of products in the same categories.

- **Social impact**

Human rights scandals in the globalised textile industry, such as the Rana Plaza collapse in 2013 or the revelation of the exploitation of Uyghurs to grow cotton in Xinjiang for major brands in 2020 (Xu *et al.*, 2021) have raised awareness. Since 2017, major French companies are subject to due diligence and must implement measures to identify, prevent and mitigate human rights, environmental and health risks throughout their value chains. NGOs and consumers want information to ensure that due diligence is applied. Since 2023, **Corporate Sustainability Reporting Directive (CSRD)** and **Corporate Sustainability Due Diligence Directive (CSDD)** are recent instruments that will produce information about social impacts and reporting could be integrated in DPP.

- **Impact on animals**

Clothes, bags and shoes are often made from animal materials. Some products require the death of the animal: fur, leather, feathers, silk and others, such as wool, do not result in the death of the animal but may cause suffering. Some animals are bred solely for this purpose: furs, exotic leathers and others are by-products of the agri-food industry. Fashion brands may want to know about the rearing conditions of animals used for their materials, and consumers may have different sensitivities, so this information can help them make informed choices.

- **Circularity**

The information contained in the DPP shall promote product circularity. This may include information on recycled content, maintenance advice, availability of repair services, instructions on how to dispose of the product at the end of its life, follow-up on product maintenance or any other information that helps to extend the useful life of products. Some committed brands offer product take-back services to give products a second life. Other brands state that they have recovered materials from obsolete stock, which can be considered a more responsible resource. Some companies offer rental services to optimise the use of products.

- **Health impact**

In France, the AGEC law requires hazardous substances above 0.1% of a product to be labelled. This reinforces the **European Union's REACH regulation**, which aims to better protect human health and the environment from the risks associated with chemical substances by making information available to consumers. This information could be supplemented by access to the tests carried out, product certification and, more generally, the safety policy applied by the brand.

- **Information on the brand**

A presentation of the brand: history, contact details, own website, employees, its commitments and results on social, environmental, societal and governance issues related to its activities, **DPEF (Extra-Financial Performance Declaration)** could be collected in the DPP to make comparable and collected data accessible to NGOs, consumers and authorities.

- **Communication/identification media**

This physical link between the product and the data can be in the form of a label with a serial number, or in a more automated way, accessible via a mobile phone, thanks to a QR code that transmits a URL to a website dedicated to product information, or thanks to an NFC chip that can be read by certain types of terminals.

- **Quantity**

Knowing the quantity produced of the same reference, to find out whether it is a limited series or a large series of the same reference, can provide information on the value of a product. Knowing the quantities marketed by a brand can also help consumers understand the type of company they are dealing with, so they can make an informed purchase.

- **Costs**

For companies with the most common model of buying finished products and selling them to retailers, cost transparency is a sensitive topic. At present, only committed companies provide this information: costs of materials, components, manufacturing, production and transport. Second-hand companies analyse sales and resale prices by category and brand to estimate a second-hand price. This information could be used to inform consumers about the value of their products. For import purposes, the value of the goods must also be declared to customs.

- **Usage & Customer feedback**

Gathering information concerning the type of usage (professional, personal…) and comments from the users concerning the product can improve the feedback to the companies. These opinions concerning the user's experience with subjective notions are difficult for brands to collect.

- **Tracking and tracing after sales**

Traceability after a product has been on the market can be the key to new business opportunities. Tracking successive sales, modifications and servicing will add value to the product by extending its traceability.

4.6. Characterisation of information in the DPP

We also propose a characterisation of the information by the following variables:

Granularity is used to identify the level of precision of the information about the product. It can be a unique identification or an identification that corresponds to a manufacturing batch or more broadly to a product reference that corresponds to several manufacturing batches with the same characteristics. In our definition of the DPP, we introduce the nuance of unique identification or batch identification because we believe that the use of a unique identifier corresponds to luxury products manufactured individually. However, if we wish to extend the use of the DPP, it should also be used for lower-value products manufactured in larger quantities. The product could receive a unique identification after its manufacture or purchase by adding an additional identifier.

Level of detail of the information ranges from the absence of information to very precise information. Without standardization of information, it loses its meaning by not allowing products to be compared with each other.

Reliability of the information ranges from the absence of information, to declared information, documented, or better, verified by a trusted third party.

Completeness measures the proportion of information completed in the DPP, taking into account the components, the stages of the supply chain, and the identified stakeholders. In the absence of common rules, it is difficult to assess the proportion of information disclosed.

The filling of DPP can be adapted and fine-tuned (according to the size of the companies…) by using these proposed variables to adjust the complexity/effort of reporting of the mandatory information.

5. Proposition of a DPP model and consultation

5.1. Proposition of a generic model of DPP for textile

Following our research work, we defined a first version of a generic model of DPP based on the lifecycle model representation (figure 8) to include all the information previously mentioned:

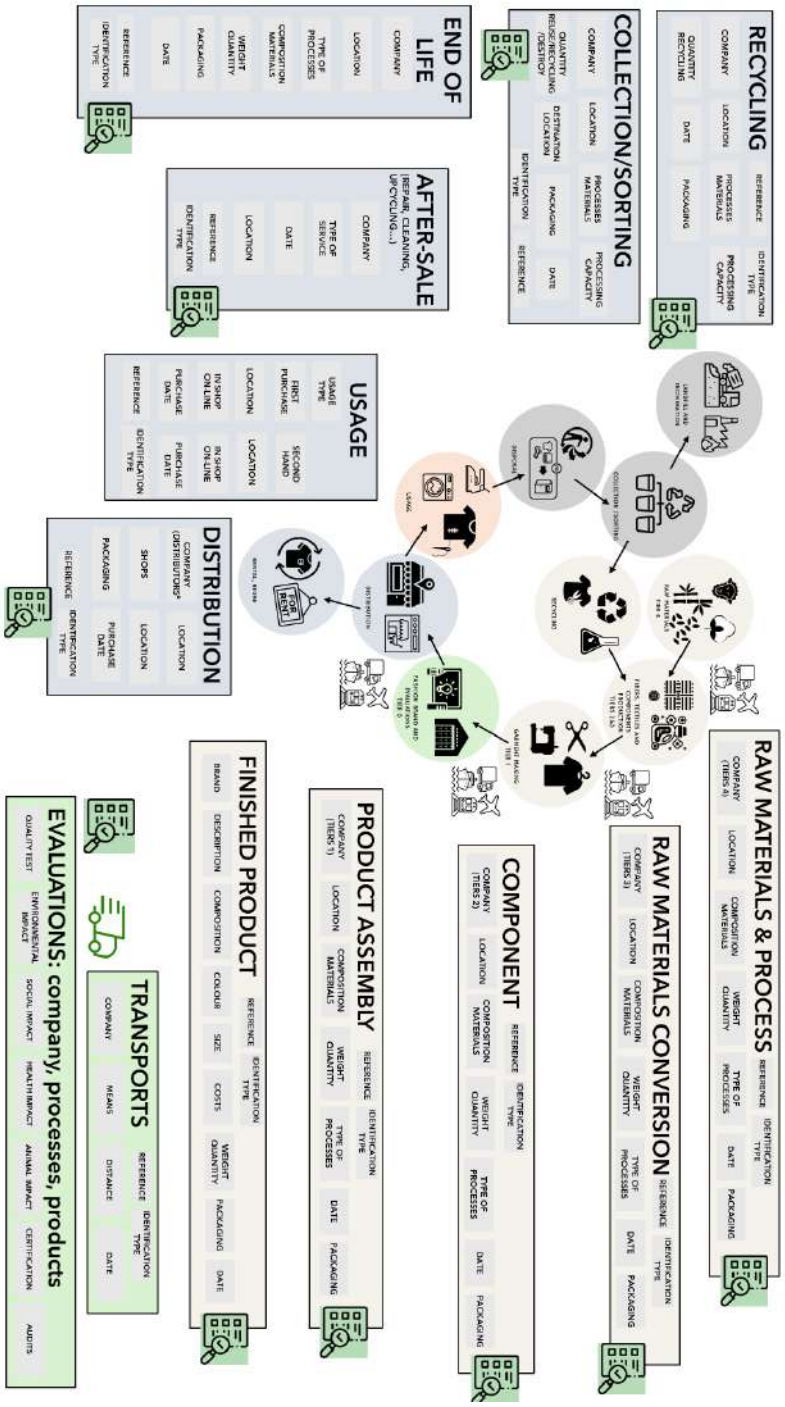


Figure 8 – Generic model of DPP for textile

This model of DPP must be seen as the list of categories of useful data that could be shared between different stakeholders to promote more circularity in the textile sector by exchange of information that could be private, limited or also open source for citizens.

The DPP model is designed to provide stakeholders throughout the entire value chain, including customs authorities, with both private and open-access to data. This data should adhere to open standards and be presented in formats that are interoperable, as well as being easy to read, search through, and organize. To ensure both the accessibility of data and the protection of intellectual property, the DPP will implement varying levels of access based on the information type and the stakeholder category. Stakeholders are anticipated to have the capability to add or modify information within the DPP, and if necessary, establish a new DPP. The guidelines for these processes, including the duration of the DPP's availability, will be specified in the delegated acts.

5.2. Evaluations of the DPP proposal based on a quantitative approach (online survey)

After different exchanges with stakeholders of DPP (brands, experts...), we have developed a simplified version of the DPP (see Figure 9) for the textile industry and a glossary to explain all the required information.

The main difference between the generic (Figure 8) and the proposed model (Figure 9) is concerning the supply chain production that was condensed into one template and not detailed for each phase to reduce the redundancy of information.

Then, we collected feedback about this model during an online survey composed of 10 questions (see full description in Annex). The survey involved 81 stakeholders and experts in textile sector (brands, manufacturers, retailers, sorters/recyclers, NGOs, DPP company…) We asked them to assess the DPP model of Figure 9 by giving their opinion on each of information by using a Likert scale as follows:

In your opinion, what categories of information should be included in the Digital Product Passport?

1. Do not include in the DPP
2. Unimportant to include
3. Neutral
4. Important to include
5. Very important to include
6. I don’t know

The global result of this survey is presented in Figure 10 with the following visual legend and format:

Majority agree to include

No consensus

Majority agree to not include

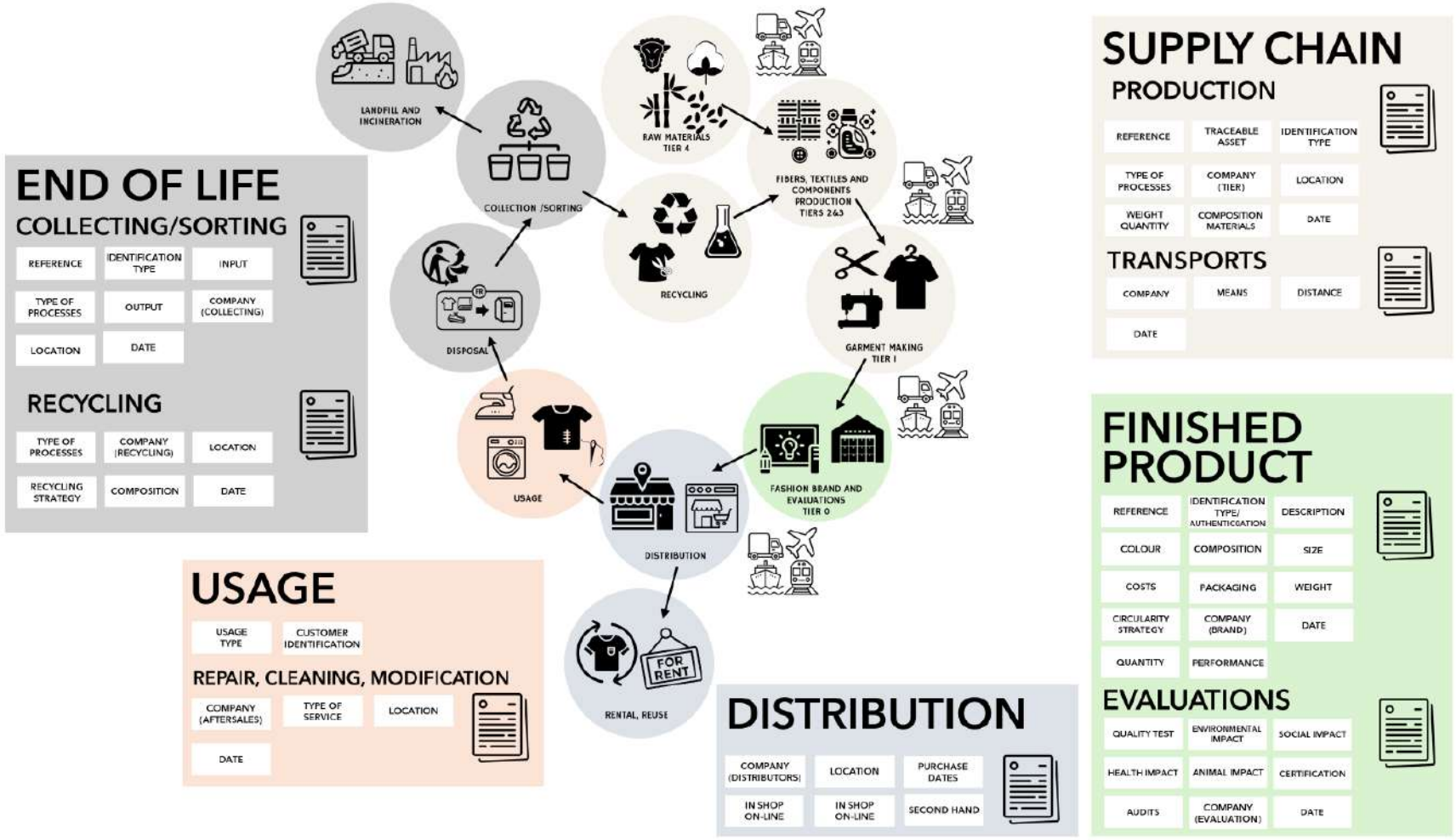


Figure 9 – Proposed model of DPP for textile

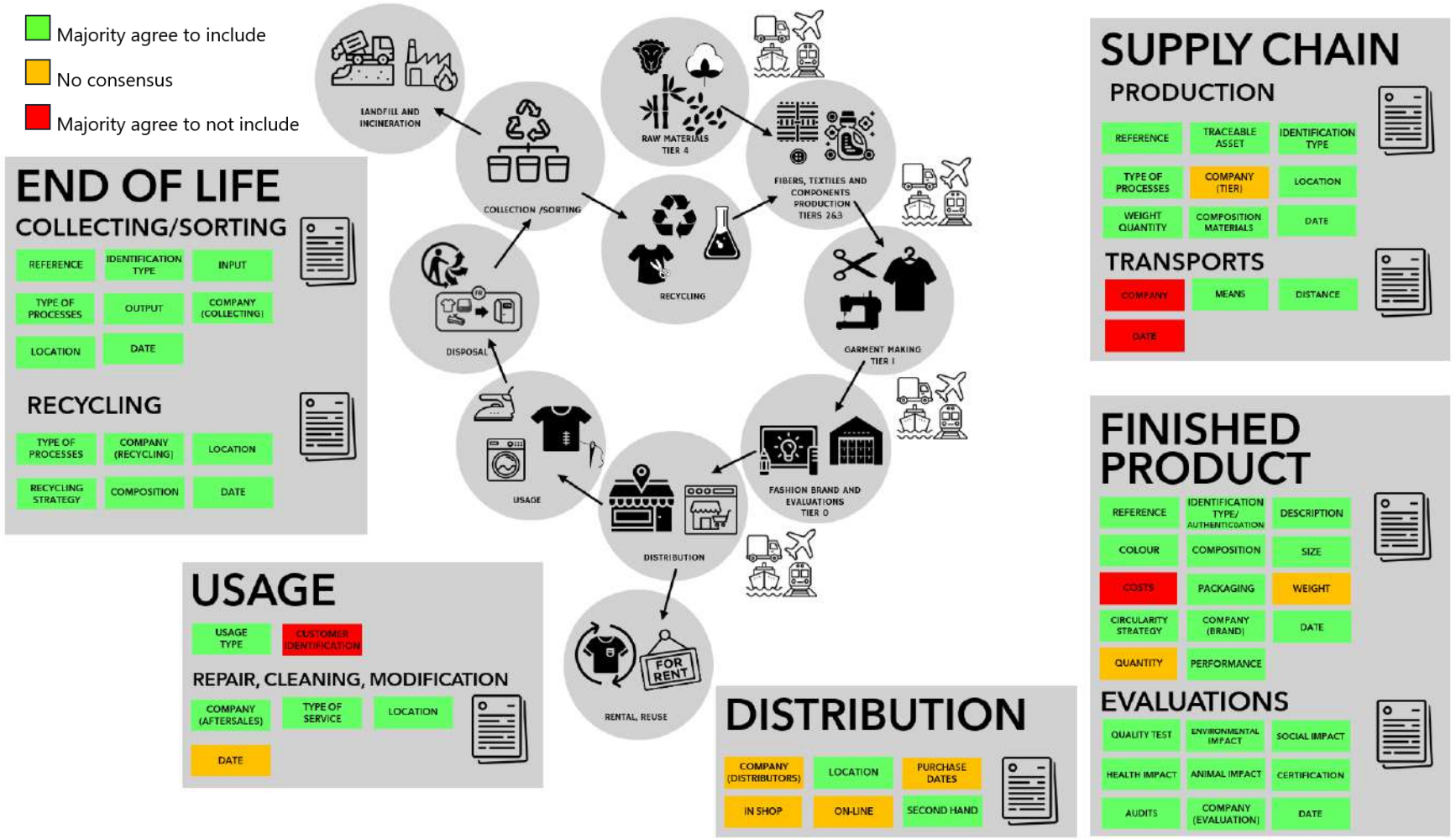
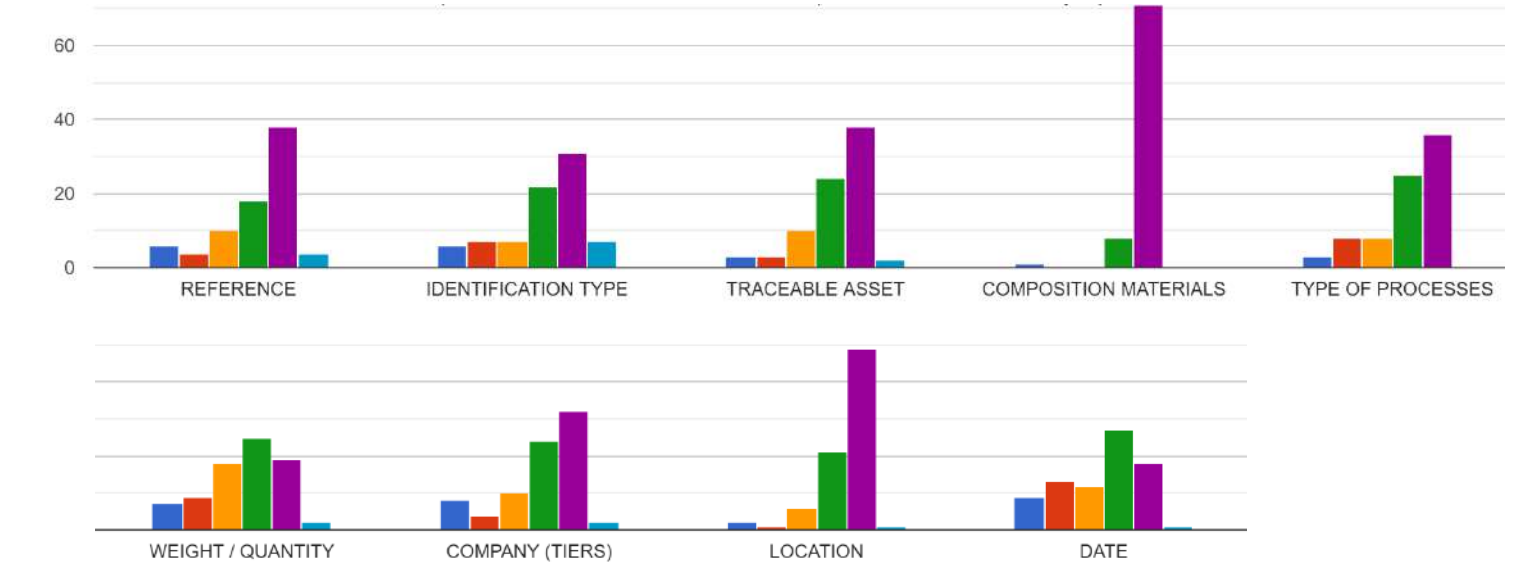


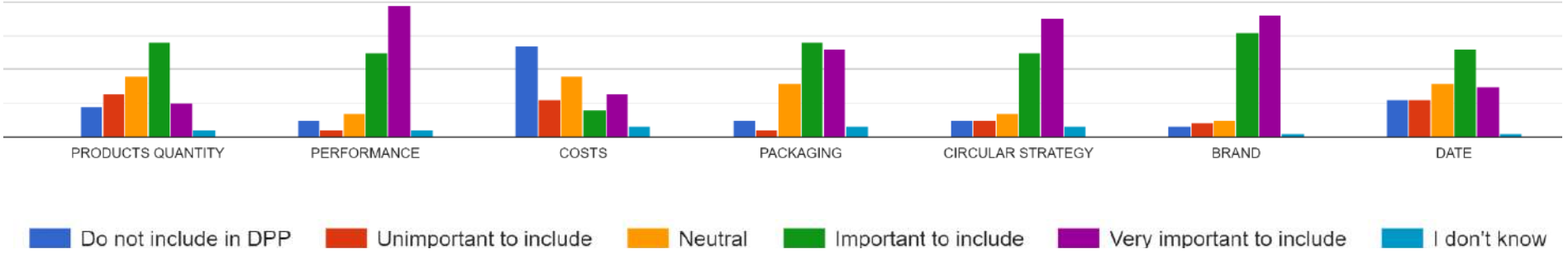
Figure 10 – Generic result of the survey

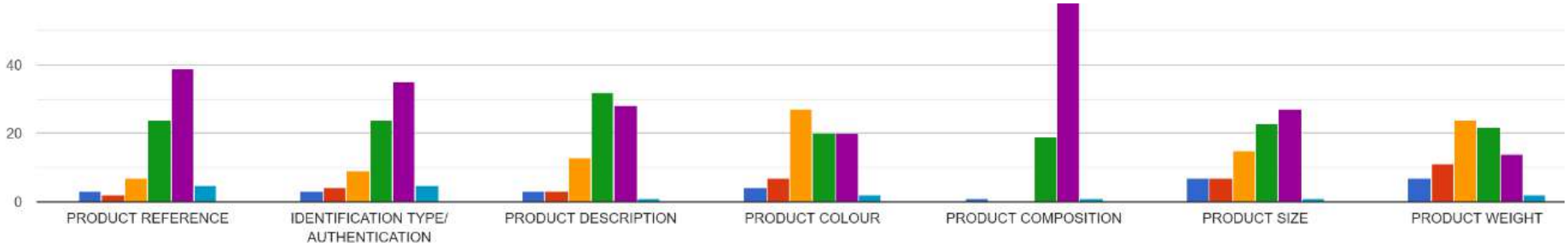
The global result of this survey is based on the average and detailed results for each question that are presented (Figure 11) with the following charts and legends (based on Likert scale):

Q1: In your opinion, what categories of information regarding textile production should be included in the Digital Product Passport?

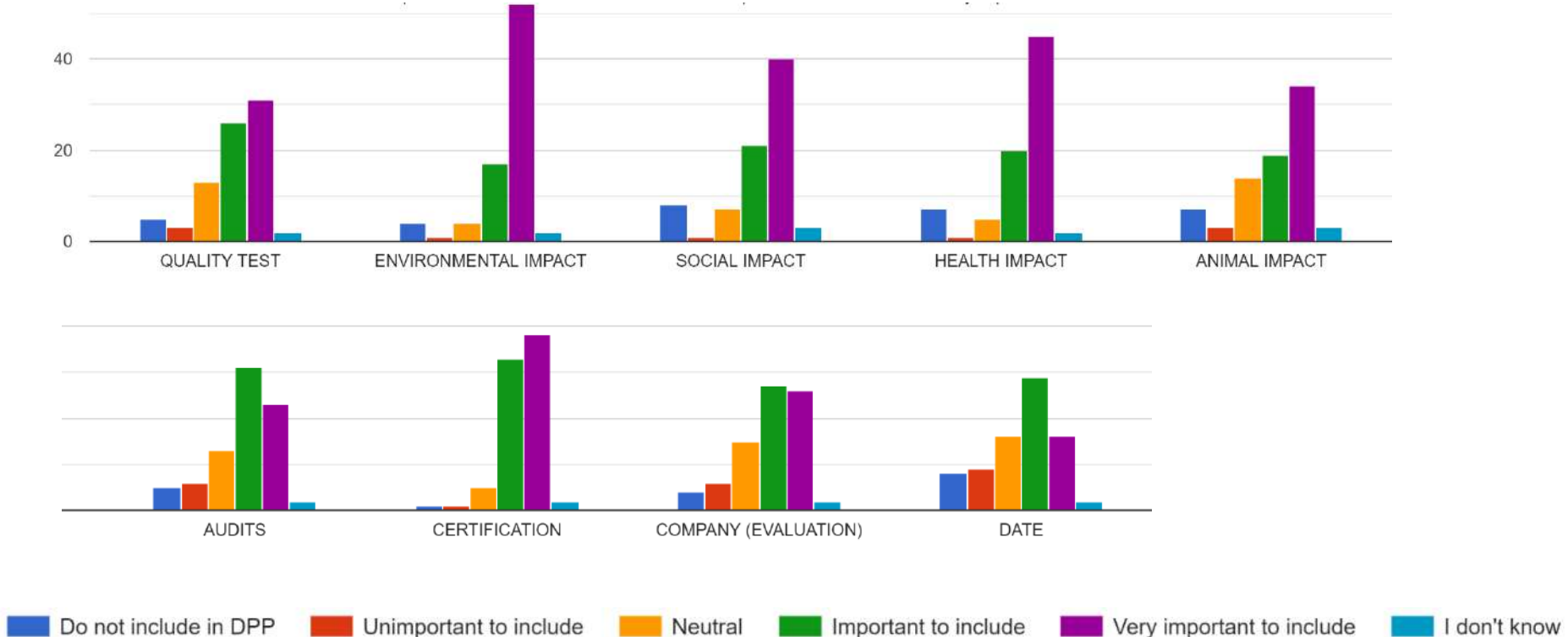


Q2: In your opinion, what categories of information regarding finished product should be included in the Digital Product Passport?

