Smart packaging:

a way to enhance

Made in Italy fashion

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Smart packaging: a way to enhance the Made in Italy fashion

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ABSTRACT

The thesis project aims to explore new possible applications of smart solutions in packaging to enhance the excellence of Made in Italy, with a focus on the fashion sector, through the application of the systemic approach.
This thesis project is part of the project "Future e-pack" launched by MICS - Made in Italy Circolare e Sostenibile, which goal is to enhance the role of packaging as a mediator between user and company, to convey information about the sustainability of the product contained through the application of digital solutions.
Based on this guideline, the thesis project analyzes the Italian fashion system in order to identify possible applications of smart packaging that can remedy the critical issues that emerged from this analysis.
The starting point is the identification of the functions of the packaging and the different technologies applied to it, so as to understand trends and latent needs for which smart packaging has already been used.
Moreover, the systemic methodology allows to analyze the Italian fashion system through a Holistic Diagnosis that has allowed to highlight the challenges and opportunities of this system.
By linking the two research projects, the holistic one and the one on packaging, the areas of intervention for the definition of the opportunities related to each of them have been identified.
Following the steps of the systemic methodology, the opportunities have been selected that have led to the delineation of three packages of integrable solutions. These strategies are based on the systemic principles of sustainability and the creation of connections, putting people at the center.
The first solution concerns the use of technologies that convey information about traceability and authenticity of the product.
The second solution involves a system of collection and reuse of used clothing, in order to reduce the generation of waste and the consumption of natural resources.
Finally, the third solution involves a system of return and reuse of recyclable packaging used in e-commerce.
These three solutions aim to promote sustainability and change the behavior of people by increasing the involvement and social and environmental responsibility that the latter should have towards their purchasing and action choices.

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INTRODUCTION

In a world where extreme consumerism and the rush to buy have created a series of serious problems, one of the most environmentally impacting is surely the production of a huge amount of waste that is literally suffocating our planet.
In marketing policies, ample space is given to the ways of packaging the product in order to entice potential customers to purchase, to the point that the containing becomes more important than the content itself. For valuable goods such as the excellence of Made in Italy, it would not be necessary to activate this psychological mechanism in the buyer, since the prestigious quality of the product is universally known and recognized. Among the areas in which Italian manufacturing excels worldwide, a prominent place is certainly occupied by fashion.
The thesis research aims to explore, through the systemic approach, new possible applications of smart packaging to enhance the Made in Italy, specifically in the fashion sector.

The thesis project aims to explore, through the systemic approach, new possible applications of smart packaging to enhance the Made in Italy, specifically in the fashion sector.
This thesis project is part of the project "Future e-pack. Digital Advanced Design for the Enhancement of Packaging as a 'Broadcaster' in the Made in Italy Supply Chain" launched by MICS - Made in Italy Circolare e Sostenibile, an Extended Partnership between Universities, of which the Politecnico of Turin is part, funded by the MUR - Ministero delle Università e della Ricerca thanks to the funds allocated by the European Union under the NextGenerationEU program from which the Piano Nazionale di Ripresa e Resilienza (PNRR) was born. It aims to explore the application of digital solutions to packaging to enhance its role as a mediator between the

company and the user by acting as a communication vehicle for the exchange of information on packaged products, in particular by focusing on their impacts within the Made in Italy supply chain. The aim is to improve the end-user experience and encourage them to make more informed and sustainable purchasing and consumption choices, and to facilitate the exchange of information between the actors involved throughout the entire supply chain. In order to achieve this goal, the design methodology derived from Systemic Design was used. The systemic approach is a cultural approach that identifies the relationships between the parts of a system as elements that generate the system itself. This approach focuses on the flow of matter, energy and information in order to develop an open system, inspired by the dynamics that exist in natural systems. As in nature, in fact, nothing is a waste and everything has value as the output of one process becomes input for another. The systemic approach outlines a design methodology that allows to analyze complex systems, detect their problems and outline solutions that allow to create a new system based on sustainability, connections and people.

This thesis is structured in four chapters. The first chapter examines the concept of packaging, going to investigate its main functions and then deepen in more detail the smart aspect, with a greater focus on active and intelligent packaging. In addition, there is an in-depth case study study so that you have a clear idea of the state of the art at which smart packaging is at the moment. The second chapter presents an in-depth research of the fashion system in Italy. The boundaries of our analysis have been extended to the entire Italian territory. The analysis was carried out in order to have a clear idea of the current fashion system in Italy starting from raw materials to the end of life. The system was analysed taking into account different aspects such as historical, productive, economic and legislative. The third chapter presents an in-depth analysis of the use of packaging in this sector, in particular by analysing the different types of packaging used along the supply chain, the flow of packaging used in the different sales channels and the end of life.
In the fourth and final chapter there is an analysis of the problems that have emerged from the research phase that lead to the delineation of three packages of solutions of which smart packaging is the protagonist.

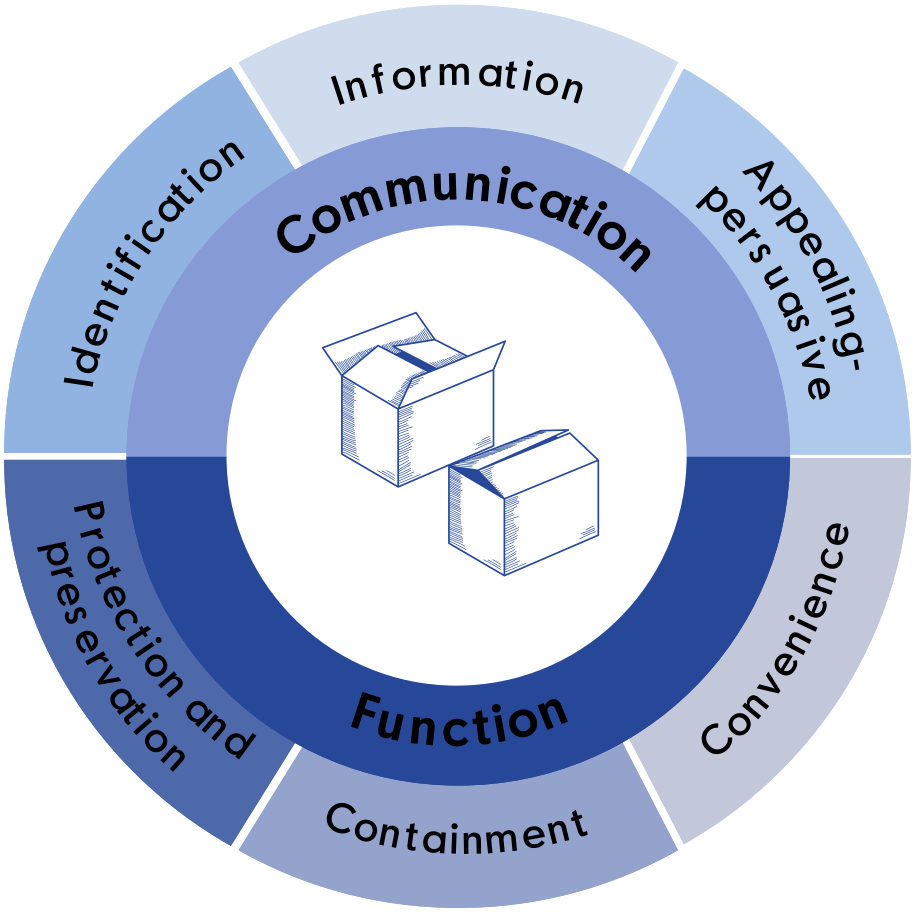
THE PACKAGING

1.1 WHAT IS PACKAGING AND ITS FUNCTION

Every object that has ever been created by man is born of a need, which can remain unchanged over time or evolve. Packaging is perhaps one of the most striking examples. Originally designed to contain food, drink and other items, as the archaeological findings show, the packaging is now not only limited to the function of containment but must also meet other needs, such as protect a product against deteriorative effects caused by exposer to and usage in the external environment, facilitate storing and communicate with the consumers by giving information about the content. But the role of the packaging is also to attract the interest of the customers by differentiating a product from its alternatives and increasing its visibility on the shelf by its shape and design. It comes as a use interface, provide consumers with ease of use and convenience. [1] [2]
It is therefore possible to divide the needs that the packaging must satisfy into two macro categories: communication and functions.

Under the function purpose, the packaging must:

- protect and preserve the product from mechanical and climatic hazards of the environment encountered during distribution and use
- contain the contents, and keep them secure until the contents finish
- be convenient, so adapt to the consumer's lifestyle, saving time, as those ready-to-eat meals, facilitating their handling, such as those easy to open, resealable etc.



Packaging functions schema

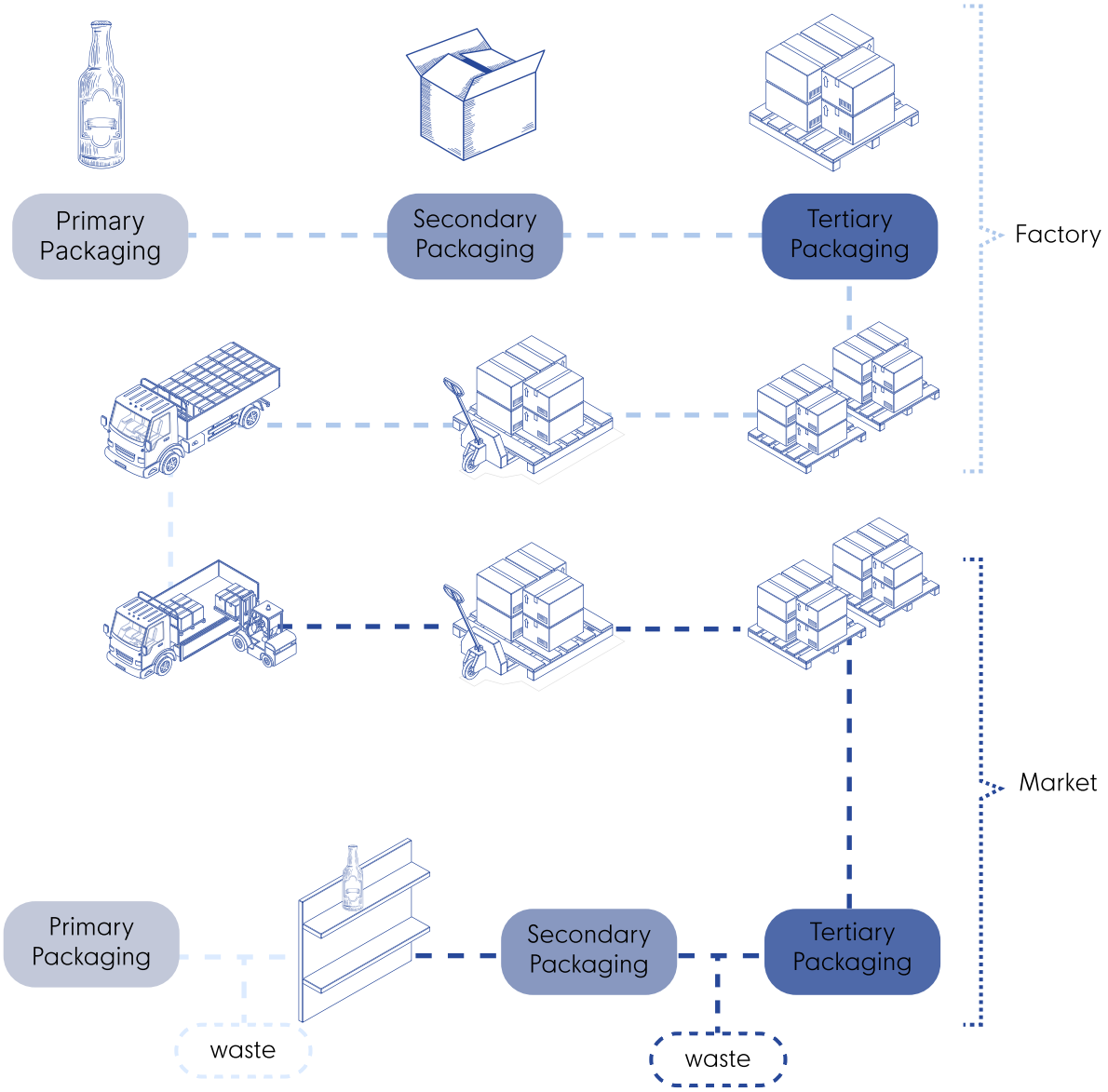
At the same time, under the communication purpose, it must:

- inform, so give to the user useful information about the product, the packaging itself and how the user has to interact with it and its content
- to be identifiable, so the packaging must make the product and the brand recognisable to the user
- to be appeal-persuasive, so draw the user's attention into the point of sale. [3] [2]

However, the additional functions reported by other authors, including machineability, that is, the packaging must allow packaging machinery to operate without too many stoppages or the process will be wasteful of material and uneconomic. [3] Also the aspect of sustainability, that is, to integrate the objectives of the sustainable development in its total life cycle throughout all stages of the supply chain, from the raw materials to the final disposal, is an ulterior factor to hold in high consideration. [4]
Every additional function and aspect to take into account, is closely linked to the type and level of packaging that you go to design.

1.2 LEVEL OF THE PACKAGING

The information that must be reported on the packaging by law or to attract users and the specific functions that must meet depend on the type of packaging on which you go to act. It is therefore necessary to go further into the levels of packaging. Article 35 of Legislative Decree No. 22 of 5 February 1997 divides the packaging into three types: primary, secondary and tertiary.
The primary packaging is in direct contact with the product and is designed to be a sales unit for the end user or consumer at the point of sale. It accompanies the product from the point of sale to the home of the final consumer. Primary packaging shall be marked to protect and inform the consumer (e.g., expiry date). In many cases, the marking of some elements for the identification and traceability of the product, are required and mandatory by law, which is why, usually, there are barcodes, data-matrix codes (e.g. QR Code) or the lot number. This is essential for the entire distribution chain, or for the eventuality of a lot recall.
The secondary packaging encloses the primary packaging. It is designed in such a way that a certain number of sales units are grouped together at the point of sale. It could be a small carton, a shrink wrap that groups a set of primary packaging together, or even display packaging. It can be sold to the consumer or serve to facilitate shelf replenishment operations. It accompanies the product from the warehouse to the point of sale. It can be removed without altering its characteristics, which is not possible with primary packaging. Because manufacturers must ensure the traceability of their products, packaged goods will often be marked with identifiers such as the GTIN code. The GTIN (Global Trade Item Number) code is a unique identifier for products sold globally: This ensures the unique identification of the items on the market along the entire distribution chain.
Tertiary packaging refers to bulk or transit packaging that contains multiple units for shipment. Tertiary packaging unifies and protects primary and secondary packaging and can include layers, wooden pallets and extensible wrapping. It is therefore designed to facilitate the handling and transport of a number of sales units or multiple packages. It, therefore, accompanies the product from the production factory to the warehouse. [5] [6]



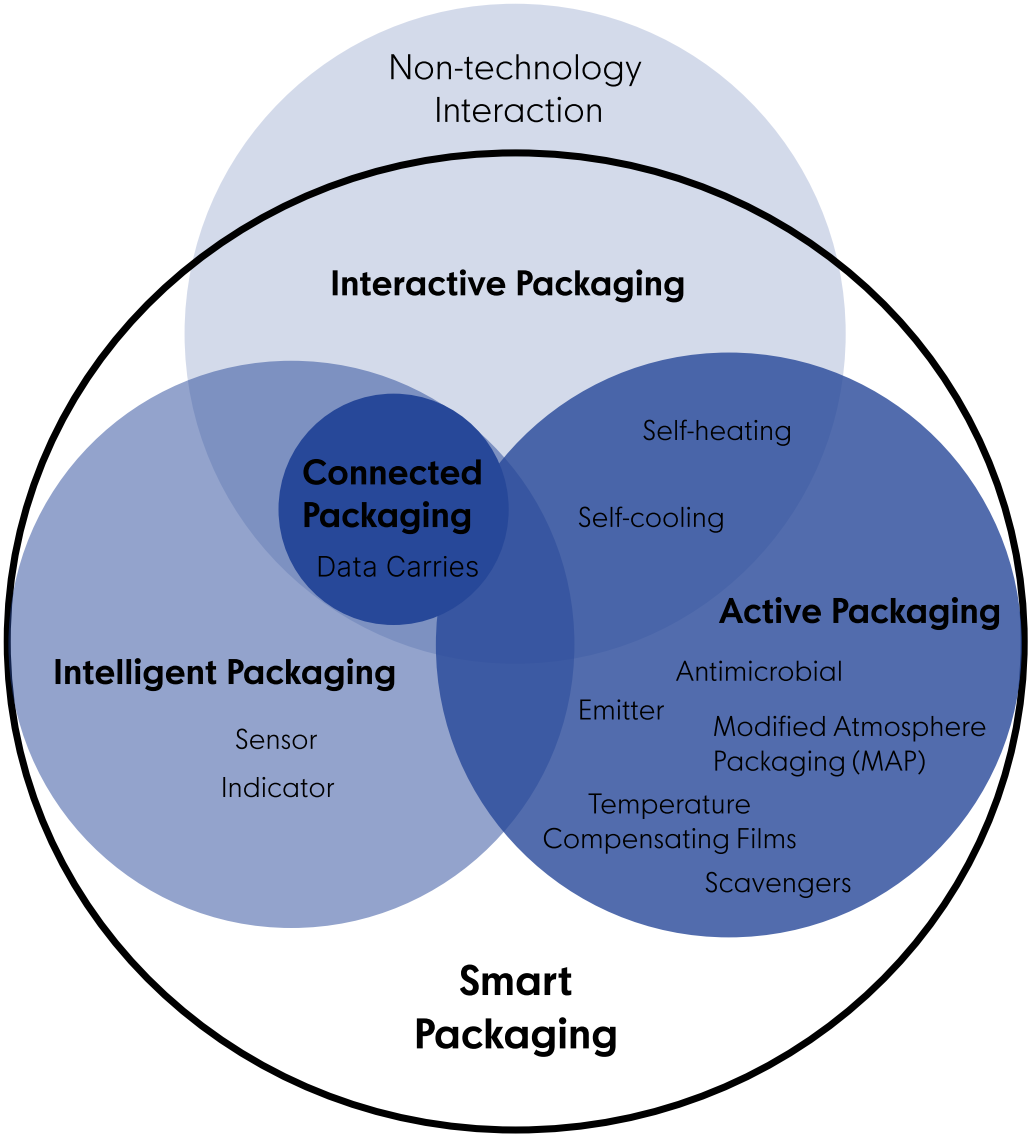
The packaging process [7]

1.3 THE SMART PACKAGING

Packaging, as mentioned, has not remained unchanged over time. An early example of evolution is found in the materials used, once used natural materials, easy to find, such as the use of leaves of mulberry bark with which the Chinese wrapped food to protect it or ceramics, as evidenced by the numerous Greek amphorae, or the famous containers, a little more macabre, of the Egyptian canopic vessels. With the passage of time and with the progress of human civilization, packaging has evolved with it, going to meet an increasing number of needs, increasing its functions to fully reflect modern civilization. We live in a society based on technology, connections and the exchange of information and packaging has evolved to integrate these aspects into it by creating a new type of packaging called smart packaging.

What is smart packaging?
There are many different definitions in the literature that try to explain what this relatively new type of packaging is. It can be defined as a packaging that is produced by adding new functions to traditional packaging and a material that not only improves basic functions but can also respond to external stimuli, in other words has interactive properties. Smart packaging therefore has the ability to communicate with its environment or with the consumer. This is achieved thanks to at least one of the electronic, mechanical, chemical, electrical or online technologies. These systems are focused on improving packaging functions to meet the growing demands of consumers, regulatory and safety requirements. These systems can be applied to primary, secondary or tertiary packaging. [1] [8]

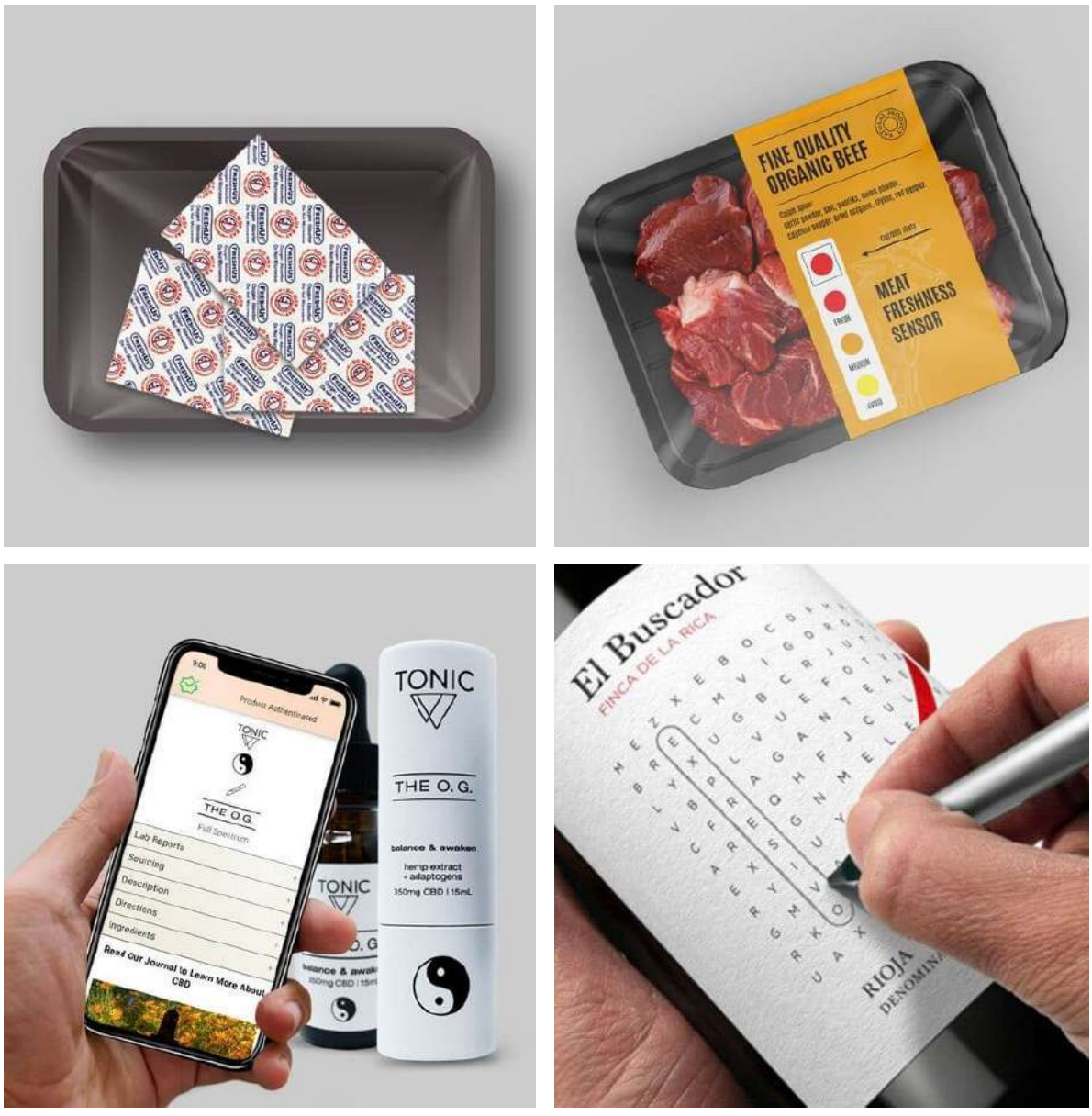
Smart packaging has many features and uses but there are four main categories: active packaging, intelligent packaging, connected packaging and interactive packaging. Active packaging means a packaging that is not limited to the protection of the product from external agents but is, also able to interact with the product itself to improve the shelf life and maintain the quality during storage. An example are the sheets that are in the meat packages. They are intended to absorb oxygen so as not to oxidize the meat and prolong its shelf life. [9] [2]
Intelligent packaging means packaging that allows you to monitor the product and transmit information. It then communicates the conditions of the packaged product, but does not interact with the product itself. An example, can be an indicator of freshness, therefore an integrated sensor that detects the freshness of the product and that communicates it to the user through a change of color on the packaging thus taking the place of the classic expiration date indicated with numbers. [9] [2] [10]
Connected packaging means packaging that has become an internet-connected device. It is a subset of intelligent packaging that integrates connecting technologies like NFC tags