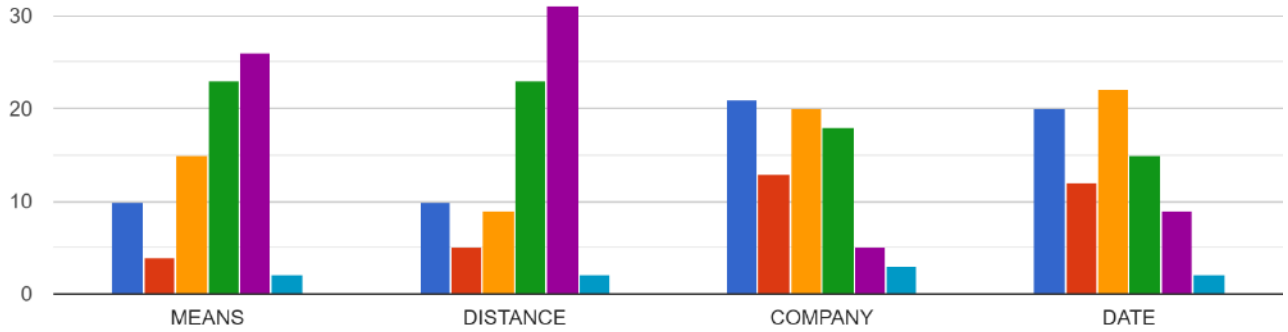




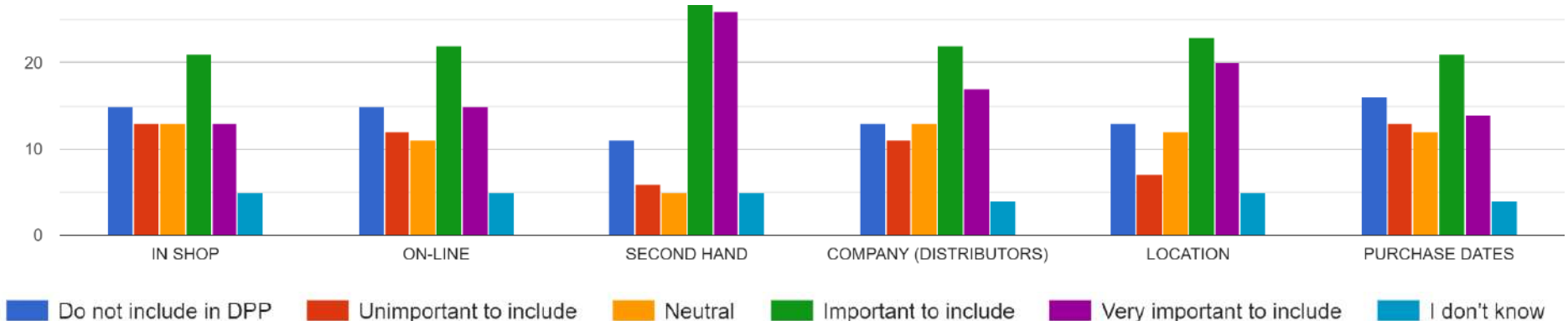
Q3: In your opinion, what categories of information regarding evaluations should be included in the Digital Product Passport?



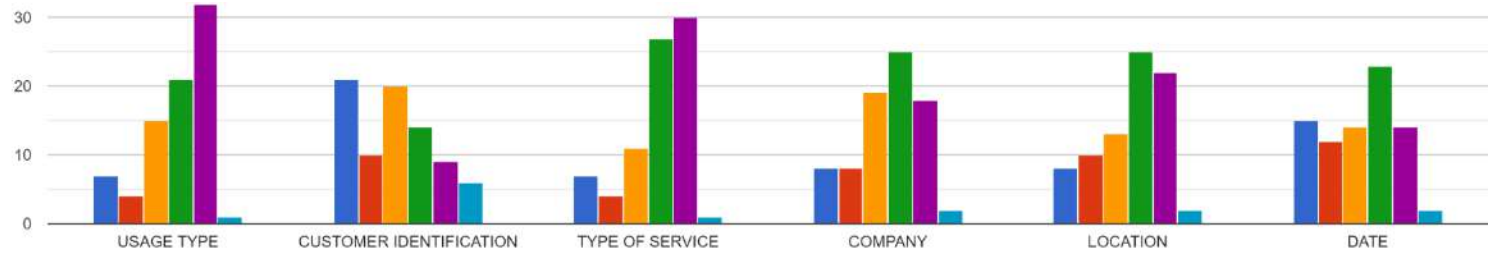
Q4: In your opinion, what categories of information regarding transport should be included in the Digital Product Passport?



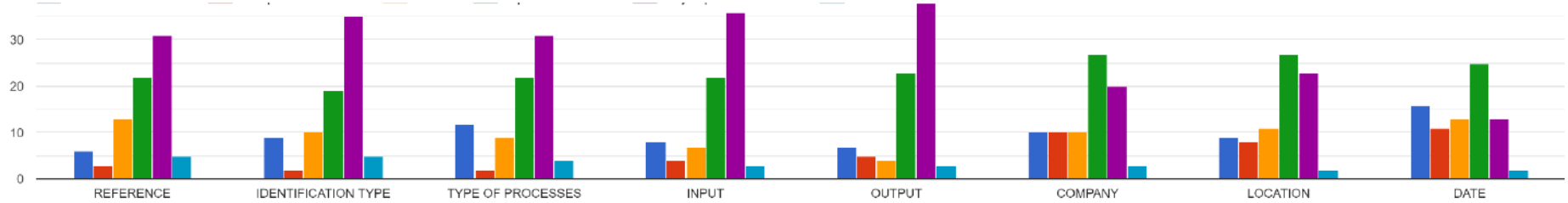
Q5: In your opinion, what categories of information regarding product distribution should be included in the Digital Product Passport?



Q6: In your opinion, what categories of information regarding product usage should be included in the Digital Product Passport?



Q7: In your opinion, what categories of information regarding product end-of-life (Collecting & Sorting) should be included in the DPP?



Q8: In your opinion, what categories of information regarding product end-of-life (Recycling) should be included in the DPP?

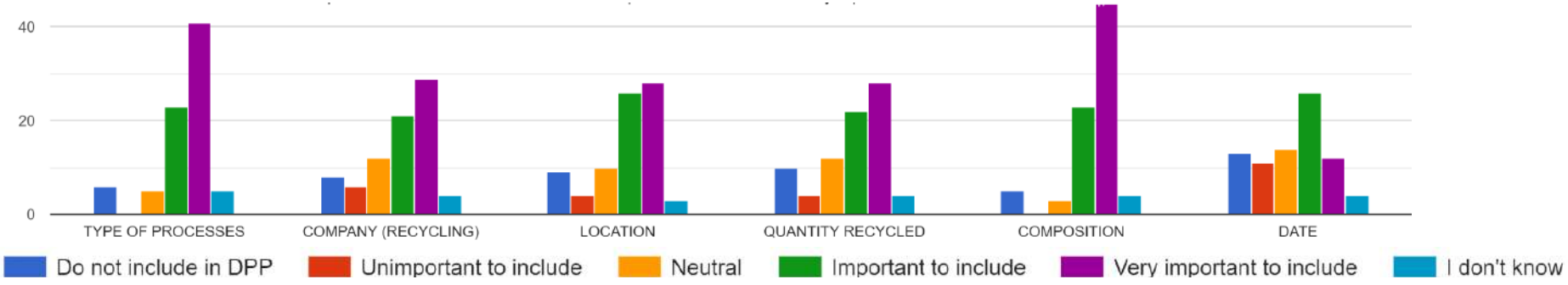
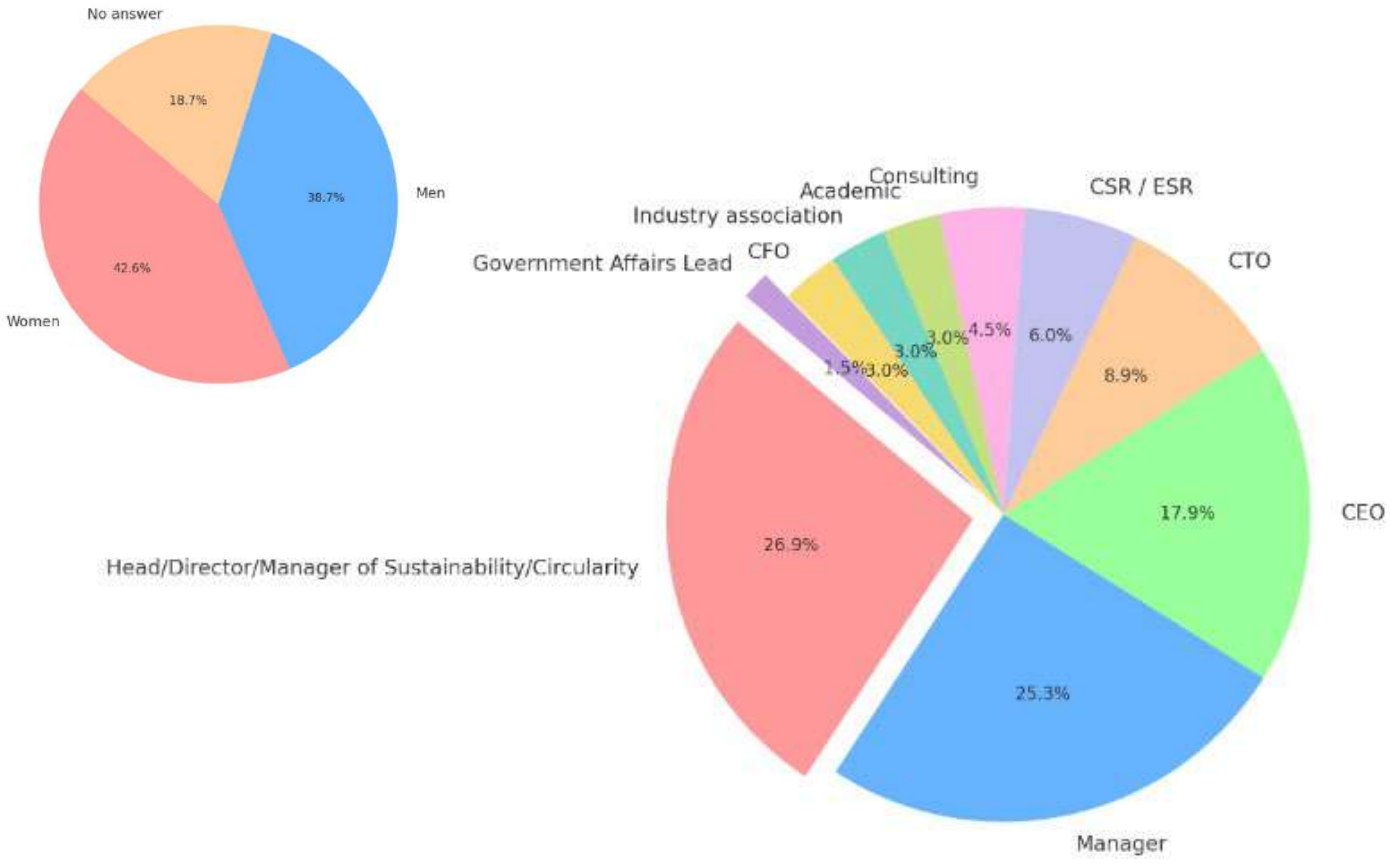


Figure 11 – Detailed results for each question concerning information of DPP

The experts were diverse in terms of gender, functions, type of organisations represented and countries (see Table 2). The survey involved 42,2% of women and 38,3 % of men while 18,5% of the respondents preferred not to disclose their gender. The experts participating in the survey represented 20 countries. The highest percentage of respondents in the sample were from Italy (33,3%), France (16,1%) Germany and Spain (7,4%).

Variable	Characteristics
Number & Gender	Survey sample composed of 81 persons. Women (42,2%) - Men (38,3%) - No answer (18,5%)
Functions	Head/Director/Manager of Sustainability/Circularity (26,9%) - Manager (25,3%) - CEO (17,9%) - CTO (8,9%) - CSR / ESR (6%) - Consulting (4,5%) - Academic (3%) - Industry association (3%) - CFO (3%) - Government Affairs Lead (1,5%)
Type of organisations	Brand/Reseller/Tier 0 (34,6%) - Supplier company/Tier 1 (11,1%) - Supplier company/Tier 2 (7,4%) - Supplier company/Tier 3 (6,2%) - Supplier company/Tier 4 (3,7%) - Distributor (4,9%) - Collection/sorting company (3,7%) - Recycling company (3,7%) - DDP expert company (12,3%) - Research organisation (4,9%) - NGO / Association (12,3%) - Others (15,2%)
Country	Austria (1,2%), Belgium (3,7%), Czech Republic (1,2%), Denmark (1,2%), European organisation in different countries (2,5%), France (16,1%), Finland (4,9%), Greece (1,2%), Germany (7,4%), Hungary (1,2%), Italy (33,3%), Japan (1,2%), Netherlands (1,2%), Poland (1,2%), Portugal (2,5%), Spain (7,4%), Sweden (1,2%, Switzerland (2,5%), Turkey (2,5), UK (2,5%), USA (1,2%)

Table 2 – Characteristics of the survey sample



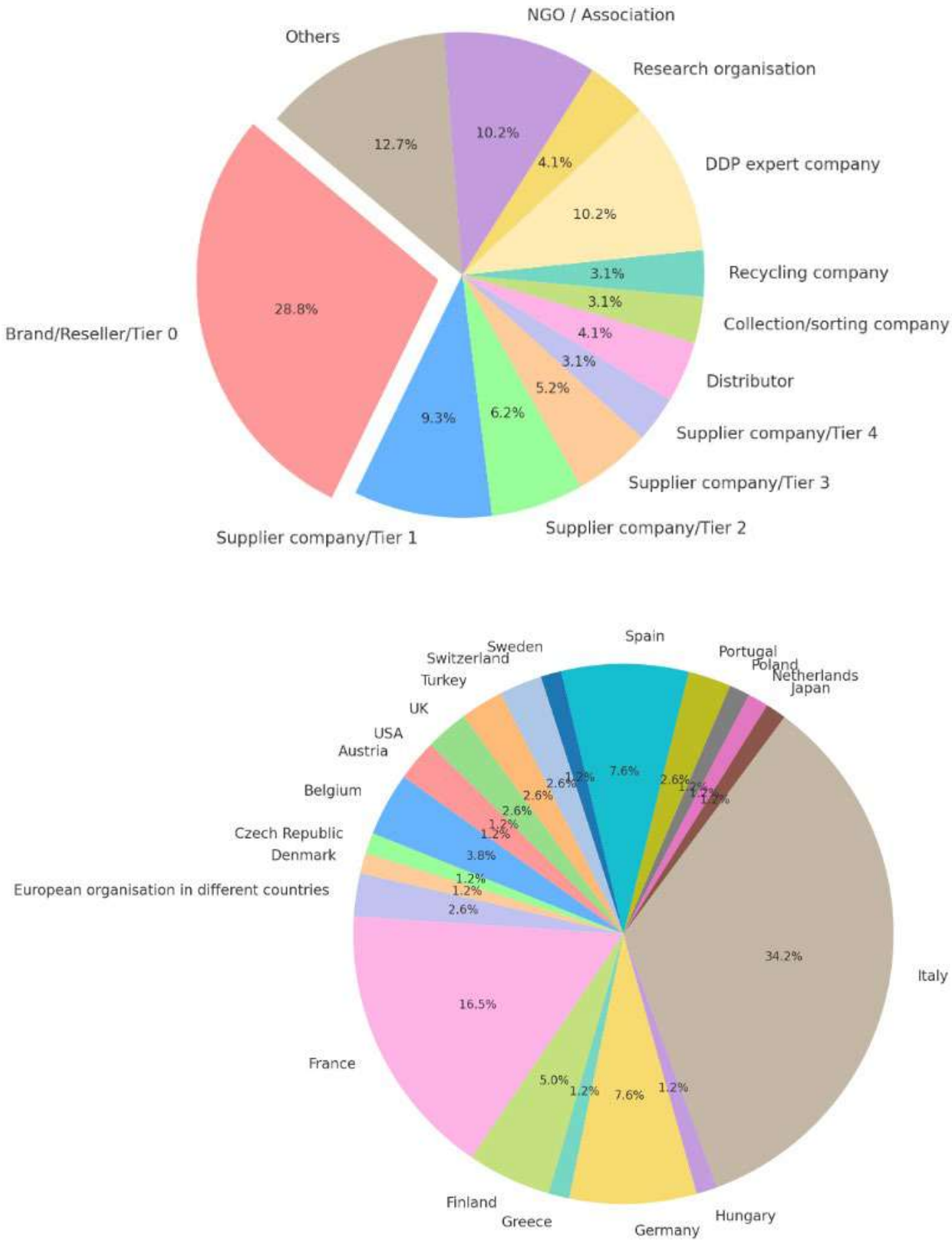


Figure 12 – Chart pie of the survey sample

We collected some interesting comments for each question. Here are some extracts of the survey:

About supply chain traceability:

"*The list of company's names involved in the production or distribution phase can be confidential for many brands due to different business strategies: patent, exclusivity contract…*" and so "*the centralisation of this information needs to administrate the data and define authorisation access"*. The information provided by the "*DPP shall enable fulfilling legal requirements, but it shall protect confidential business information"*.

"It will be very difficult to track everything until Tier 4 with full detailed information, especially if this need to be done to the smallest possible trims used in a product".

"Fashion supply chain is very complex and data collection from tiers 3-4 can be very difficult (language, technology, resources etc.)"

About accessibility to information and confidentiality:

"We recommend to ensure that data collection is conducted in accordance with established protocols. Furthermore, we advise that the disclosure of such information should adhere to a policy of need-based transparency, with details being shared solely when it is deemed essential for the decision-making process."

"Each actor in the supply chain should be responsible for its own local data. Businesses should also be guaranteed the protection of secured business data. Currently, the collection of data is usually done through company-specific requests and access to the data can be challenging. Data quality and reliability should be ensured (standards are needed). Collection, compile, summarize and quality assurance is very resource intensive. Data is mostly manually collected, compiled and screened from many different sources, this increases the likelihoods of errors and need for double checks, hence extensive time and resources. Therefore, it is expected that this will include a significant cost burden which should be taken into account."

"Like to see all above information needed at DPP, but not all available to everybody. There need to be different kind of user views to manage which info to show'n to whom".

"We highlight the importance of ensuring that the data collection is conducted in accordance with a recognition of business confidential information (for example disclosure of company tiers) and industry standards, as well as adhering to a policy of need-based transparency, with details being shared solely when it is deemed essential for the decision-making process. The foreseen information requirements should be further discussed on how much detail is required, balancing consumer rights, practicality, and company competitiveness. For example, the type of textile manufacturing process and the date of the manufacturing process that addresses Tier 2 and beyond can be considered less relevant for consumers while bringing heavy administrative burdens for companies".

About costs:

"Most of the product information are legally required and can be considered as important to include. However, costs of the manufacturing must not be included as a mandatory information as this is a confidential information to the business. Disclosing the cost could have a huge negative impact to the competitiveness of a company. Adding together the supplier list, location, and other information proposed, the business model of a brand would be entirely revealed. Company should be protected to ensure a fair competition and to share only necessary information to consumer relevant to traceability and circularity only".

About performances and tests:

"On the performance of the product, it could be beneficial only when harmonized standards are available to evaluate each indicator, however, presentation of a singular life expectancy metric may set unrealistic expectations if product's functionality and character is not taken into consideration".

"All test reports, certificates and impact reporting might be complicated to understand for a normal consumer. Even many professionals do not understand all of the details. We need to take care that the information flow is there, but it needs to result in a easy understandable presentation".

About evaluation and certification:

"Some information may be made available to relevant parties to facilitate B2B communication and market surveillance, such additional information may refer to e.g. voluntary certification and information to calculate the product footprint".

"There has been a proliferation of a thousand certifications for which everyone follows a different certification".

"Certification and audit types/names are important to add (e.g., ISOxxx, ENxxx, etc.) with CE compliance certificates to include also".

"If every product must have an evaluation, it will become extremely expensive for companies and is a direct handover to "auditing companies" around the world. Huge workload for companies that are at the end of the supply chain".

"DPP should offer the possibility to give voluntary information about any evaluation".

About transport:

"For the same SKU, depending on different shipment the mean, distance, company and date of transport may be different. The implementation of a system that tracks all of its for each single item is extremely challenging for any company. The sector is not ready for this. Other topics need to be prioritized".

About distribution:

"Many companies cannot determine in advance the distribution channel. Sometimes there is cross-channelling. It only makes sense for large companies with high volumes with strictly separated channels"

About usage:

"Have more information about usage is fundamental to being able to measure the circular economy. Understanding garment flows through multiple use cycles is one of the key unlocks for stopping slowing down leakage from the system. There are obvious potential issues regarding data privacy which may obstruct this"

"These are all interesting details that helps the brands to analyse the use of their product. But if it is adding on too much complexity it should remain optional. These details could be add-on for the luxury sector products where they are authenticity verification and ownership tracing could be added on the DPP".

"How can you monitor the product lifecycle after 1st sale? Unless RFID becomes compulsory to products and all points of sale/repair/waste platforms?"

"This section is key for measuring garments in the circular economy. I would be hesitant to include any customer identification".

About end of life:

"This elements in this section are critical for the implementation of EPR. This phase will help companies from the EPR Extended Producer Responsibility to give a longer use to products."

"Detailed composition might be difficult to give in some recycling methods. Bigger tolerance should be tolerated if the next further use of material doesn't require detailed information."

"This category of information should be further aligned with Waste Framework Directive and End of Waste Criteria as well as other legislations linked to product's end of life".

6. Phases and policy options about DPP deployment

Based on the results of this survey and our research work, we propose in this section different phases concerning the DPP deployment at EU level. Policy options are proposed for each phase and in general for the DPP's deployment regarding the main objectives:

- promoting traceability and transparency of the textile sector,
- informing consumers to foster "educated purchase" and encourage good practices to increase durability of product and their recycling,
- fostering information exchanges between the different stakeholders to increase the rate of reuse (repair, second hand…) and recycling in close-loop at the end-of life,
- assessing the global impacts of the textile sector to foster reduction and promote a more sustainable textile sector,
- ensuring protection and competitiveness of the European companies and citizens to fight the growth of fast-fashion and their negative impacts (health, social, environmental, economic).

According to the results of this study, we recommend 3 phases for the progressive DPP deployment at the European level.

- **Phase 1.** Deployment of a "minimal & simplified DPP" for textile at short-term horizon 2027
- **Phase 2.** Deployment of an "advanced DPP" for textile at mid-term horizon 2030
- **Phase 3.** Deployment of a "full circular DPP" for textile at long-term horizon 2033

6.1. Phase 1: Deployment of a "minimal & simplified DPP" at the European level (2027)

Based on our study and the different results from our survey, we propose the following **"minimal & simplified DPP"** (see figure 13) that could be proposed for deployment in Europe with a short-term phase. This "minimal & simplified DPP" proposal is:

- mainly based on dissemination of the following mandatory information (in green in figure 13)
    - in the **composition** of the product: information on the incorporation of **recycled material**, on the presence of any **dangerous substance**, on the presence of **plastic microfibers**
    - Information on the **recyclability of the product**
    - Information on the traceability of **the supply chain production**: at least the **location** of the following main **processes** (for clothing): confection, weaving, knitting, dyeing, printing but also the wet processes (tannery, dyeing...) that have significative impact. The shoes sector can be also integrated with the following processes: stitching, assembling, finishing.
    - Information on the **packaging** of the finished product: Recycled content, Recyclability, Possibility of re-use
    - Information of the **environmental impact** and especially on the innocuity of the product
- Completed by additional information (in blue in figure 8) that will be useful for Lifecycle analysis.
    - **Weight & Quantity** and **composition materials** of the main components to assess the material resources impacts.

- **Means** and **distance** to evaluate the impact of **transport.**

The information (in green on figure 13) need to be already collected and disseminated by major producers according to the AGEC Law in France since January 2023 and will progressively be extended in 2025.

During this phase 1, the main recommendations are the following:

- A simple and pedagogic system to display Environmental Labelling information to consumers should be deployed and unified (initiatives and study are in progress in different countries)

- The adoption of DPP can be fine-tuned (according to the size of the companies, etc… by using the 4 proposed variables (granularity, level of detail, reliability, completeness) to adapt the complexity/effort of reporting of the mandatory information.

- Other stakeholders (distributor, aftersales, audit/evaluation, sorting/recycling companies) are asked to prepare to collect all the others information and interoperability POC (proof of concept) between the different information systems and tracking support (QR code, barcode, RFID…) should be encouraged to exchange data.

- The extension and application of DPP (at national or European level) to the foreign products designed and manufactured outside Europe should be encouraged to protect the European textile sector against the fast fashion.

- The mandatory and requested information of this "simplified DPP" can be adapted as the Commission will revise the textile labelling Regulation (planned for the 4th quarter 2024) to introduce specifications for physical and digital labelling of textiles, including sustainability and circularity parameters based on requirements under the proposed Regulation on eco-design for sustainable products.

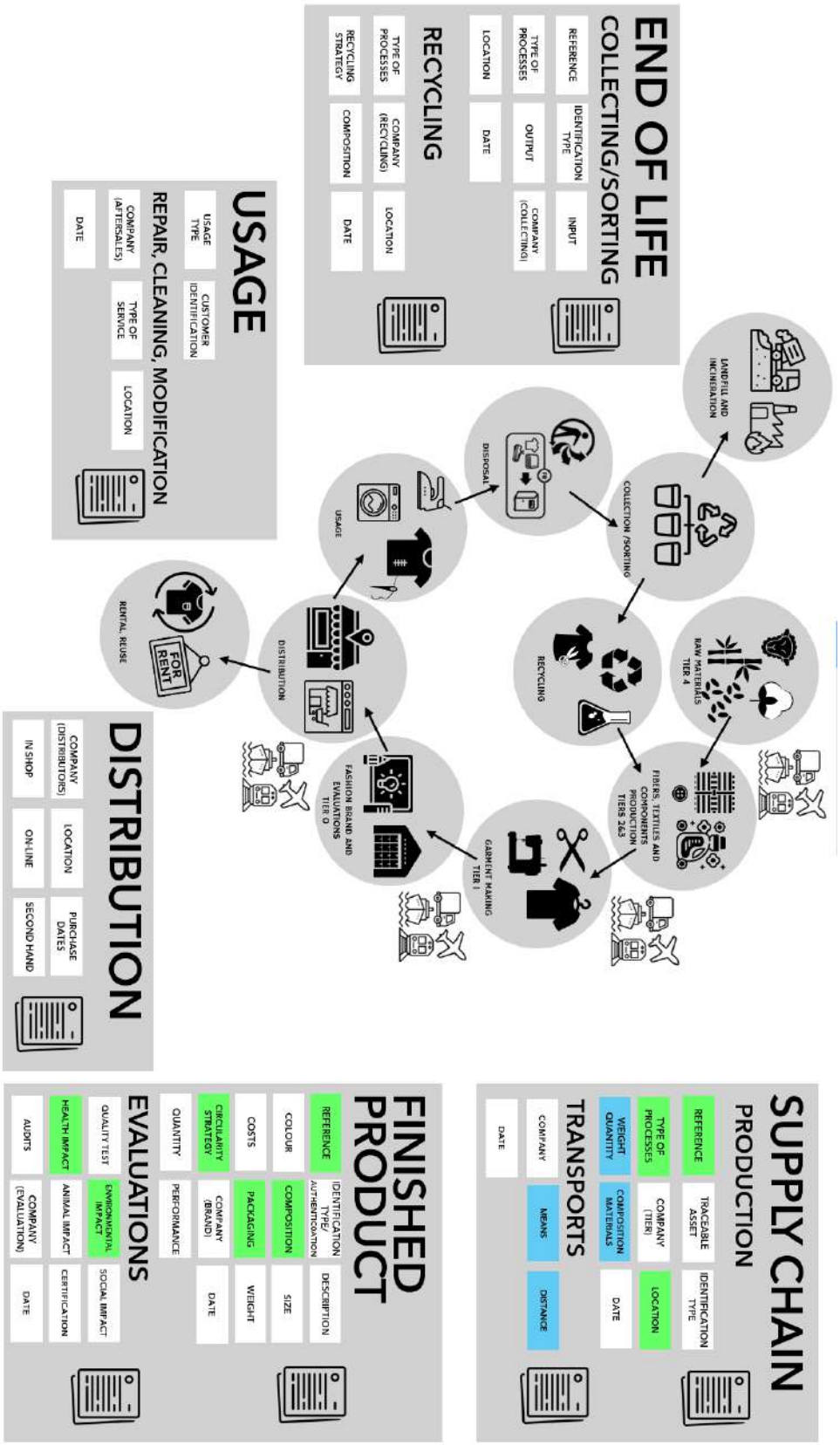


Figure 13 – Simplified DPP Model for phase 1

6.2. Phase 2: Deployment of an "advanced DPP" at the European level (2030)

During this second phase, based on the learnings of the first phase and return on experimentation, the **"advanced DPP"** (see figure 14) could progressively be extended to other stakeholders and more information are collected all along the life cycle.

- The **supply chain** is more and more documented with mandatory information (in green) and additional information (in blue) are collected taking into account of confidentiality and restricted access to the DPP.