Relation between the differnt type of smart packaging

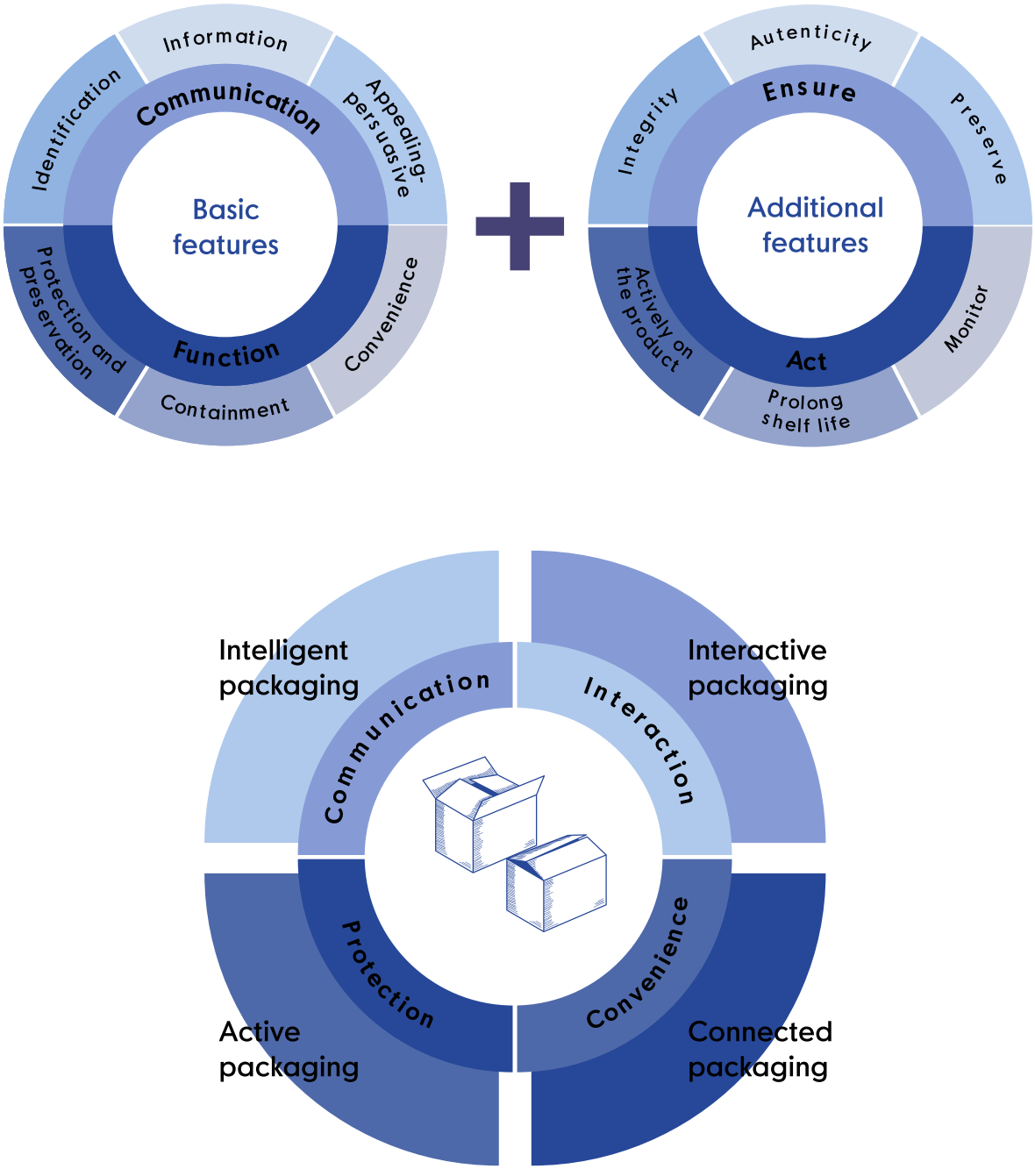
and QR codes directly into packaging. It provides information directly from the cloud, with real-time content, such as, give more information about the product, authenticate the product, or provide another type of customer engagement.
The user can interact directly with these technologies using their phone to launch digital experiences that act as a digital extension of physical packaging without the need to download an app. An example is the presence of a QR Code on the package, such as cereals. By scanning the QR Code you can access interracial games, additional information about production and the brand itself. [9] [11]

Interactive packaging is a type of packaging which have communicate features. This type of packaging is designed to create an interactive experience for the user, often leveraging technology to add value, information, and engagement opportunities. [12]
In the following sections we will analyze in more detail the different types of smart packaging.



In order: active packaging, intelligent packaging, connected packaging and interactvie packaging [13] [14]

In summary, the additional features that smart packaging allows serve to ensure product integrity, authenticity and preserve manufacturing characteristics. It can also actively act on the product, monitor the physico-chemical status of the product in real time and extend its life cycle. [15]



Purpose of the smart packaging

1.3.1 ACTIVE SMART PACKAGING

As mentioned in the previous section, active packaging is able to interact actively with the product. This interaction occurs by inserting subsidiary constituents into the packaging or into the packaging material to enhance the performance of the package system.

Depending on the type of interaction that takes place between the packaging and the product, active packaging is classified into four types: scavenger, emitter, preservative releaser or other.

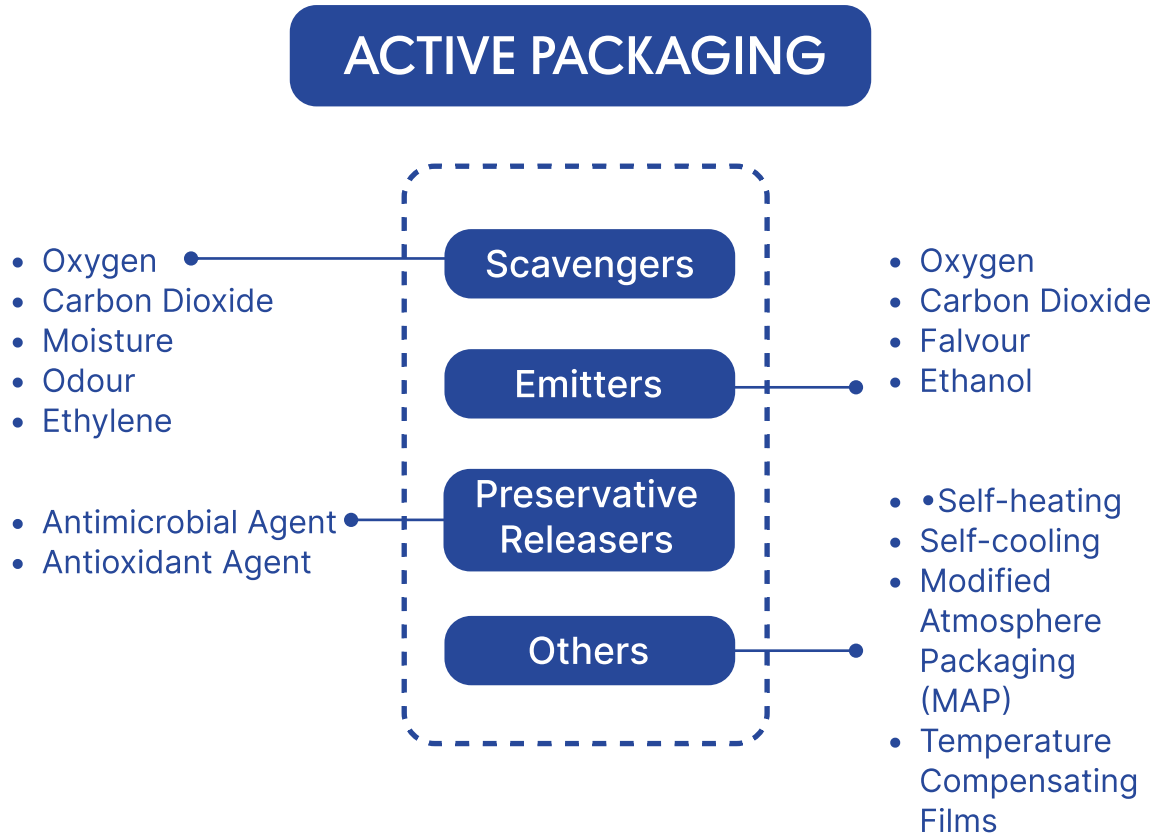
Scavengers help, by absorbing different substances produced by products, to preserve the content of the packaging, so as to extend its shelf-live, maintain quality and avoid the growth of aerobic microorganisms. On the market there are different types of scavengers that allow to absorb oxygen, carbon dioxide, ethylene, moisture and odours.

Emitters emit substances to compensate, usually, the absorption of oxygen or carbon dioxide so as not to collapse the packaging. Their are also use as antimicrobial agents. On the market there are different types of emitters that administer substances such as oxygen, carbon dioxide, ethanol and flavour.

The Preservative Releasers packaging have preservative properties for extending the shelf-life of a wide range of food products avoiding the oxidation of products or the formation of bacteria and fungi. On market there are two types of preservative releaser: antimicrobial agent and antioxidant agent.

The other type of active packaging affect the internal environment of the packaging by changing the temperature to provide an optimal consumption service or by controlling the atmosphere to preserve the product longer. To this category belong abilities such as self-heating and self-cooling and sistem that act on the internal environment of the packaging such as Modified Atmosphere Packaging (MAP) and Temperature Compensating Films. [xx]

We will go now to deepen each of these types.



Active packaging systems schema

OXIGEN SCAVENGER

Oxygen scavenger (also called oxygen absorbers) are usually used in food. They help maintain food product quality by decreasing food metabolism, reducing oxidative rancidity, inhibiting undesirable oxidation of labile pigments and vitamins which makes food less palatable, control enzymatic discoloration and inhibit the growth of aerobic microorganisms.
The main oxygen absorption systems are based on the removal of oxygen through the chemical oxidation of iron powder or the use of enzymes. In the first case, the iron placed in a small sachet is oxidized into iron oxide. For reasons of effectiveness, the material used to make the sachet is highly permeable to oxygen and in some cases to water vapor. Iron-based oxygen scavengers have the ability to absorb oxygen in products even with high humidity levels or even containing liquids.
In enzymatic oxygen scavenging systems, an enzyme reacts with a substrate to remove oxygen. These systems are more expensive than iron-based systems because of the cost of enzymes used for oxygen removal. Enzyme oxidation systems are also sensitive to temperature, pH and water activity. Both of this systems can be incorporated into sachets, adhesive labels or immobilised onto packaging film surfaces.
[9] [1].

To summarize, this category prolongs the shelf-life of the product while preserving its quality, also preventing the growth of aerobic microorganisms. In addition it is an active packaging solution already widely known and used. However, the substances that give it this particular property make it toxic if ingested.

CARBON DIOXIDE SCAVENGER/EMITTER

The function of carbon dioxide within a packaging environment is to suppress microbial growth. Therefore, a carbon dioxide generating system can be viewed as a technique complementary to oxygen scavenging. Many commercial sachet and label devices can be used either to scavenge or emit carbon dioxide. Given the usual combination of these two actions, absorb oxygen and carbon dioxide, on the market you can find sachets and labels with double action. They typically contain iron powder for scavenging oxygen and calcium hydroxide, which scavenges carbon dioxide when it is converted to calcium carbonate under sufficiently high humidity conditions. One of the problems that can be encountered when using absorbers is the collapse of the packaging or the development of a partial vacuum that can make the packaigng that the user wants to buy less attractive. To overcome this problem, dual-action oxygen scavenger/carbon dioxide emitter sachets and labels have been developed that absorb oxygen and generate an equal volume of carbon dioxide. These sachets and labels usually contain ferrous carbonate and a metal halide catalyst.[9]
To summarize, this category extends the shelf-life of the product while preserving the quality and Preserve the packaging visually. However, the substances that give it this particular property make it toxic if ingested. In addition it is not very well known and applied.

ETHYLENE SCAVENGER

Ethylene scavenger is most used in food field because ethylene is a growth-stimulating hormone that accelerate ripening and senescence through increasing the respiration rate of fruits and vegetables, thus shortening the shelf-life. For these reasons, the removal of ethylene from the headspace slows senescence, thereby prolonging shelf-life.

The best-known and widely used ethylene absorption system is potassium permanganate in silica. Potassium permanganate oxidises ethylene to acetate and ethanol and in the process changes colour from purple to brown, and hence indicates its remaining ethylene scavenging capacity. Silica is kept in a highly permeable sachet or can be

incorporated into a packaging film. Potassium permanganate can't be integrated into the surface of packaging films that contact food due to its toxicity. Another system for ethylene adsorption is based on impregnating zeolite with potassium permanganate. This system not only absorbs ethylene from the environment, but can also absorb other organic compounds such as benzene, toluene and xylene. Potassium permanganate-based ethylene scavengers are available in sachets to be placed inside blankets or tubes that can be placed in produce storage warehouses or are incorporated into sachets for inclusion into produce pack, and embedded into paper bags or corrugated board boxes for produce storage. [9] [1]
To summarize, this category extends the shelf-life of the product while preserving its quality. However, the substances that give it this particular property make it toxic if ingested.

MOISTURE ABSORBER

Food quality and shelf-life can be maintained and extended by using various absorbers or desiccants to soak up moisture, which inhibits microbial growth and moisture-related degradation of texture and flavour. Moisture scavengers physically absorb and hold onto water molecules from the surrounding environment. Drying agents use both physical and chemical sorption to remove moisture from the environment and lower relative humidity in the headspace. Silica gel is the most widely used moisture scavenger, as it is both non-toxic and non-corrosive. Moisture absorbers are manufactured in the form of sachets, pads, sheets, or blankets. [9] [1]
To summarize, this category prolongs the shelf-life of the product while preserving its quality, also preventing the growth of aerobic microorganisms. However, the substances that give it this particular property also make it toxic if ingested.

ODOUR ABSORBER/FLAVOUR RELEASER

Odour absorbers make use of antioxidants that allow to eliminate unpleasant odours caused naturally by the product, or arising from the material from which the packaging is made.
The use of flavour/odour absorbers and releasers in the commercial sector, such as food, is controversial because they can mask natural spoilage reactions, causing consumers to mislead them about the condition of packaged food. Europe and the USA have effectively prohibited flavour/odour absorbers and releasers due to this reason. Nevertheless, flavour/odour absorbers and flavour-releasing films are commercially used in Japan and have a several applications. [9]
To summarize, this category is very useful in the pharmaceutical industry as

it removes unpleasant odors that do not indicate a decay of medicine but are intrinsic to the substances used. But exactly this aspect, masking the smell, can mask the natural deterioration reactions and thus mislead consumers about the condition of packaged foods. For this reason, in Europe and the USA, their application in the food sector is illegal.

ETHANOL EMITTER

Ethanol emitters are a part of preservative releasing technologies, but they are usually packaged in sachets instead of impregnated preservative releasing films. Ethanol is used an antimicrobial agent because it's effective against mould, inhibit the growth of yeasts and bacteria. When food is packed with an ethanol emitting, moisture is absorbed by the food and ethanol vapour is released and diffuses into the package headspace. [9]
To summarize, this category extends the shelf-life of the product while preserving the quality, also increasing the safety of the product. However, the substances that give it this particular property make it toxic if ingested.

ANTIMICROBIAL AGENT

To inhibit the reproduction of microorganisms and bacteria that could compromise the quality of products, thus increasing safety and shelf life of the product, packaging materials, edible films and coatings can be reinforced with antimicrobials to form a protective barrier to prevent and delay microbial growth. An example can be the use of synthetic silver zeolite directly incorporated into food contact packaging film. The purpose of the zeolite is to allow slow release of antimicrobial silver ions into the surface of food products. [9] [1]
To summarize, this category extends the shelf-life of the product while preserving the quality, also increasing the safety of the product. However, this type of application is not so common.

ANTIOXIDANT AGENT

To prevent oxidation that could compromise product quality and increase safety and shelf life, antioxidant agents can be added to the packaging. Encasing antioxidants in packaging material is more beneficial than directly including them in food formulations. So, most of the antioxidant systems are manufactured in the form of sachets, pads or labels, or incorporated into the packaging monolayer or multilayer materials. [1]
To summarize, this category extends the shelf-life of the product while preserving the quality, also increasing the safety of the product. However, this type of application is not so common.

SELF-HEATING AND SELF-COOLING

Active packaging for temperature control involves the use of innovative insulating materials, self-heating and cooling packaging. An example of self-heating packaging is self-heating aluminium and steel cans and containers for sake, coffee, tea and ready meals. They are heated by an exothermic reaction when quicklime and water positioned in the base are mixed. For the self-cooling, an example is self-cooling cans that are cooled by an endothermic dissolution of ammonium nitrate and chloride in water. Another way to keep a product's refrigeration longer is by using an insulating packaging. One example is a special non-woven plastic with many air pore spaces that slows down the heat exchange between the inside and outside of the package. Another approach to maintaining refrigerated temperatures is to increase the thermal mass of the food package so that it is able to withstand temperature increases. An example is the ice cream trays used in ice cream shops. [9]
To summarize, this category optimizes the preparation time, as it "prepares" the product to be consumed whenever and wherever you want without the use of electricity to do so. However, these systems are single-use and difficult to recycle.

MODIFIED ATMOSPHERE PACKAGING (MAP)

Modified atmosphere packaging (MAP) is traditionally used to preserve the freshness of fresh produce by controlling their biochemical metabolism, for example, respiration. Nitrogen flushing, vacuum packaging and carbon dioxide injection have been used to create, inside the packaging, an unnatural gas environment. MAP dramatically extends the shelf life of packaged food products, and in some cases food does not require any further treatments or any special care during distribution. [9] [16]
To summarize, this category prolongs the shelf-life of the product while preserving its quality, but being an unreal environment can cause the growth of aerobic microorganisms if not properly preserved.

TEMPERATURE COMPENSATING FILM

Temperature compensating film is formed by polymers that can abruptly change their permeability, adhesion or viscosity when heated or cooled by just a few degrees by a built-in temperature switch. They can control the respiration rate of fresh-cut horticultural produce. This process of change involves a physical, it can be repeatedly reversed. [9] To summarize, this category prolongs the shelf-life of the product while preserving its quality, preventing the growth of aerobic microorganisms. In addition, this process, being physical and non-chemical, is reversible and repeatable. However, it is a type of application not very common and difficult to recycle.

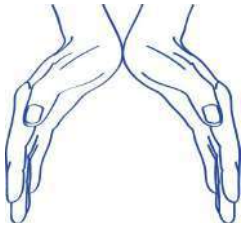
The following comparative table (TABLE 1) aims to summarize and compare the different types of active packaging on the basis of their porpuse, based on the division shown in the previous sections, the distance at which these systems act, technical stability and at what level of packaging they are applied.

TABLE 1: Comparison table of the different types of active packaging

Active System	Specific type	Purpose	Working distance	Technical stability	Level of application
Scavenger	Oxygen	Function: protection	In contact/Short	High	Primary Packaging
	Carbon Dioxide	Function: protection	In contact/Short	High	Primary Packaging
	Moisture	Function: protection	In contact/Short	High	Primary Packaging
	Odour	Function: protection	In contact/Short	High	Primary Packaging
	Ethylene	Function: protection	In contact/Short	High	Primary Packaging
Emitter	Oxygen	Function: protection	In contact/Short	High	Primary Packaging
	Carbon Dioxide	Function: protection	In contact/Short	High	Primary Packaging
	Falvour	Function: protection	In contact/Short	High	Primary Packaging
Preservative releaser	Antimicrobial Agent	Function: protection	In contact/Short	High	Primary Packaging
	Antioxidant Agent	Function: protection	In contact/Short	High	Primary Packaging
Others	Self-heating	Function: convenience	In contact	High	Primary Packaging
	Self-cooling	Function: convenience	In contact	High	Primary Packaging
	Modified Atmosphere Packaging (MAP)	Function: protection	In contact/Short	High	Primary Packaging
	Temperature Compensating Films	Function: protection	In contact/Short	High	Primary Packaging

It follows that the main function of active packaging is to protect against substances that alter the quality of the product. It works in contact or at a short distance from the product, so it's mainly located in the primary packaging.