- The information concerning **finished product** and their **evaluations** are almost collected for transparency for the customers and some information (colour, size, weight, composition…) are collected for **end-of-life** actors in order to facilitate the sorting and the recycling of product.

- **Aftersales** services and **second-hand** are progressively tracked to assess the durability and promote long-life products.

During this phase 2, the main recommendations are the following:

- Interoperability and standardisation between systems of information in the textile sector (PIM, supply chain software, PLM, ERP, LCA, second-hand platforms…) and certification/audits need to be generalized to connect with this advanced DPP and collect information automatically (by using API, standard, common protocol…)

- Interoperability and standardisation between tracking support (QR code, bar code…) need to be also developed to facilitate the exchange of information from raw material producer to recycler.

- The DPP is generalised to all the textile and apparel sector and products coming from foreign countries are also concerned by providing a DPP in line with European rules.

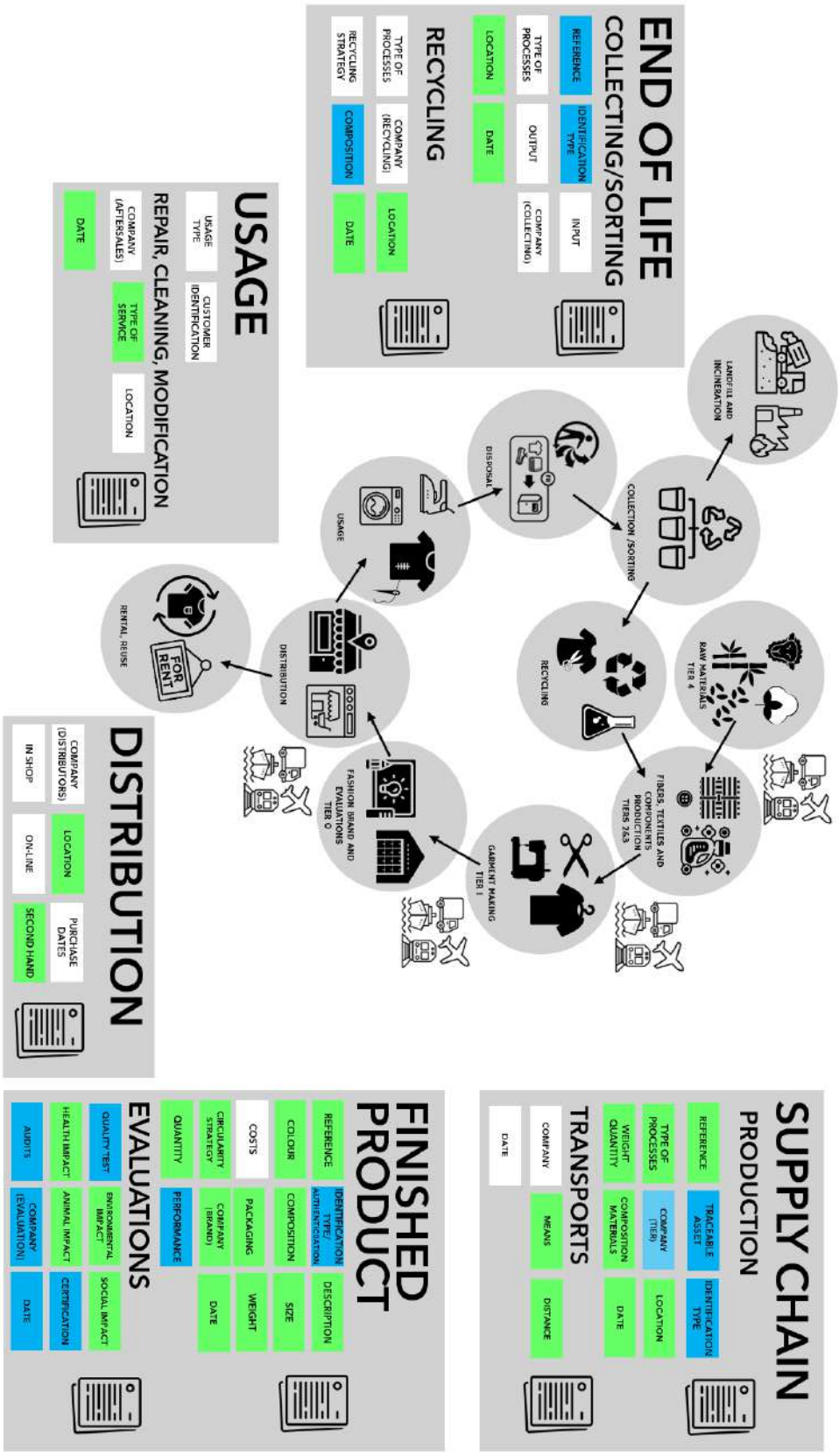


Figure 14 – Advanced DPP Model for phase 2

6.3. Phase 3: Deployment of a "full circular DPP" at the European level (2033)

During this last phase, a **"full circular DPP"** (figure 15) can be fully deployed to promote circularity in the textile sector.

- The information of **supply chain** is fully integrated with restrictive access to preserve confidentiality and business of the companies.

- The **finished products** are completely documented by heritage of the upstream information. The DPP helps the brand to automatise the impacts calculation and provide information to obtain the different labels.

- The **distribution**, **usage**, and **aftersales services** are tracked and traced to increase and communicate on the durability of products and increase the collecting processes for a better management of deposit.

- The **sorting** and the **recycling** processes are more efficient by retrieving information in the DPP about the design and manufacturing techniques of the products to increase their industrial processes of end of life in quantity and quality.

- The rate of **recycling material** in close loop is higher with information exchange via DPP between recyclers and upstream suppliers (Tier 4 or 3) to reduce the extraction of natural origin material.

At this stage, the DPP is complete and there is only remaining information concerning cost and customer identification that the respondents of the survey consider "To not include". During this phase 3, the main recommendations are the following:

- The scalability of the DPP represents a significant challenge, and it will be crucial to leverage the experience and insights gained from earlier phases of its deployment, including surveys, workshops, and frequently asked questions (FAQs). This approach will ensure that lessons learned are effectively incorporated into future expansions, enhancing the DPP's adaptability and effectiveness across broader applications.

- The DPP is generalised to the maximum of stakeholders in the textile and apparel sector including foreign countries to foster circularity and reduce drastically the impacts by analysing of data (using AI) by authorities to define new regulations based on good practices.

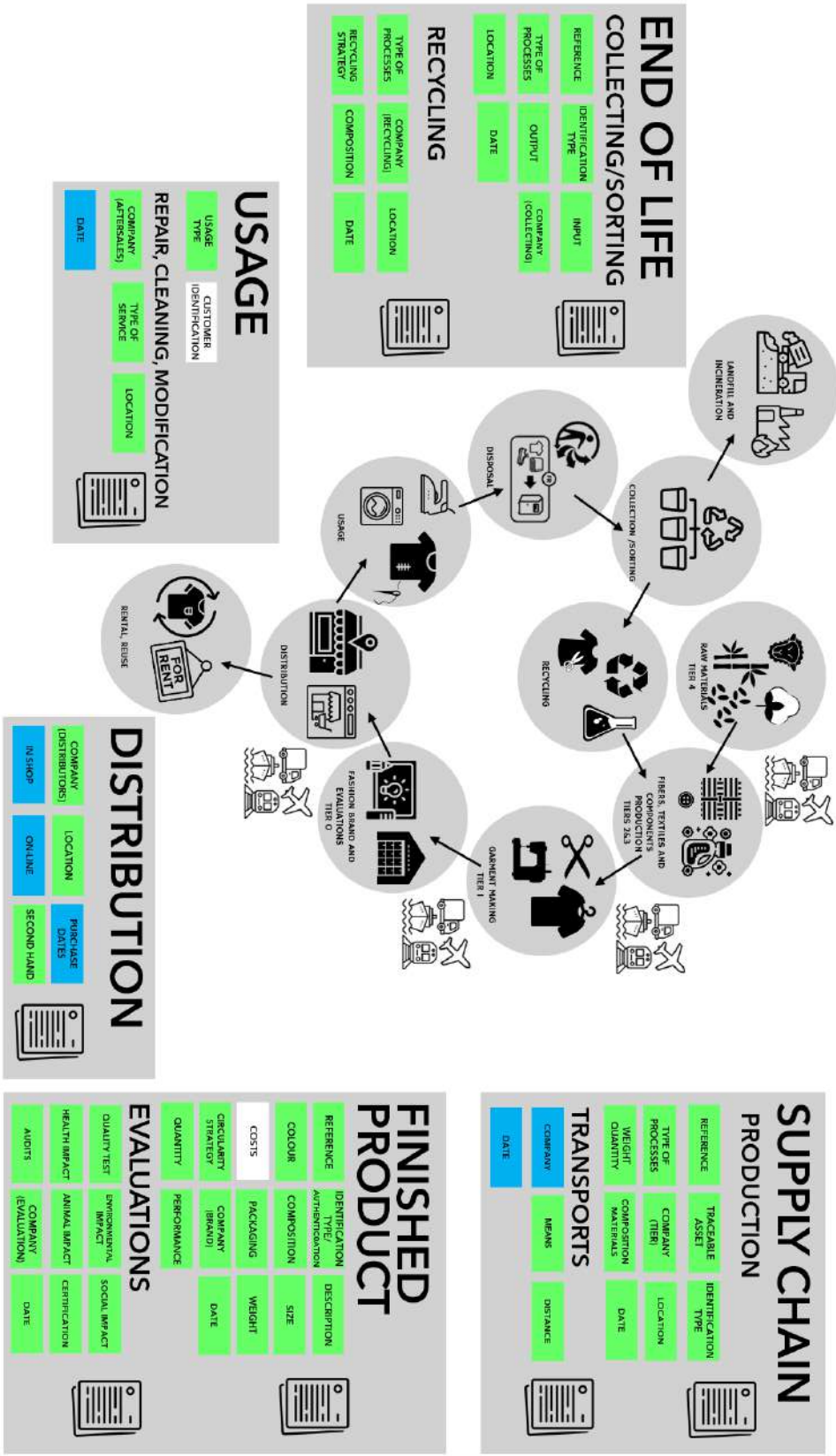


Figure 15 – Full circular DPP Model for phase 3

6.4. Policy options for the DPP's deployment in Europe

The DPP's potential to increase transparency and efficiency in information-sharing for both supply chains and consumers was highlighted in the Commission's proposal for a new **Eco-design for Sustainable Product Regulation (ESPR)** that takes into consideration other regulations and other Union policies (e.g., the **European Green Deal**, **Industrial Strategy for Europe, EU strategy for sustainable and circular textiles, Green Claims, Corporate Sustainable Due Diligence, Market Surveillance Regulation**). It also provides information on delegated act developments, regulation exemption rules, obligations of actors along the supply chains, regulation enforcement and compliance, policy, and standard harmonization among state members and with national policies, and SME implications. The ESPR contains information on technical aspects of the DPP that should apply to different sectors.

Deploying a Digital Product Passport (DPP) for the textile sector involves creating a digital identity for products that provides detailed information about their lifecycle, from production to disposal. Therefore, we proposed a step-by-step approach and policy options to be in line with the EU strategy for sustainable and circular textiles: "by 2030, textiles on the EU market should be durable and recyclable, largely made of recycled fibres, free of hazardous substances and produced in an environmentally friendly way while respecting social rights. Fast fashion should be 'out of fashion' and re-use and repair services would be widely available."

Here are the main policy options that could facilitate the deployment of DPP in the textile sector and each of these propositions are characterised according to the following classification:

- Technical impact **(T)**
- Social impact **(S)**
- Environmental impact **(Env)**
- Economic impact **(Eco)**
- Knowledge management impact **(KM)**

- **Regulatory Framework:** *Establish legal requirements for the implementation of DPP, defining the scope, standards, and timelines for compliance.* **(T, KM, Eco)**

This point includes to define exactly the mandatory information to disclose to validate or challenge the proposed DPP models in this study.

We encourage the European Commission and the Member States to safeguard the harmonisation of the DPP with other European and national policies and initiatives to ensure legal certainty and predictability with a sufficient transition period for businesses. This is a crucial point to avoid a fragmented EU single market and bureaucratic burdens for business operators, especially SMEs.

We propose also a step-by-step approach (3 phases in this study and 4 variables) for the implementation and the timeline of the proposed deployment's phases could be adapted according to the size and impact of the producers (companies, brands...). The implementation of the information disclosure within the DPP can take place in different stages according to the typology of producers. For example, the DPP can be mandatory for producers with an annual turnover of more than XX million euros and at least XX,000 units of products placed on the European market each year and then expanded to smaller organisations progressively.

- **Standardization and Interoperability:** *Develop and adopt standardized formats and protocols for DPP to ensure compatibility and interoperability across different platforms, systems, and technical devices.* **(T, KM)**

DPP needs common and structured identifiers and data exchange to guarantee interoperability and avoid data duplications that is also an environmental challenge. This would facilitate the exchange of information between stakeholders in the textile supply chain in particular, performance requirements for each product should rely on a harmonised and standardised methodology and be carefully fine-tuned to ensure technical and economic feasibility.

The DPP should be designed as a standard gateway base on the DPP's implementation on current databases, data infrastructures, data standards and data-sharing best practices in order to avoid duplication and an unnecessary administrative burden.

There are numerous existing solutions and initiatives to collect data with different modes: manually, import/export of spreadsheet, or by extracting or connecting with API (application programming interface), or standard (GTS[17]). The DPP could be developed in collaboration with other existing software dedicated to textile (non-exhaustive list): CRM (EON[18]), traceability of supply chain (Antares Vision Group[19], e-SCM[20], IDFACTORY[21], Retexcycle[22], Twintag[23], Trustrace[24]…), CAD/PLM/PDM/PIM (Modaris[25], inriver[26]…), ESG&CSR (Tilkal[27], Entity Systems[28], 3E Exchange[29]…), LCA/carbon footprint (PefTrust[30], Footbridge[31], Fairlymade[32], SGS[33]…), circular performance indicator (Circular IQ[34]…), material certification (Textile Exchange[35]).