PROTECT



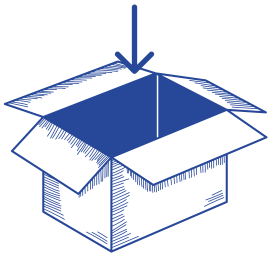
against substances that alter the quality of the product

WORKING DISTANCE

in contact

at short distance

LOCATED



inside the Primary Packaging

1.3.2 CASE STUDIES OF ACTIVE PACKAGING

In this section we present a collection of case studies, whose research has been carried out to understand the state of the art of the application of active packaging.
The case studies have been researched for each type of active packaging.

For each case study it is reported the type of active packaging that is used, the name of the product and the manufacturer so as to allow the identification, the year, to understand the start or development period of this technology, the place, in order to geographically place its use, the field of application, to understand in which sectors it is most used, the level of packaging to which it is applied, therefore when placed in a primary, secondary or tertiary packaging, the solution aim for which it is used and finally a brief description of its operation.

In the following sections this information will be used to make an overall picture of the state of the art of smart packaging, also combining the case studies related to intelligent packaging that will be presented in the next sections.

AGELESS™
Mitsubishi Gas Chemical Co. Ltd
Japan, since 1997

Type: Oxygen scavenger
Level: Primary Packaging
Application field: Food, Arts and Culture, Pharmaceuticals / Health, Consumer Electronics
Solution aim: Prolong the shelf-life of the product

The AGELESS™ is a bag containing iron powder that, reacting with oxygen, allows to remove oxygen by oxidizing iron powder, thus preventing food products from oxidizing in advance. It is also used to maintain the efficacy of medicine, protect metal and electronic parts, and even help preserve cultural artifacts such as books, textiles, and works of art. [17]

FreshMax®
Multisorb Technologies, Inc.
USA, /

Type: Oxygen scavenger
Level: Primary Packaging
Application field: Food
Solution aim: Prolong the shelf-life of the product

FreshMax is a bag containing iron powder that, reacting with oxygen, allows to remove oxygen by oxidizing iron powder, thus preventing food products from oxidizing in advance. By adhering directly to packaging, these oxygen absorbers for food minimize direct contact with your products. [18]

Oxyguard® containers
Toyo Seikan Kaisha Ltd.
Japan, /

Type: Oxygen scavenger
Level: Primary Packaging
Application field: Food, Beverage, Pharmaceuticals / Health, Cosmetics / Personal Care
Solution aim: Prolong the shelf-life of the product

This iron based oxygen scavenger is used in the middle of the multi-layer structure with a barrier layer on the outside and a polyethylene or polypropylene layer on the inside. This allows to have all the pakaging that is a oxigen scavengers itself without adding a separate sacket. [19]

SHELFPLUS®O2
ALBIS PLASTIC
Switzerland, /

Type: Oxygen scavenger
Level: Primary Packaging
Application field: Food, Beverage, Pharmaceuticals/Health, Cosmetics/Personal Care, Home Care / Household Accessories and Appliances
Solution aim: Prolong the shelf-life of the product

Originally developed by CIBA, SHELFPLUS® O2 is mixed with packaging materials such as PE, PP, PA or EVA. It acts as an absorber of the oxygen left in the packaging head space and in the product itself. In addition, it reduces the extent to which oxygen penetrates the packaging. [20]

DAREX®
Henkel
Germany, 2017

Type: Oxygen scavenger
Level: Primary Packaging
Application field: Beverage
Solution aim: Prolong the shelf-life of the product

Originally developed by Darex Packaging Technologies, DAREX® is a closure sealants, applied to crowns and caps, that ensure freshness of many bottled drinks. Its durable can sealants ensure food and beverage freshness and protection from contamination. [21]

ZerO2®
Food Science Australia
Australia, /

Type: Oxygen scavenger
Level: Primary Packaging
Application field: Food, Beverage,
Solution aim: Prolong the shelf-life of the product

ZerO2® is the registered trade name for a range of oxygen scavenging plastic packaging materials that are inactive until activated and thus can be subjected to conventional extrusion-based converting processes in the manufacture of packaging such as film, sheet, coatings, adhesives, lacquers, bottles, closure liners and can coatings. [9]

ZerO2 Cap
CARLSBERG
Denmark, 2019

Type: Oxygen scavenger
Level: Primary Packaging
Application field: Beverage
Solution aim: Prolong the shelf-life of the product, Instructions for Use, Reuse and End-of-Life Management

Beer stopper can absorb excess oxygen to keep the original quality and flavor longer. The absorption takes place thanks to the insertion of a coating in the inner part of the cap, this allows the excess oxygen to escape avoiding oxidation phenomena. [22]

CRYOVAC® BDF®
Sealed Air
USA, /

Type: Oxygen scavenger, Moisure absorber
Level: Primary Packaging
Application field: Food
Solution aim: Prolong the shelf-life of the product, User Social and Environmental Awareness, Instructions for Use, Reuse and End-of-Life Management

The roll-up film CRYOVAC® BDF® is an ultra-thin co-extruded polyolefin formulation with aroma and oxygen barrier properties as well as anti-condensation. It has been developed with multiple layers to protect the integrity of a wide range of perishable products. [23]

ATCO®
Standa Industrie
France, /

Type: Oxygen scavenger
Level: Primary Packaging
Application field: Food, Pharmaceuticals / Health
Solution aim: Prolong the shelf-life of the product

ATCO® can be produced in the form of sachet, label or strips cut. Its capacity of oxygen absorbion is allowed by iron based technology that absorb excess oxygen and preserve the quality of the product, thus avoiding the addition of additives. [24]

ATCO® BOX
EMCO Packaging Systems
UK, /

Type: Oxygen scavenger
Level: Primary Packaging
Application field: Food
Solution aim: Prolong the shelf-life of the product

ATCO® BOX Oxygen Absorbers are capable of absorbing oxygen in very large quantities to completely eliminate oxygen in bulk containers to extend shelf life & maintain product efficacy. All the components are fully traceable and contain only food grade materials. [25]

ATCO® Carbon Dioxide Absorbers Sachets
EMCO Packaging Systems
UK, /

Type: Carbon dioxide scavenger
Level: Primary Packaging
Application field: Food, Beverage, Gardening
Solution aim: Prolong the shelf-life of the product

ATCO® Carbon Dioxide Absorbers Sachets eliminate pack CO2 to maintain product efficacy and pack integrity. Particularly suitable for products that generate CO2 and run the risk of pack burst or displeasing aesthetics as a consequence of pack inflation. [26]

ATCO® IL
EMCO Packaging Systems
UK, /

Type: Oxygen scavenger, Carbon dioxide emitter
Level: Primary Packaging
Application field: Food, Pharmaceuticals / Health
Solution aim: Prolong the shelf-life of the product

ATCO® IL Oxygen Absorber and CO2 Generator eliminate pack oxygen and generate CO2 to compensate for the volume of oxygen absorbed. This is particularly suitable for rigid or semi rigid packs, where pack collapse is undesirable, and the generated CO2 compensates the pack volume that is lost due to the oxygen absorption. [27]

OxyFresh™ Sachets

EMCO Packaging Systems
UK, /

Type: Carbon dioxide scavenger, Oxygen emitter
Level: Primary Packaging
Application field: Food, Pharmaceuticals / Health, Gardenig
Solution aim: Prolong the shelf-life of the product

OxyFreshTM generates and releases oxygen into a pack headspace, and absorb CO2 if also required. [28]

OMRI LISTED Super Fresh Media Sachets

Ethylene Control, Inc.
USA, 2020

Type: Ethylene scavenger, Odour absorber, Antimicrobial agent
Level: Primary Packaging
Application field: Food, Gardening
Solution aim: Preserve the product during transport

OMRI LISTED Super Fresh Media is a sachet that, inserted inside the fruit crates allows you to protect the product throughout the shipping route, absorbing Ethylene produce by the fruit. This technology also prevents the formation of mold, rot, bacteria, viruses, listeria and more, it also removes odors. [29]

BION Ethyl Stopper

EMCO Packaging Systems
UK, /

Type: Ethylene scavenger
Level: Primary Packaging
Application field: Food
Solution aim: Prolong the shelf-life of the product

Manufactured using Tyvek® the ethylene absorber sachets are able to optimise the air by sanitising it by removing ethylene and VOC's in modified atmosphere packaging. The structure of the sachets allows gaseous interchanges and has a high level of resistance to water. [30]

KIF Sachet
Keep It Fresh
India, /

Type: Ethylene scavenger, Moisture absorber, Antimicrobial agent
Level: Primary Packaging
Application field: Food, Gardening
Solution aim: Preserve the product during transport

KIF sachet absorbs ethylene gas from the pack thanks to the special minerals in the sachet that selectively absorb ethylene molecules and gets oxidized to water and carbon dioxide. It, also, create a bacteria free environment to extend the shelf life of packed fresh fruit and vegetables. [31]

BEfresh Tecnology
Kerako Ceramic Technologies
Spain, /

Type: Ethylene scavenger, Moisture absorber, Antimicrobial agent
Level: Primary Packaging
Application field: Food, Gardening
Solution aim: Preserve the product during transport

BEfresh sachets remove ethylene and other contaminants, such as VOCs, fungal spores, bacteria, present in the transport and storage of fruit, vegetables and ornamentals. This sachets protect perishable products from source through to their final destination during the whole distribution chain. [32]

BEfresh Home
Kerako Ceramic Technologies
Spain, /

Type: Ethylene scavenger, Moisture absorber, Antimicrobial agent
Level: Primary Packaging
Application field: Food
Solution aim: Preserve the product during transport

BEfresh sachets absorbs ethylene gas that is naturally released by fruits and vegetables and causes ripening. It is a non-invasive and safe system that does not affect the natural cycle of perishable products, preserving their flavor and aroma. [33]

Ethylene Remover
Shenzhen Chunwang New Materials Co.,Ltd
China, /

Type: Ethylene scavenger
Level: Primary Packaging
Application field: Food
Solution aim: Preserve the product during transport

Ethylene Remover is a sachet that, absorbing ethylene, allows shippers to ship and store ethylene sensitive product without the fear of premature ripening. By removing Ethylene from the storage and shipping environment, growers and shippers reduce spoilage of their products.. [34]

Antimold-Mild®
Freund Corporation
Japan, /

Type: Ethanol emitter
Level: Primary Packaging
Application field: Food
Solution aim: Prolong the shelf-life of the product

Antimold-Mild® is made from powderized Ethanol. Ethanol gas undergoes gradual evaporation from powdered Ethanol filled in a packet to suppress the propagation of microorganisms adhering to foods and to prevent the growth of mold. [35]

Negamold®
Freund Corporation
Japan, /

Type: Oxygen scavenger, Ethanol emitter
Level: Primary Packaging
Application field: Food
Solution aim: Prolong the shelf-life of the product

Negamold® is a quality preservation agent with two functions of an Ethanol evaporation agent and oxygen absorber. This is suitable for quality preservation of foods high in water activity value (relative humidity), with the function of suppressing the growth of mold, propagation of Bacillus subtilis and fermentation by yeast. [36]

HI-DE CAN
Toyo Seikan Kaisha Ltd.
Japan, /

Type: Moisture absorber
Level: Primary Packaging
Application field: Food
Solution aim: Prolong the shelf-life of the product

A user-friendly container with moisture-proof and light-resistant properties with a combination of aluminum can body and plastic cap. Suitable for protecting contents vulnerable to deterioration by light or moisture. [37]

IntelliSorb®
Multisorb Technologies, Inc.
USA, /

Type: Moisture absorber
Level: Primary Packaging
Application field: Pharmaceuticals / Health
Solution aim: Prolong the shelf-life of the product

IntelliSorb® moisture regulating sorbents balance the physical and chemical and stability of products. These intelligent sorbents play an active role in environmental management within your device or drug packaging. [38]

CILICANT ACCUFLIP
CINICANT ACTIVE PACKAGING
India, /

Type: Moisture absorber
Level: Primary Packaging
Application field: Pharmaceuticals / Health
Solution aim: Prolong the shelf-life of the product

Accuflip is an Equilibrium relative humidity (ERH) regulator which regulates the ERH within a specified range to protect the product. It contains a specialised sorbent which has the ability to adsorb and desorb moisture in order to maintain the specified range of the ERH level according to the requirement of the primary packaging. [39]

TranSorb®
Multisorb Technologies, Inc.
USA, /

Type: Moisture abrosrber
Level: Tertiary Packaging
Application field: Logistics, Shipping and Delivery
Solution aim: Preserve the product during transport

TranSorb® packs are moisture absorbers for shipping containers. It ensure that cargos arrive to its final destination in a saleable condition by protecting products from moisture, rust and product spoilage. [40]

DesiMax®
Multisorb Technologies, Inc.
USA, /

Type: Moisture abrosrber
Level: Primary Packaging
Application field: Pharmaceuticals / Health, Consumer Electronics
Solution aim: Prolong the shelf-life of the product

DesiMax® moisture absorber labels is a square low-profile label that can be affixed, attached or incorporated onto packaging material that avoids co-mingling with product. It can be use in the packaging of pharmaceuticals, diagnostic test kits, medical products and electronics. [41]

Drikette®
Multisorb Technologies, Inc.
USA, /

Type: Moisture absorber
Level: Primary Packaging
Application field: Food
Solution aim: Prolong the shelf-life of the product

Drikette® Desiccant Paper is a clean, adsorbing paper comprised of silica gel. Featuring millions of adsorbent particles contained in a semi-rigid cellulose fiber matrix, this desiccant paper enables fast drying and versatility in package design. [42]

SaniSorb®
Multisorb Technologies, Inc.
USA, /

Type: Moisture absorber
Level: Primary Packaging
Application field: Pharmaceuticals / Health
Solution aim: Waste Disposal Optimization

SaniSorb® pouches provide fast and easy infectious waste fluid containment in operating room suction canisters and red bag waste by quickly solidifying biohazardous fluids. These proven pouches dissolve within minutes on contact with fluid to quickly absorb and immobilize liquids. [43]

Polysorb®
Multisorb Technologies, Inc.
USA, /

Type: Moisture absorber
Level: Primary Packaging
Application field: Consumer Electronics
Solution aim: Preserve the product

Fully integrated (built-in) sorbent protection that is invisible to the consumer. Turn ordinary internal product components into their own desiccant packaging. By incorporating desiccant properties directly into the product's thermoplastic component or housing, the products adsorb moisture their own hermetically sealed interior space. [44]

DesiCap®
Multisorb Technologies, Inc.
USA, /

Type: Moisture absorber, Odour absorber
Level: Primary Packaging
Application field: Pharmaceuticals / Health
Solution aim: Prolong the shelf-life of the product

DesiCap® custom-designed standard caps and vials are desiccants that keep bottle contents fresh and dry. With the desiccant sealed in the cap container, it protects the products from moisture damage or odors, using a desiccant cap that requires no additional insertion or application on production line. [45]

StabilOx®
Multisorb Technologies, Inc.
USA, /

Type: Moisture abrosrber
Level: Primary Packaging
Application field: Pharmaceuticals / Health
Solution aim: Prolong the shelf-life of the product

StabilOx® oxygen absorber packets are a solution that resides inside the packaging instead of the drug product. It has been produced for products that need oxygen and moisture management solutions. [46]

Dri-Fresh Fresh-Hold™ OA
Sirane Group
UK, /

Type: Moisture abrosrber, Odour absorber
Level: Primary Packaging
Application field: Food
Solution aim: Prolong the shelf-life of the product

Dri-Fresh® Fresh-Hold™ OA odour absorbing pad is a strip that allows both to absorb odors and moisture inside the packaging. They are safe for food and can be placed directly in contact with food. Retain their ability to absorb odors even when wet. [47]

CILICANT^{FG} ACTIVATED CARBONR
CINICANT ACTIVE PACKAGING
India, /

Type: Odour absorber, Flavour emitter
Level: Primary Packaging
Application field: Pharmaceuticals / Health
Solution aim: Prolong the shelf-life of the product

CILICANTFG Desiccant Pouches can be safely used in direct contact with pharmaceuticals and nutraceuticals. Activated carbon in pharmaceutical packaging is useful for enhancing the chemical stability of drug products by adsorbing persistent and reactive odour released by the formulation of the drug. [48]

+42°
The 42 Degrees Company
Spain, /

Type: Self-heating
Level: Primary Packaging
Application field: Beverage
Solution aim: Optimum consumption temperature, Optimize the preparation time, Ready to be consumed

This product is designed for both mass consumers but also for soldiers on mission and humanitarian missions, allowing them to have a hot meal. The self-heating can will heat up by +42°C in only 3 minutes. The heat comes from an exothermic reaction between calcium oxide and water. [49]

Push & Drink
Leonardos srl
Italy, /

Type: Self-heating
Level: Primary Packaging
Application field: Beverage
Solution aim: Optimum consumption temperature, Optimize the preparation time, Ready to be consumed

Push&Drink is a range of instant beverages with a technology that heats the drink in its own pouch, so the consumer always have a hot drink handy. The coffee or tea in the pouch is separated from the heating system. [50]

Pocket Bar Auto-Riscaldante
Pocket Bar
Italy, /

Type: Self-heating
Level: Primary Packaging
Application field: Beverage
Solution aim: Optimum consumption temperature, Optimize the preparation time, Ready to be consumed

Pressing the part indicated on the package, inside one of the compartments breaks a layer of aluminum that causes an exothermic reaction between the calcium oxide and the water contained in the sachet. This reaction generates heat which is then transferred, by means of tinplate, to the beverage contained in the other compartment. [51]

Gogol-Mogol
KIAN
Russia, 2011

Type: Self-heating
Level: Primary Packaging
Application field: Food
Solution aim: Ready to be consumed

Each egg is packaged individually in a multi-layered container. The external layer is made of recycled cardboard; the layer below contains some chemicals which are activated when a tag is pulled. A chemical reaction is then triggered, heating up the egg. After a few minutes, the egg is fully cooked and ready to eat. [52]

Self-Chilling Can
ICTech
South Korea, 2018

Type: Self-cooling
Level: Primary Packaging
Application field: Beverage
Solution aim: Optimum consumption temperature, Optimize the preparation time, Ready to be consumed

Icetech has made a can that self-cools in a very short time. [53]

Pocket Bar Auto-Raffreddante
Pocket Bar
Italy, /

Type: Self-cooling
Level: Primary Packaging
Application field: Beverage
Solution aim: Optimum consumption temperature, Optimize the preparation time, Ready to be consumed

Pressing the part indicated on the package, inside one of the compartments breaks a layer of aluminum that causes an endothermal reaction between ammonium salts and the water contained in the sachet. This reaction generates freshness which is then transferred, by means of tinplate, to the beverage contained in the other compartment. [54]

Self-Cooling Cosmetics Container

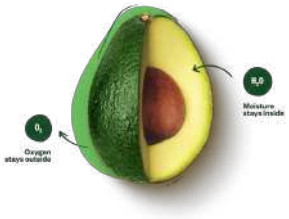
ICTech
South Korea, 2018

Type: Self-cooling
Level: Primary Packaging
Application field: Cosmetics / Personal Care
Solution aim: Optimum consumption temperature, Optimize the preparation time, Ready to be consumed

Icetec come up with self-cooling cosmetics. The consumers are able to keep using cooled cosmetics at every time they pump it. No more extra cooling device is required to get cooled cosmetics. [55]

Apeel

Apeel
USA, 2019



Type: Modified Atmosphere Packaging
Level: Primary Packaging
Application field: Food
Solution aim: Prolong the shelf-life of the product, Preserve the product during transport

Apeel is an additional peel recreated with the same properties of natural peels. This is a coating that blocks moisture inside and rejects oxygen avoiding the production of microbes that will deteriorate the quality of the fruit. [56]

Xgo™

j-tech systems
UK, /

Type: Modified Atmosphere Packaging
Level: Primary Packaging
Application field: Food
Solution aim: Prolong the shelf-life of the product, Preserve the product during transport

Is a resealable lidding film for produce that's packed in PET trays. The film is one of the Xgo™ modified atmosphere range of products and features condensation control. This film slows down the respiration of fresh produce, inhibits production of ethylene, inhibits microbial decay and minimises weight loss and shrivelling. [57]

Intelimer™Tape Wax Substitute type
Nitta
Japan, /

Type: Temperature Compensating Films
Level: Primary Packaging
Application field: Consumer Electronics
Solution aim: /

This tape bonds at the switching temperature and above, and holds fast when cooled below that. Can be peeled off if heated up to above the switching temperature again. [58]

Matter
Matter
USA, 2020

Type: Antimicrobial Agent
Level: Primary Packaging
Application field: /
Solution aim: Prolong the shelf-life of the product

Matter provides protection against microbes thanks to silver ion technology that eliminates the opportunity for microbes to exist on a protected surface. It stops bacteria's ability to metabolize by preventing it from converting nutrients into energy, which inhibits bacterial survival, reproduction and colonization. [59]

SANICO®
Standa Industrie
France, /

Type: Antimicrobial Agent
Level: Primary Packaging
Application field: Food
Solution aim: Prolong the shelf-life of the product

Sanico® is a solution of antifungal coating that recalls the traditional French technique of preservation of cheese and salami, ensuring the non-fungal. [60]

1.3.3 INTELLIGENT SMART PACKAGING

Intelligent packaging integrates cutting-edge technologies to create interactive and functional packaging solutions. In this field, the application of technology aims to monitor the state of the product and transmit relevant information. Unlike active packaging systems that interact directly with the product, intelligent packaging does not directly affect the product itself. Depending on the specific goals and technologies employed, intelligent packaging can offer a variety of functionalities.