The question of the interoperability of EU DPP for textile is already complex so it will be difficult to design a common DPP for different industrial sectors.

- **Data Privacy and Security:** *Implement strict data privacy and security measures to protect sensitive information contained in DPP.* **(S, KM, T)**

Policies should ensure compliance with data protection regulations and establish guidelines for data sharing and access taking into account that access rights should be differentiated for the various categories of data users (companies, authorities, consumers…). Current EU projects are ongoing[36], and the CIRPASS[37] project will provide results and preconisation about these points in

[17] https://www.globaltextilescheme.org/en/
[18] https://www.eon.xyz/
[19] https://www.antaresvisiongroup.com/
[20] https://e-scm-solutions.com/en
[21] https://theidfactory.com/
[22] https://retexcycle.com/en/retexcycle-system/
[23] https://twintag.com/
[24] https://trustrace.com/
[25] https://www.lectra.com/en/products/modaris-expert
[26] https://www.inriver.com/
[27] https://www.tilkal.com/
[28] https://www.entitysys.eu/
[29] https://exchange.3eco.com/
[30] https://peftrust.com/
[31] https://footbridge-impact.com/en/
[32] https://www.fairlymade.com/
[33] https://www.sgs.com/en/services/product-carbon-footprint
[34] https://circular-iq.com/
[35] https://textileexchange.org/d-trackit/
[36] https://www.trick-project.eu/
[37] https://cirpassproject.eu

March 2024 by focusing on developing a roadmap for DPP in three sectors: electronics, batteries and textiles.

In our study, DPP data is mainly held by brands and technological partners. Authorities will need access to this data, and if DPP become mandatory, there will be a need to anticipate the necessity of storing them for at least the product's lifespan.

The questions regarding data reliability and verifiability, legal liability for data published and access to data by companies along the whole supply chain remain unanswered to date and need to be duly addressed by the Commission and the Member States prior to the DPP's implementation. The creation of a European data space dedicated to DPP could fulfil this challenge.

For DPP implementations involving usage, we recommend to not integrate personal data of customers (e.g., user registrations, product ownership history), because adherence to General Data Protection Regulation (GDPR) principles will be mandatory. If the data of consumers in the DPP system are not integrated and fully anonymized, the GDPR requirements typically do not apply according to authorities like the European Data Protection Board (EDPB) that have set high standards for what constitutes effective anonymization.

- **Incentives for DPP adoption:** *Provide incentives for companies to adopt DPP, such as tax breaks, subsidies, or access to preferential financing.* **(Eco, KM, T)**

Encourage innovation through grants or competitions for developing DPP technologies and solutions. We must stress here the considerable amount of investment needed for the digitalisation of the textile ecosystem and therefore the European Commission, should increase their funding efforts and instruments in this regard.

There is also the need to create strong incentives for recycling in both production and demand. We underline the need for a competitive European secondary market for recycled materials that allows producers to move towards higher rates of recycled materials in their products.

We advocate to create "collaboratives marketplaces of circular materials" involving actors (sorters/recyclers/producers but also textile brand designers) to increase the rate of use of recycled materials.

- **Consumer Engagement:** *Educate and engage consumers about the value and significance of DPP to drive demand for products with digital passports.* **(S, Env)**

This central point needs to develop a standard methodology and effective system for information accessibility with a high level of affordability for all the consumers.

The information of the DPP need to be filtered, synthetised and simplified in a comprehensive format to empower the citizens. National initiatives and projects, as well as European Product Environmental Footprint (PEF) will contribute to define such standard for the methodology (for example for the footprint calculation).

There is a need to define also at the European level a synthetic and comprehensive customer interface of the DPP. We encourage to design a visual format like for example a textile eco-score (with A to E evaluations), graph, icons… that could be developed taking into account of national or brand initiatives. We think that the use of QR codes or digital labels that consumers can easily scan for information is widely accepted by customers.

- **Innovation and Technology Development:** *Foster innovation in digital technologies that support the data storage and the integration of DPP into textile products with the lower impact.* **(T, Env)**

The DPP ought to be readily available to various users, such as suppliers, consumers, and recyclers, by scanning a data carrier directly located on the product. This approach ensures that the information is accessible throughout the product's life cycle. Additionally, the Eco-design for Sustainable Product Regulation (ESPR) mandates that this data carrier must be physically attached to the product, its packaging, or included within the documentation that comes with the product.

To ensure interoperability, some features need to be standardised to guarantee compatibility with external components such as scanning devices. We encourage to benchmark tracking technology provider (atma.io[38], arianee[39], Authentic Vision[40], aware[41], Charming[42], circularity.ID[43], itmatters[44], Checkpoint[45], Trimco Group[46], tappr[47]…) but also to assess precisely the impact of the different technology to define the best candidates for DPP.

We advocate to analyse the impact (by a Lifecycle Analysis) of the different available data carrier technology (barcode, watermark, QR code, GS1, RFID Tag, NFT, Blockchain, DNA analysis...) to assess the footprint at a global scale.

For the choice, we must keep in mind that it could be nonsensic to integrate hight-tech technology with environmental impact for tracking millions of garments especially with the emergence of sustainable manufacturing processes like biodegradable and sustainable fibres (bio-based fibres) to be used throughout the textile value chain.

- **Monitoring and Reporting:** *Establish mechanisms for monitoring compliance and evaluating the impact of DPP on sustainability goals.* **(Env, Eco)**

We assert that transparency in product origins and the broader value chain is crucial. The DPP is well-positioned to make a substantive contribution in tandem with Extended Producer Responsibility (EPR) initiative, where the disclosure of material data is imperative for effective ecomodulation and the enhancement of recycling processes. This process requires regular reporting from companies on their progress and the outcomes can be achieved with DPP.

We encourage to launch DPP pilot projects during experimental phase and to set an implementation period for SMEs, and especially microenterprises. Based on lessons learnt from the pilot project and taking account of SMEs capacities, to support them in ensuring full compliance with the regulation.

Measuring the sustainability of garments produced outside the European market requires international collaboration on sustainability standards and certifications.

Adopting DPP globally, with interoperability with others information system can ensure that sustainability criteria are uniformly applied and communicated, facilitating a global shift towards sustainable garment production.

[38] https://www.atma.io/

[39] https://www.arianee.org/

[40] https://www.authenticvision.com/technology

[41] https://wearaware.co/

[42] https://www.charmingtrim.com/charming-digi

[43] https://circularity.id/

[44] https://itmatters.fr/

[45] https://checkpointsystems.com/

[46] https://www.trimco-group.com/solutions/productdna

[47] https://www.usetappr.com/

- **Circular Economy Integration:** *Align DPP policies with broader circular economy strategies, ensuring that product information includes end-of-life options such as reuse, repair, recycling, and disposal instructions.* **(Env, Eco, S)**

This point is important to stimulate brands to generate new sustainable business model and offer based on circularity by reducing impact and volume of product but capturing more added value by services (like proposed by the PSS -Product Service System approach).

This mindset change can be amplified by merging artistic and technological training for workers in the textile ecosystem, by continuously promote the mobility of skilled labour across Europe to preserve European knowhow and the cultural heritage of textile crafting skills.

We also encourage the establishment of incentives to support the DPP deployment in the reuse and rentals sectors, as well as businesses focused on extending the life of garments and their recycling.

There is a need to fund at both EU and national level into research, innovation and the scaling up of infrastructure[48] for the high-quality manual and/or automatic composition sorting of textiles in order for the industry to be ready to make use of collected waste by means of recycling, reusing or repairing and to reduce the drastically the impact due to the quantity of garments send in foreign countries.

There is also the challenge with the DPP to harmonise end-of-waste criteria and waste definition for textiles in order to ensure a move towards higher rates of recycled materials in textile products.

- **Capacity Building and Education:** *Support capacity building for all stakeholders in the textile sector to understand and implement DPP.* **(S, Eco)**

  This could include training programs, workshops, and educational resources on the benefits and technical aspects of DPP.

  The transition of the textiles ecosystem to a circular economy by implementing DPP can also present a significant potential for creating new green jobs that need to facilitate access to innovative educational curricula for the development of relevant skills, including for the necessary digital transition of the textile industry with DPP, in particular for SMEs which often lack skilled employees.

  We highlight here the need to increase the skills and attractiveness and perspectives of employment for young professionals in the textile ecosystem (by soliciting European initiatives[49]).

  We want also to underline the business opportunities and alternative business models for reuse and repair and their contribution to a more sustainable and circular textiles ecosystem, as well as the potential for job creation through the development of reuse and recyclability sectors in the EU.

- **Collaboration and Partnerships**: *Promote collaboration between governments, industry, and non-governmental organizations to support the development and deployment of DPP and circularity at national and European level.* **(KM, Eco)**

  International partnerships can help harmonize standards and practices across countries. At European level, there are some federations (EURATEX), clusters & network (EU Textile 2030,

[48] See examples: https://www.cisutac.eu/, https://cetia.tech/home-en, https://www.rehubs.eu/, https://reverseresources.net

[49] See examples: https://www.tclfskills.eu, https://new-european-bauhaus.europa.eu, https://www.metaskills4tclf.eu

Textranet), projects & initiatives (Textile ETP, NETFAS, TEXROAD) that can be solicited to collaborate to harmonize DDP standards.

The EU research and innovation agenda have to support DPP and generally the whole circularity for industrials sectors (especially for textile, transport, energy… with the worst impact on origin material extraction and pollutions).

The next funding opportunities such as the Next Framework Programme (FP10) or through the European Innovation Council (EIC) have to be oriented on a "worldwide circularity paradigm" as a societal challenge with also onboarding as leading role the European Institute of Innovation and Technology and Knowledge and Innovation Communities.

7. General conclusions about DPP

Digital Product Passport (DPP) is a decisive tool for circularity and can play an important role in enabling new sustainable business models for textiles. The Importance of DPP in the production of sustainable garments in Europe is vital for the textile industry, allowing brands to communicate their eco-friendly initiatives effectively at the crucial moment of purchase by the consumers. This approach not only meets the regulatory push for sustainability but also aligns with consumer expectations for transparency and ethical consumption, driving the industry towards a more sustainable future.

The research questions of this study were the following:

- What is the state of the art of the current situation in textile industry regarding its readiness and willingness to implement a Digital Product Passport? What is the most critical learning from similar initiatives from other industries already experienced in different sectors like construction, fisheries and agriculture?

These questions have been addressed by providing a state of the art of different sources of information (scientific, regulation, fieldwork, ongoing initiative) concerning DPP in different sectors. This study shows that the DPP is a hot topic for the different sectors and especially for the textile.

With this study on DPP dedicated to textile products, we have focused our attention on the essential data that enables the establishment of circularity within the textile sector. However, different initiatives and projects on DPP highlights the challenges to deploy the DPP to a wide range of products in other sectors, enabling an ambitious transition of the European economy to be even more global and cross-sectoral.

- What are the main challenges in making the DPP a feasible tool for the textile sector within the proposed timeline of the Commission?

The initiatives we have studied in this research are limited and focus on a portion of brand collections and current initiatives. The generalization of DPP to many products will need to address certain challenges. The effectiveness of the means employed to collect, analyse, and store this data relies on data standardization. It is necessary to define open standards and formats for DPP data to ensure interoperability and access for all stakeholders of circularity, including companies that do not have complex technologies and means to digitize their supply chain.

Another significant point revealed by our survey is the need for harmonization of regulations, market surveillance, and traceability, especially concerning products entering the EU market. It's mentioned that the DPP should support local expertise, particularly for SMEs, designers, and artisans, and should also integrate with open-source hardware communities and initiatives. DPP shall provide information on the final product set by legal requirements to comply with information requirements defined in Eco-design for Sustainable Product Regulation / Delegated Act e.g.: durability, reusability, recyclability, recycled contents.

- Assuming that the DPP will have to be implemented as a step-by-step, where can the most significant positive impact be achieved? And is it feasible to design the implementation accordingly?

The DPP is seen as an important step towards sustainable product lifecycle management, but there are questions and concerns about its practical implementation, including data security, costs, and the potential impact on businesses and global supply chains. Additionally, there are suggestions to

focus on essential and relevant data points, secure data collection and storage, and consider the long-term evolution of DPP.

There is a consensus that DPP will be positive for environmental by increasing the circularity of textile in the European market. We proposed in this study a step-by-step approach that can be adapted according to the different stakeholders by using the 4 proposed variables and taking into account of public/private access.

- How can the DPP help make textile-to-textile circularity more efficient by allowing collectors/sorters to gain quick, concise information on the garment bill-of-materials?

This study shows that the rate of reuse of textile could be monitored and be increased with the DPP by the information exchange among the value chain.

The DPP will facilitate the technical and organisation aspects to scale up the industrialisation of end of life in the textile sector that need to be rethink by a collective approach to increase the circularity.

- How can the DPP play a role in the implementation of extended producer responsibility schemes? How can we link the disclosure of product sustainability information to EPR to provide effective incentives to brands?

Overall, this study reflects the wide-ranging impact of integrating DPP into Extended Producer Responsibility (EPR) schemes, particularly in the context of ensuring sustainability, traceability, and responsible production practices in the garment and textile industry. PEF (Product Environmental Footprint) rules should be clearly integrated with the DPP to make data comparable. Assessment and verification should not be too burdensome for small textile companies. The vitality of the textile industry and the opportunities of small operators must be taken into account.

During our survey, we received multiple comments discussing the implementation of a global DPP and its integration into Extended Producer Responsibility (EPR) schemes, particularly in the context of sustainability in the garment and textile industry. There is a common emphasis and consensus on the need for transparency, consumer empowerment, and the standardization of sustainability criteria across the supply chain. The integration of the DPP into EPR schemes marks a transformative step towards sustainable product lifecycle management. By offering a transparent platform for tracking the environmental footprint of products, DPP enhances EPR schemes, enabling producers to provide detailed insights into the sustainability of their products from creation to end-of-life.

DPP can and will support implementation of EPR but the transition period must be progressive and long enough for companies to adapt their operations to the new legislation. The policy and regulatory landscape for textiles in the EU is going to change significantly over the next few years. Alignment between DPP with EPR regulatory reporting requirements (The Policy Hub 2023) will maximise overall efficiency for producers and regulators alike, fostering higher levels of compliance.

- How can we encourage the production of sustainable garments in Europe? How measure the sustainability of garments that are produced outside the European market?

Incentivizing brands to disclose product sustainability information is crucial. Strategies such as tax benefits, subsidies for adopting sustainable practices, and regulatory requirements for sustainability disclosure can drive brands towards transparency. Here, the interoperability with others systems like Product Information Management (PIM), Product Lifecycle Management (PLM), Enterprise Resource Planning (ERP), Lifecycle Analysis (LCA)… play a critical role as consolidators of this information, ensuring that detailed, accurate, and accessible sustainability data is available to the different stakeholders and consumers at the point of purchase. This not only empowers consumer choice but also positions sustainability as a competitive advantage for brands.

As the European Parliament (Ehler, C. et al. 2023), we stress the need to support SMEs to adopt DPP within the textile ecosystem by the creation of a network of regional and national sustainability and innovation textiles hubs to assist companies, in particular SMEs, in the twin digital and green transition. The authors note the opportunity which the Enterprise Europe Network and the European Digital Innovation Hubs may offer in this regard.

When the DPP will be mandatory in Europe, garments made outside of the EU should be subjected to the same DPP requirements as garments made in the EU to ensure fair competition rules between brands. The DPP can be also used to protect EU citizens from unsustainable textile production. European countries have national rules to produce textile products, using chemicals that are not harmful to the inhabitants of production areas and their users. That is why textiles that come from outside Europe should be controlled by DPP analyse and have laboratory tests to ensure that they do not contain products that are harmful to their users and that they are made by certified companies that do not use slave labour or use harmful chemicals.

The DPP concept indeed parallels the role of a traditional passport, but in the context of products, especially those circulating within or entering the European market. Just as a passport is a document that identifies a citizen and grants them the right to travel or gain entry into foreign countries, the DPP could serve as a digital identity for products, ensuring they meet the necessary standards and regulations for their lifecycle within the European market. The DPP can promote the production of sustainable garments in Europe and onboard foreign countries in a new sustainable circular economy paradigm.

The DPP have to be carefully implemented to ensure that it does not devolve into a bureaucratic burden that overshadows its beneficial intentions. It's essential that the framework for DPP is designed to streamline processes rather than complicate them, thereby preserving the initiative's core objectives of sustainability and transparency.

The DPP is not merely a requirement mandated by law; it represents a conscientious commitment to the welfare of future generations. By embracing DPP, we are not just complying with regulations, but are actively participating in a responsible act that lays the foundation for a more sustainable and ethical approach to production and consumption for the benefit of our planet and its future inhabitants.

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Annex: Online Survey and glossary of DPP

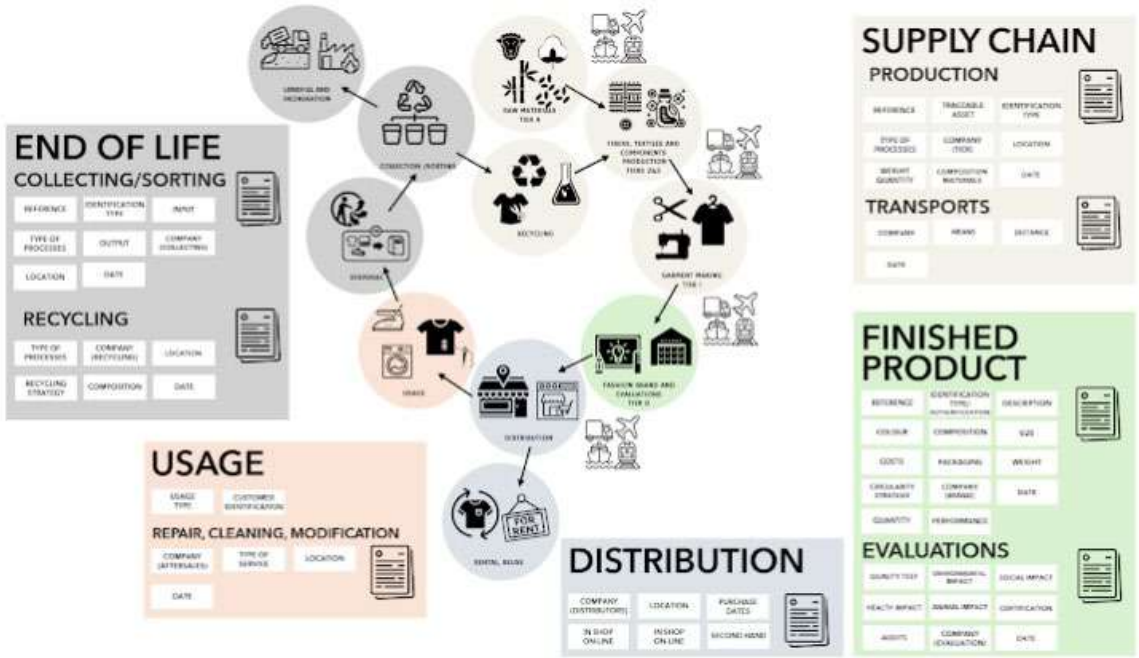
Digital Product Passport (DPP) for Textile/Fashion sector

This survey is conducted online to gather feedback concerning the DPP for the textile and fashion sector.

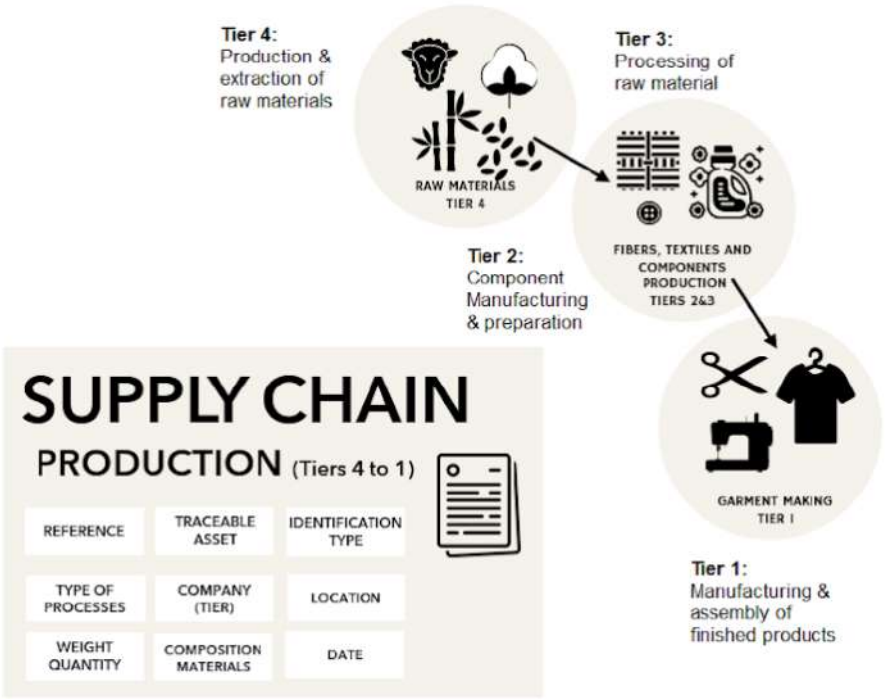
Your opinion about DPP

We kindly ask for your cooperation in completing this Digital Product Passport form.

Thank you for considering the evaluation of the following **DPP proposal**



Q1: In your opinion, what categories of information regarding **textile production** should be included in the Digital Product Passport? *



	Do not include in DPP	Unimportant to include	Neutral	Important to include	Very important to include	I don't know
REFERENCE	○	○	○	○	○	○
IDENTIFICATION TYPE	○	○	○	○	○	○
TRACEABLE ASSET	○	○	○	○	○	○
COMPOSITION MATERIALS	○	○	○	○	○	○
TYPE OF PROCESSES	○	○	○	○	○	○
WEIGHT / QUANTITY	○	○	○	○	○	○
COMPANY (TIERS)	○	○	○	○	○	○
LOCATION	○	○	○	○	○	○
DATE	○	○	○	○	○	○

Comments and observations about Question 1:

Glossary for Question 1 about Supply Chain:

Reference: A unique identification number used to track the different items or assets involved in the production of a product

Identification type: Technology used for information storing/retrieval during all supply chain steps (labels with serial number, bar code, QR code, RFID chip, NFC chip, Blockchain...)

Traceable assets: List of items (raw material, fabric, trims...) transformed/transported in logistics units along the whole supply chain to manufacture the product.

Composition materials: List of materials of the product...

Type of processes: List of processes concerning the manufacturing & assembly of the product (spinning, washing, combing, Knitting, weaving, dyeing, finishing, gluing...)

Weight/Quantity: List of the different materials, trims, and associated consumption

Company (Tiers): List of the companies involved in the supply chain:

- Tier 4: Production and extraction of raw materials (Breeder, Grower, Producer...)

- Tier 3: Processing into raw material (Spinning, washing, carding, combing...)

- Tier 2: Component Manufacturing and Preparation (Knitter, weaver, ennobler...)

- Tier 1: Manufacture of finished products (Assembler, garment workshop...)

Location: Country, region, or city where the operations are done

Date: Dates of the different operations

Q2: In your opinion, what categories of information regarding **finished product** should be included in the Digital Product Passport? *

	Do not include in DPP	Unimportant to include	Neutral	Important to include	Very important to include	I don't know
PRODUCT REFERENCE	◯	◯	◯	◯	◯	◯
IDENTIFICATION TYPE/AUTHENTICATION	◯	◯	◯	◯	◯	◯
PRODUCT DESCRIPTION	◯	◯	◯	◯	◯	◯
PRODUCT COLOUR	◯	◯	◯	◯	◯	◯
PRODUCT COMPOSITION	◯	◯	◯	◯	◯	◯
PRODUCT SIZE	◯	◯	◯	◯	◯	◯
PRODUCT WEIGHT	◯	◯	◯	◯	◯	◯
PRODUCTS QUANTITY	◯	◯	◯	◯	◯	◯
PERFORMANCE	◯	◯	◯	◯	◯	◯
COSTS	◯	◯	◯	◯	◯	◯
PACKAGING	◯	◯	◯	◯	◯	◯
CIRCULAR STRATEGY	◯	◯	◯	◯	◯	◯
BRAND	◯	◯	◯	◯	◯	◯
DATE	◯	◯	◯	◯	◯	◯

Comments and observations about Question 2:

Glossary for Question 2 about Finished Product:

Reference: Identification number of the finished product

Identification type / Authentication : Technology used for information storing/retrieval or authentication of the product (labels, serial number, barcode, QR , RFID, NFC, Blockchain...)

Description: Technical Sheet description (Product type, size/measurements, manufacturing technics...)

Product Characteristics: Color, size (XS – XXL), weight...

Quantity: Number of products

Composition: Bill of materials of the product...

Performance: Indicators such as expected lifespan and optimal recommendations of use/washing...

Costs: Cost transparency can include costs of materials, components, manufacturing, production and transport and pricing for second-hand sales

Packaging: Legal information regarding packaging (% of Recycled Materials, Reusability, Recyclability).

Circular strategy: Services proposed by brands to promote circularity of their products by foresight care, rental, repair, reuse, recycling, return...

Brand: (or Reseller) company name

Date: Dates of the different operations (delivery...)

Q3: In your opinion, what categories of information regarding **evaluations** should be included in the Digital Product Passport? *

	Do not include in DPP	Unimportant to include	Neutral	Important to include	Very important to include	I don't know
QUALITY TEST	◯	◯	◯	◯	◯	◯
ENVIRONMENTAL IMPACT	◯	◯	◯	◯	◯	◯
SOCIAL IMPACT	◯	◯	◯	◯	◯	◯
HEALTH IMPACT	◯	◯	◯	◯	◯	◯
ANIMAL IMPACT	◯	◯	◯	◯	◯	◯
AUDITS	◯	◯	◯	◯	◯	◯
CERTIFICATION	◯	◯	◯	◯	◯	◯
COMPANY (EVALUATION)	◯	◯	◯	◯	◯	◯
DATE	◯	◯	◯	◯	◯	◯

Comments and observations about Question 3:

Glossary for Question 3 about Evaluation:

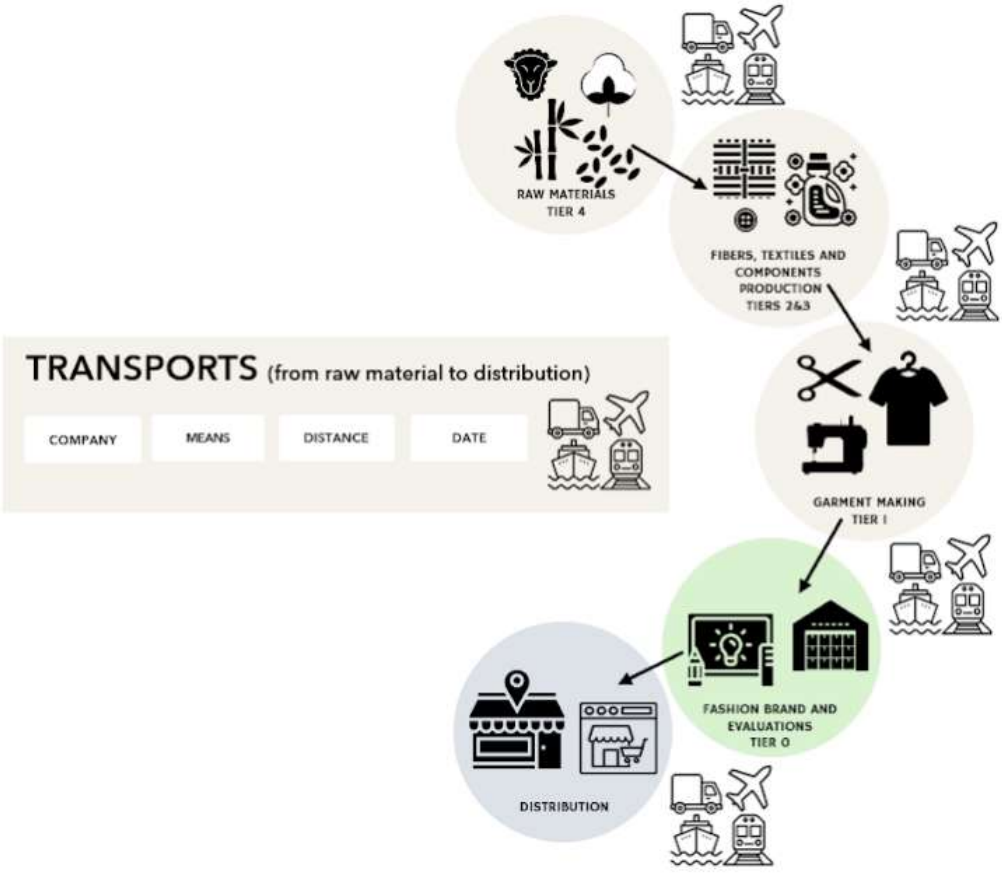
Finished products evaluations: including **quality tests**, and impact evaluations: **environmental, social, health, animals**...