Intelligent packaging systems primarily utilize three types of technologies: data carriers, indicators, and sensors. [61]

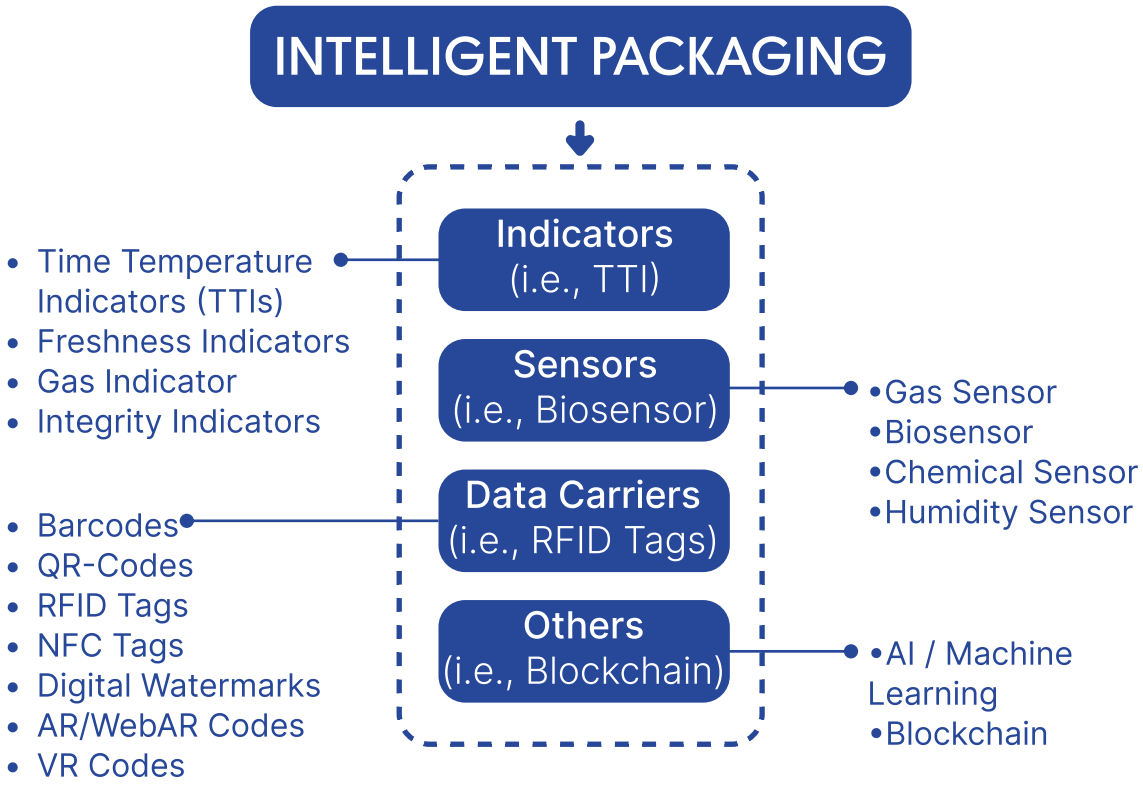
Among these, various indicators are employed to track critical data: Time Temperature Indicators (TTIs) and Freshness Indicators reveal temperature fluctuations during storage or transport, ensuring products remain in optimal conditions. Gas Indicators and Integrity Indicators monitor gas composition and packaging integrity, vital for product freshness and safety.

Intelligent packaging also includes a range of advanced sensor technologies: Gas Sensors, Biosensors, Chemical Sensors, and Humidity Sensors: These sensors can detect specific environmental conditions within the packaging and provide real-time feedback through smart devices when necessary.

Furthermore, intelligent packaging systems extensively use various data carrier technologies: Barcodes, QR Codes, RFID Tags, NFC Tags, Digital Watermarks, and Augmented Reality/ Virtual Reality Codes: These technologies not only track product information but also provide detailed data about the product's origin, processing, and shelf life.

With the integration of Artificial Intelligence/Machine Learning and Blockchain technologies, intelligent packaging is increasingly applied in food safety and supply chain management, offering more comprehensive and transparent product tracking and quality control solutions. The development of these technologies significantly enhances operational efficiency in the food industry and consumer trust.

Next, we will delve into the various technological applications within intelligent packaging.



Intelligent packaging systems schema

INDICATORS

Indicators determine the presence or absence of a substance, the extent of a reaction between different substances or the concentration of a particular substance. This information is visualized by direct changes, e.g., different color intensities. Depending on the indicator they are placed inside or outside of the package.

Time-Temperature Indicators (TTIs) are smart packaging technologies designed to monitor and display the elapsed time and temperature history of a product from the time of production or packaging to its consumption. The advantages of TTIs include providing real-time information about temperature exposure, which is helpful for transportation, and enhancing supply chain visibility. However, there are also disadvantages such as high cost, limited shelf life, potential for false readings, and the complexity involved in the design.[61]

Integrity indicators help monitor and ensure the integrity or condition of the packaging itself. These indicators detect and communicate whether the packaging has been tampered with, damaged, or compromised in any way. The advantages of integrity indicators include ensuring products remain safe and uncontaminated by detecting unauthorized tampering or damage, thereby boosting consumer confidence. On the downside, they can be costly, difficult to share data, and require specific infrastructure.[62]

Gas indicators or gas leakage indicators in smart packaging are technologies designed to detect and communicate the presence of gases, especially in situations where gas leakage can be hazardous or affect the quality of packaged products. The advantages of gas indicators include keeping products safe and ensuring product integrity, which is vital in industries like pharmaceuticals and medical devices to maintain sterility and prevent contamination during storage and transport. However, integrating gas indicators into packaging can increase production costs, require proper calibration and maintenance for accuracy and reliability, and have limited applicability.[63]

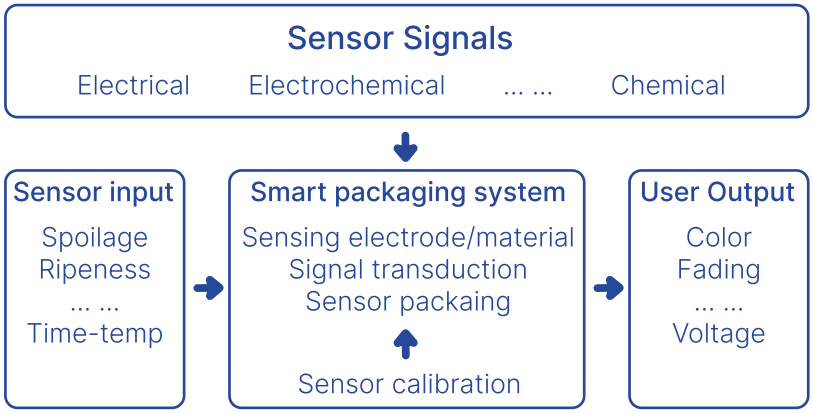
Freshness indicators, also known as freshness sensors or freshness labels, monitor and communicate the freshness or shelf life of perishable products, such as food and beverages. The advantages of freshness indicators include improved consumer experience, enhanced food safety, and assistance for retailers and suppliers in inventory management by identifying products and enabling better stock rotation. However, the disadvantages include limited applicability as freshness indicators are most beneficial for perishable products, potential for false readings, and high cost.[61]

The table below presents a comprehensive comparison of four major intelligent packaging indicators. These indicators include Time Temperature Indicators (TTIs), Freshness Indicators, Gas Indicators, and Integrity Indicators. Each indicator varies in terms of cost, sensitivity, fineness, durability and stability, security, environmental impact, and purpose.

Indicators	Cost	Sensitivity	Fineness	Durability and Stability	Security	Environmental Impact	Purpose
Time Temperature Indicators (TTIs)	Low	High	High	Medium	Medium	Low (Use of environmentally friendly materials, recyclable)	Function: protection
Freshness Indicators	Medium	High	Medium	Medium	Medium	Low (Small amount of chemical substances, no significant environmental impact)	Function: protection
Gas Indicator	Medium	High	Medium	Medium	High	Medium (may contain special sensors and require special handling of waste)	Function: protection
Integrity Indicators	Low	Medium	High	High	High	Low (usually physical changes, not involving harmful chemicals)	Function: protection

TABLE 1: Comparison table of the different types of Indicators

Sensors



Details of a smart packaging systems[71]

A sensor is a device used to detect, locate, or quantify energy or signal-transmitting material to evaluate its physical and chemical properties. Most sensors have two basic and important parts: the receiver and the converter. In the context of smart packaging, sensors play a crucial role in improving product quality and safety by monitoring critical parameters. They provide real-time monitoring and traceability, enabling better supply chain management, and help reduce waste and spoilage by closely monitoring conditions.

However, the use of sensors in packaging also has drawbacks. The increased cost of sensors can be significant, and they require regular maintenance and calibration to ensure accuracy, posing reliability issues. Additionally, the production and disposal of electronic sensors raise environmental concerns. The sustainability of these sensors, in terms of both materials and energy use, is an important consideration.[64]

Gas sensors are crucial components in smart packaging systems, used to detect the presence of gaseous analytes within the packaging environment. These sensors include oxygen sensors, carbon dioxide sensors, water vapor sensors, ethanol sensors, metal oxide semiconductor field effect transistors (MOSFETs), and organic conductive polymers. By monitoring changes in gas composition, gas sensors help in detecting leaks, spoilage, or other quality issues in packaged products. They ensure that the atmosphere inside the package remains optimal, thereby extending the shelf life of perishable goods and maintaining their safety and quality.[65]

Biosensors are advanced devices designed to record and transmit data related to biological reactions within the packaging environment. They are composed of organic or biological materials, such as enzymes, hormones, nucleic acids, and antigens of microbes and bacteria. Biosensors can detect microbial activity, biological contamination, and biochemical changes in the packaged products. This real-time monitoring capability is essential for ensuring food safety, pharmaceutical integrity, and the overall quality of sensitive goods. By providing early detection of potential hazards, biosensors help in preventing health risks and enhancing consumer confidence.[66]

Chemical sensors are sophisticated tools used to detect the presence, activity, composition, and concentration of specific chemicals or gases in the packaging environment. These sensors operate by adsorbing or desorbing target substances, which then trigger a detectable signal. Chemical sensors are invaluable for monitoring the chemical integrity of products, identifying contamination, and ensuring compliance with safety standards. They play a vital role in various industries, including food, pharmaceuticals, and chemicals, by providing accurate and timely information about the chemical status of packaged goods, thereby safeguarding consumer health and product quality.[64]

Humidity sensors are devices that measure the moisture or humidity levels within the packaging environment. These sensors gather data on humidity, which is then converted into readable signals for IoT devices, software, or applications. Maintaining the correct humidity level is crucial for the preservation of many products, especially those sensitive to moisture, such as electronics, pharmaceuticals, and certain food items. Humidity sensors help in preventing mold growth, product degradation, and spoilage by ensuring the internal environment of the packaging is kept within optimal moisture levels. This contributes significantly to extending the shelf life and maintaining the quality of the packaged products.[67]

The table below presents a comprehensive comparison of six major intelligent packaging sensors. These sensors include Gas Sensors, Biosensors, Chemical Sensors, Humidity Sensors, Movement Sensors, and Temperature Sensors. Each sensor varies in terms of cost, response time, fineness, durability and stability, sensitivity, environmental impact, and purpose.

Sensors	Cost	Response Time	Fineness	Durability and Stability	Sensitivity	Environmental Impact	Purpose
Gas Sensor	Medium	Fast (<1 second)	High	High	High	Medium (depends on manufacturing materials and disposal)	Function: protection
Biosensor	High	Medium (seconds to minutes)	Very High	Medium	Very High	High (may require special disposal)	Function: protection
Chemical Sensor	High	Medium (<10 seconds)	High	Medium	High	Medium (depends on manufacturing materials and disposal)	Function: protection
Humidity Sensor	Medium	Fast (<1 second)	Medium	High	Medium	Low (often made with eco-friendly materials, recyclable)	Function: protection
Movement Sensor	Medium	Very Fast (<1 millisecond)	Medium	High	Medium	Low (most sensors are electronic and recyclable)	Function: protection Communication
Temperature Sensor	Low	Fast (<1 second)	High	High	Medium	Low (electronic components are recyclable, minimal environmental impact)	Function: protection

TABLE 1: Comparison table of the different types of Sensors

Data Carriers

Data carriers play a pivotal role in enhancing the efficiency of information flow within the supply chain. Unlike sensors that monitor the quality of products, the primary function of data carriers is to ensure robust traceability, facilitate automation, and provide protection against theft and counterfeiting.