Audits and certifications: compliance facilities verification by third parties, authorities, labels...

Company: organisation (company, authorities, NGO...) in charge of the evaluation/ verification/ control...

Date: Dates of evaluation/audit/test...

Q4: In your opinion, what categories of information regarding **transport** should be included in the Digital Product Passport? *



	Do not include in DPP	Unimportant to include	Neutral	Important to include	Very important to include	I don't know
MEANS	○	○	○	○	○	○
DISTANCE	○	○	○	○	○	○
COMPANY	○	○	○	○	○	○
DATE	○	○	○	○	○	○

Comments and observations about Question 4:

Glossary for Question 4 about Transport:

Means of transports: Maritime, road, air, rail...

Distance: traveled distance by the different items (raw material, finished product...)

Company: name of the transport companies...

Date: Dates of transport operations

Q5: In your opinion, what categories of information regarding **product distribution** * should be included in the Digital Product Passport?

	Do not include in DPP	Unimportant to include	Neutral	Important to include	Very important to include	I don't know
IN SHOP	○	○	○	○	○	○
ON-LINE	○	○	○	○	○	○
SECOND HAND	○	○	○	○	○	○
COMPANY (DISTRIBUTORS)	○	○	○	○	○	○
LOCATION	○	○	○	○	○	○
PURCHASE DATES	○	○	○	○	○	○

Comments and observations about Question 5:

Glossary for Question 5 about Distribution:

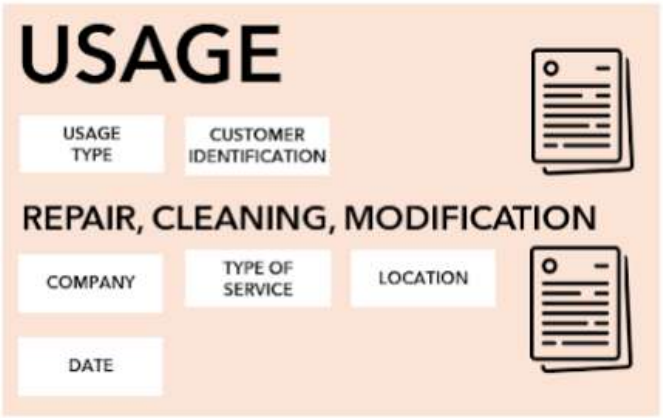
Type of purchase: In shop, on-line (website), second-hand...

Company: Distributor, shops, second-hand platforms/store...

Location: Country, region, city...

Date: Dates of purchase, or delivery...

Q6: In your opinion, what categories of information regarding **product usage** should be included in the Digital Product Passport? *



	Do not include in DPP	Unimportant to include	Neutral	Important to include	Very important to include	I don't know
USAGE TYPE	○	○	○	○	○	○
CUSTOMER IDENTIFICATION	○	○	○	○	○	○
TYPE OF SERVICE	○	○	○	○	○	○
COMPANY	○	○	○	○	○	○
LOCATION	○	○	○	○	○	○
DATE	○	○	○	○	○	○

Comments and observations about Question 6:

Glossary for Question 6 about Usage:

Usage type: Professional use/personal, protective equipment...

Customer identification: name (or number for anonymization)

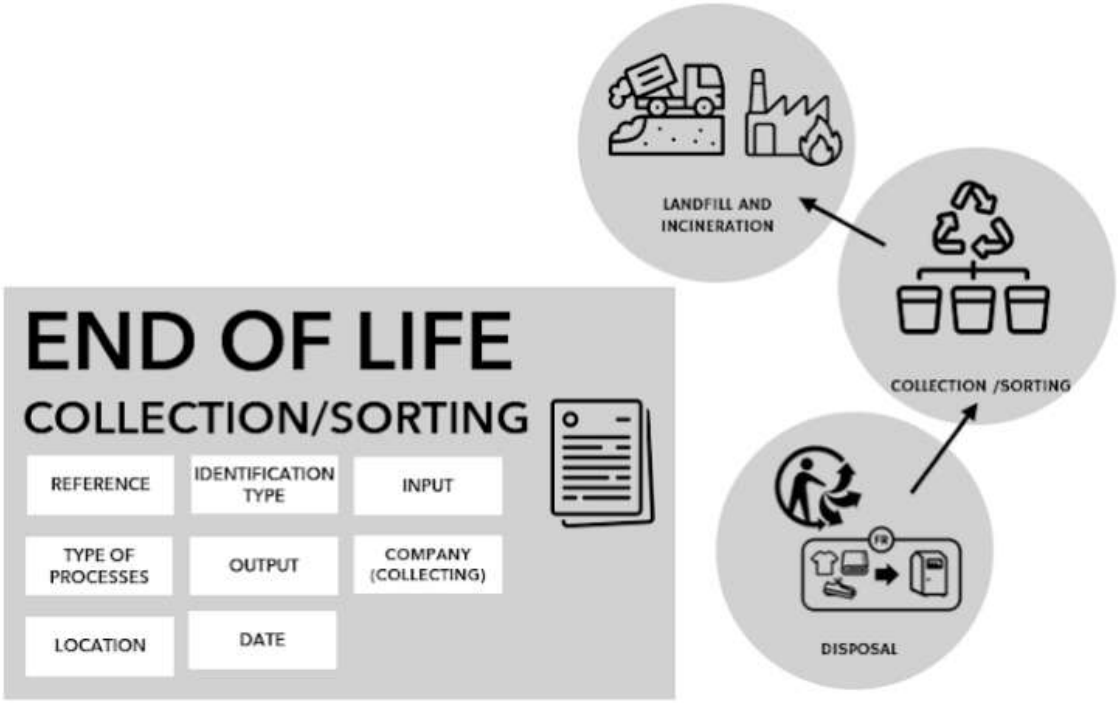
Type of services: aftersales operations on the product (maintenance, repair, dry cleaning, upcycling...)

Company: aftersales organisations (repairing, cleaning, upcycling...)

Location: Country, region, city where the aftersales services are done

Date: Dates of aftersales services...

Q7: In your opinion, what categories of information regarding **product end of life (Collecting & Sorting)** should be included in the Digital Product Passport? *



	Do not include in DPP	Unimportant to include	Neutral	Important to include	Very important to include	I don't know
REFERENCE	○	○	○	○	○	○
IDENTIFICATION TYPE	○	○	○	○	○	○
TYPE OF PROCESSES	○	○	○	○	○	○
INPUT	○	○	○	○	○	○
OUTPUT	○	○	○	○	○	○
COMPANY	○	○	○	○	○	○
LOCATION	○	○	○	○	○	○
DATE	○	○	○	○	○	○

Comments and observations about Question 7:

Glossary for Question 7 about End of life (collecting/sorting):

Reference: Identification number of the collected product

Identification type: Technology used for information storing/retrieval (labels with serial number, bar code, QR code, RFID chip, NFC chip, Blockchain...)

Types of processes: manual, automatic sorting, washing, double checking...

Input: deposit origin/type, quality of the collected product, product's brand origin...

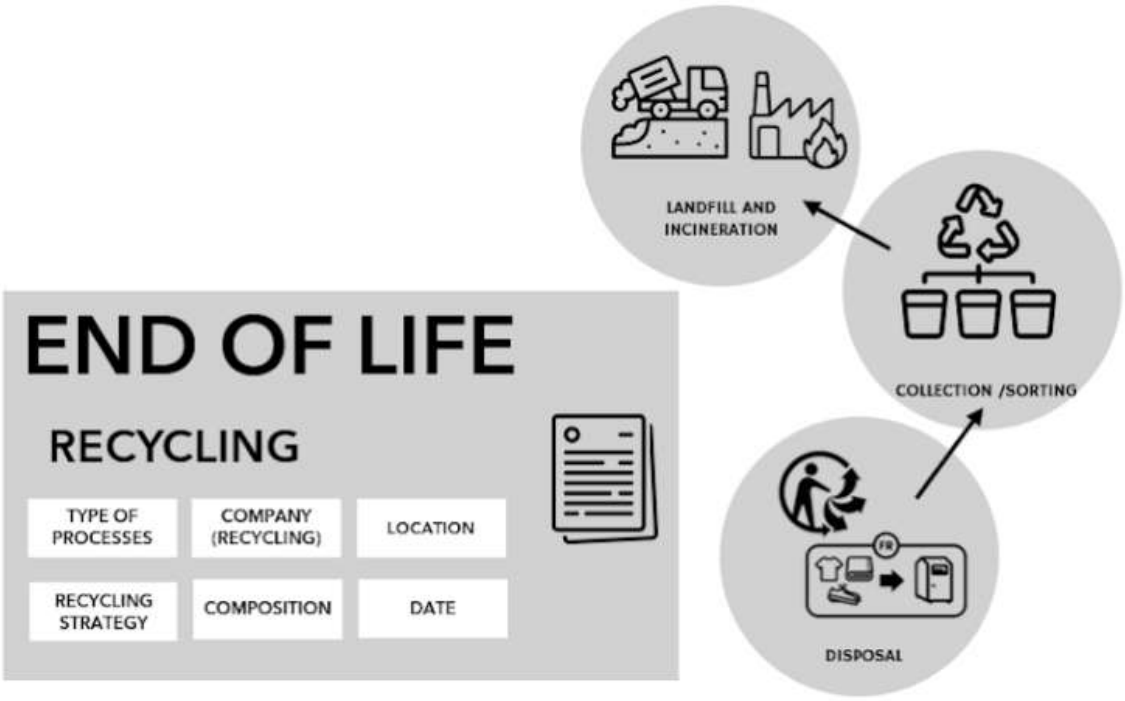
Output: reuse (second-hand, upcycling...), recycling or refuse-derived fuel

Company: Collecting/sorting operators and second-hand distributors

Location: Country, region, city for collecting/sorting operations and reuse destinations

Date: Dates of operations

Q8: In your opinion, what categories of information regarding **product end of life (Recycling)** should be included in the Digital Product Passport? *



	Do not include in DPP	Unimportant to include	Neutral	Important to include	Very important to include	I don't know
TYPE OF PROCESSES	○	○	○	○	○	○
COMPANY (RECYCLING)	○	○	○	○	○	○
LOCATION	○	○	○	○	○	○
QUANTITY RECYCLED	○	○	○	○	○	○
COMPOSITION	○	○	○	○	○	○
DATE	○	○	○	○	○	○

Comments and observations about Question 8:

Glossary for Question 8 about End of life (recycling):

Types of processes: mechanical recycling, chemical recycling...

Recycling Strategy: close-loop recycling (textile to textile), open-loop recycling/ downcycling (textile to others sectors) or refuse-derived fuel

Composition: final recycled material composition (characteristics, quality...)

Company: Recycling operators...

Location: Country, region, city...

Date: Dates of operations

Q9: Do you have any **general feedback or opinions** regarding the DPP contributions for the textile? For example:

- How can the DPP contribute to the implementation of extended producer responsibility schemes (EPR)?
- How can we effectively incentivize brands to disclose product sustainability information through EPR?
- How can the DPP promote the production of sustainable garments in Europe?
- How can we measure the sustainability of garments produced outside the European market?
-...

Q10: In your opinion, **what category of information is lacking** in this DPP proposal and in the futur?

Your profile

Your Name
(This information will not be disseminated)

Your function
(This information will not be disseminated)

Name of your Company/Organisation
(This information will not be disseminated)

Type of company/organisation *

- [ ] Brand, Reseller (Tier 0)
- [ ] Supplier company (Tier 1)
- [ ] Supplier company (Tier 2)
- [ ] Supplier company (Tier 3)
- [ ] Supplier company (Tier 4)
- [ ] Distributor
- [ ] Aftersales company (repair, cleaning...)
- [ ] Collection/sorting company
- [ ] Recycling company
- [ ] Transport company
- [ ] DDP expert company (technology, solution...)
- [ ] Labels/autorities
- [ ] Research organisation
- [ ] NGO / Association
- [ ] Media
- [ ] Other:

Country *

Message or comment for us?

We would like to express our gratitude for your participation in this survey. This study has been commissioned by the Panel for the Future of Science and Technology (STOA) European Parliament.

The study will be presented at the European Parliament on the 14th of March 2024.

Panel for the Future of Science and Technology (STOA)
European Parliament

This study focuses on the Digital Product Passport (DPP) within the textile industry, framed within the EU's strategy for sustainable and circular textiles. It examines the potential, needs, benefits, and challenges associated with deploying the DPP for all stakeholders throughout the European textile sector's value chain. The DPP offers benefits to all actors in this complex value chain, including producers, supply chain tiers, regulatory authorities, sorters, recyclers, and consumers. It is crucial to identify where added value can be generated, particularly in terms of traceability, sustainability, and business strategy. This research is grounded in a review of regulatory texts, scientific literature, existing initiatives, and proposes a generic model of the DPP for the textile sector. Drawing on a survey of over 80 stakeholders, it gathers essential insights and outlines a three-phase deployment scenario with policy options aimed at fostering a circular economy to minimize the sector's overall footprint.

This is a publication of the Scientific Foresight Unit (STOA)
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