Barcode

QR-Code

One-dimensional barcodes are patterns of parallel spaces and bars that encode data based on their arrangement. These barcodes are cost-effective, easy to use, and widely employed to facilitate inventory control, stock recording, and checkout processes in various industries. The data encoded in a one-dimensional barcode can be quickly read by a scanner and translated by an associated system, streamlining operations and improving efficiency. However, these barcodes have limitations, such as the lack of unique identification, limited storage capacity for information, and vulnerability to information theft. This makes them less suitable for applications requiring high security and detailed data storage.[61]

NFC is a short-range wireless connectivity standard that uses magnetic field induction to facilitate communication between devices. NFC technology relies on bi-directional communication, meaning data is exchanged in both directions. It allows for faster and more automatic communication between devices, is backward compatible with other RFID devices, and establishes automatic connections between two NFC-compatible devices. However, NFC

Two-dimensional barcodes, commonly known as QR codes, offer significantly more memory capacity due to their combination of dots and spaces arranged in an array or matrix. This increased capacity allows them to include a greater amount of information, making them ideal for applications like packaging dates, batch numbers, and preparation instructions. However, similar to one-dimensional barcodes, QR codes do not provide unique identification and are susceptible to information theft. Despite these vulnerabilities, their versatility and ability to store more data make them a popular choice for many modern applications.[61]

An RFID system comprises three components: a tag, which is formed by a microchip connected to a tiny antenna; a reader, which emits radio signals and receives responses from the tag; and middleware, which bridges the RFID hardware and enterprise applications. RFID tags can store up to 1 MB of data, support non-contact and non-line-of-sight data collection, and allow multiple tags to be read simultaneously, each with a unique code. However, they are more expensive, require a more powerful electronic information network, and,

operates within a very short range and is prone to security vulnerabilities such as eavesdropping. [68]

Digital watermarks are marks or pieces of code embedded into digital data, such as videos, pictures, or audio. They come in various types, including visible, invisible, public, and fragile watermarks. Digital watermarks provide a very secure technique for protecting digital content, as the embedding is done by a key. The embedded version of a file remains digital, making it easy to transmit and use without altering the file format. However, visible watermarks can be easily removed or overlaid by other watermarks. [69]

AR/WebAR codes create interactive experiences by combining the real world with computer-generated content. These are QR codes that serve as anchors for augmented reality (AR) experiences, with WebAR leveraging web browsers to deliver immersive AR interactions. The advantages of AR/WebAR codes include enhanced interactivity, improved digital marketing, increased user engagement, real-time updates, and effective data collection. However, they require specific equipment with appropriate technology, can be costly to implement.

unlike QR codes, cannot be generated and distributed via email or other electronic means.[61]

VR Codes (Virtual Reality Codes) are an innovative type of data carrier that refers to "Virtual Reality Codes" or "Virtual Reality QR Codes." When you scan a VR code, it can launch an app or website that immerses you in a 360-degree virtual environment or provides an augmented reality experience. These codes significantly enhance interactivity, making them valuable tools in digital marketing and increasing user engagement through immersive experiences. They also enable real-time updates and efficient data collection, providing valuable insights into user behavior and preferences.
However, VR Codes come with several drawbacks. They require specific equipment with the appropriate technology to function correctly, which can be a technical constraint. The high cost associated with developing and deploying VR experiences can be a barrier for some organizations. Additionally, using WebAR codes typically requires a good internet connection to deliver a seamless experience. Despite these challenges, VR Codes offer a compelling way to engage users and provide rich, interactive experiences.

The following table shows a comprehensive comparison of the seven main smart packaging data carriers. These data carriers include barcodes, QR codes, RFID tags, NFC tags, digital watermarks, AR/WebAR codes, and VR codes. Each data carrier has different performance in terms of data capacity, read range, read speed, cost, technical stability, security and privacy, device requirements, unique identification and use.

Data Carriers	Data Capacity	Read Range	Read Speed	Cost	Technical Stability	Security and Privacy	Devices Requirement	Unique Indentification	Purpose
Barcodes	Low (20-25 characters)	Short (few centimeters)	Medium (milliseconds to seconds)	Low	High	Low	Scanner	Yes	Communication
QR-Codes	Medium (several hundred characters)	Medium (few cm to 1m)	Fast (milliseconds)	Low	High	Medium	Camera	Yes	Communication
RFID Tags	High (thousands of characters)	High (up to several meters)	Fast (milliseconds)	Medium	High	High	RFID Reader	Yes	Communication
NFC Tags	Medium (several hundred characters)	Short (few centimeters)	Fast (milliseconds)	Medium	High	High	NFC Device	Yes	Communication
Digital Wateremarks	High (invisible information)	Not applicable (integrated with media)	Variable (depends on media playback speed)	Variable (depends on technology and implementation complexity)	Variable (depends on technology and implementation complexity)	Medium	Specialized software	Yes	Communication
AR/WebAR Codes	High	Variable (based on device and environment)	Variable (depends on network speed)	High	Medium	Medium	Smartphone	Yes	Communication
VR Codes	High	Variable (based on device and environment)	Variable (depends on computer processing power)	High	Medium	Medium	VR Equipment	Yes	Communication

TABLE 1: Comparison table of the different types of Data carriers

Other Solutions

AI and machine learning are powerful tools that enhance productivity and traceability in various applications. These technologies can significantly reduce manpower requirements and increase overall efficiency. Machine learning algorithms can predict demand, optimize inventory, and reduce waste, making them ideal for supply chain optimization. Despite their advantages, implementing AI and machine learning technologies involves high initial costs and requires specialized expertise that may not be readily available. The effectiveness of these algorithms also heavily depends on the quality and quantity of data provided..[70]

Blockchain technology is a digital ledger that ensures secure, transparent, and tamper-proof record-keeping of transactions. It offers several features valuable for safety and quality control. Blockchain can create a unique digital identity for each product, track the entire journey of products, and provide transparency and accountability throughout the supply chain. Additionally, the data recorded on the blockchain can be verified by multiple parties, such as farmers, suppliers, and retailers. However, blockchain technology also comes with challenges, including high implementation costs, security issues in permissioned blockchains.[70]

1.3.4 CASE STUDIES OF INTELLIGENT PACKAGING

In this section, we present a collection of case studies aimed at understanding the current state of intelligent packaging applications. These case studies have been meticulously researched for each type of intelligent packaging technology.
For each case study, the following information is reported: the type of intelligent packaging used, the product name, and the manufacturer, enabling precise identification. Additionally, the year is provided to understand the inception or development period of the technology, along with the location to geographically contextualize its use. Furthermore, the field of application is discussed to determine the sectors where it is most utilized, and the level of packaging it applies to, whether primary, secondary, or tertiary. The intended solution or purpose for its use is also outlined, followed by a brief description of its operation.
In subsequent sections, this information will be synthesized to create an overall picture of the state of the art in smart packaging. The insights gained from these case studies will be combined to present a comprehensive view of the intelligent packaging landscape, as detailed in the upcoming sections.

Innoscentia Label
Innoscentia
Sweden, 2022

Technology: QR-Codes, Gas Sensor, BioSensor
Level: Primary Packaging
Application field: Food
Solution aim: Brand System Information, Product Impacts Information

The labels changes color according to the gas levels inside the package. This indicates the freshness of a product so whether the product is safe to eat or not. Thereis a QR Code that allows to gain more information on the label as wellas additional insigts on the product and producer. [72]

Star Wars Coca Cola limited edition
Coca Cola and Inuru
Singapore, 2020

Technology: Touch Sensors
Level: Primary Packaging
Application field: Beverage
Solution aim: User Engagement, Gamification and Reward System

Thanks to Inuru's OLED (=Organic LED) technology Coca COla create a packaging with the new light up label for the Star Wars Coca Cola limited edition. Coca Cola Singapore and Inuru created a label with glowing lightsabers, that light up when the label is touched.[73]

FACT Water
Crown&Olly Bolton
USA, 2018

Technology: QR-Codes, Blockchain
Level: Primary Packaging
Application field: Beverage
Solution aim: User Engagement, Gamification and Reward System, Brand System Information, Product Impacts Information

Crown has produced physical beverage can with blockchain technology for FACT Water.Each can will be marked with a 2D unique scannable code, making FACT beverage cans to have a unique digital identity. [74]

O'air
Deeez.co
Americas, 2021

Technology: QR-Codes, AR/WebAR Codes
Level: Primary Packaging
Application field: Pharmaceuticals / Health
Solution aim: User Social and Environmental Awareness

AR technology was added to this project. After scanning the QR code and installing the app, the design on the packaging can be seen in 3D form. Shaking the packaging causes the liquid inside the 3D capsules to move as well. [75]

Sustainable HF RFID Assisted E-fulfilment Package
Buonamici, La Ranocchiaia, SPO and Il Cavallino
Italy, 2014

Technology: NFC Tags
Level: Primary Packaging
Application field: Food
Solution aim: Product Characteristics Information / Digital ID, Counterfeiting Protection

Italian olive oil brands Buonamici, La Ranocchiaia, SPO and Il Cavallino are integrating NFC tags into their product lines to enable authentication and enhance consumer engagement, by delivering product information and other relevant content to customers' smartphones.[76]

Remi Martin Club
Remi Martin
French, 2015

Technology: NFC Tags
Level: Primary Packaging
Application field: Beverage
Solution aim: Product Impacts Information, Theft Protection

French spirits brand Rémy Martin is to launch a connected cognac bottle equipped with an NFC tag that will let consumers check the product is authentic and whether it has been opened and resealed, as well as allowing them to retrieve rewards and special offers after it has been purchased. [77]

Delage Bag
Delage & Inside Secure
French, 2014

Technology: NFC Tags
Level: Primary Packaging
Application field: Fashion
Solution aim: Product Characteristics Information / Digital ID, Theft Protection

Each bag will have a unique chip and a unique digital serial number. Consumers with an NFC smartphone equipped with Selinko's free mobile app will be able to use the tag to access information about their product and confirm its authenticity as well as access marketing offers. [78]

Tapp Smart Sticker
Cambridge Consultants
U.K., 2018

Technology: NFC Tags
Level: Primary Packaging
Application field: Pharmaceuticals / Health
Solution aim: Product use and monitoring

Introducing Tapp, a 'smart' system, designed to incentivize, guide and support patients. Tapp is a low-cost, easy-to-use adherence monitor which utilizes cheap, disposable electronics that are adhered to standard blister packaging in combination with smart phone technology.[79]

Cambio Coffee
Mitsubishi Gas Chemical Co. Ltd
Japan, since 1997

Technology: QR-Codes
Level: Primary Packaging
Application field: Food
Solution aim: Logistics, Transport and Storage Optimization, Brand System Information, Tracking and Traceability

Currently, the roaster and the delivery company enter data onto the blockchain. The plan is to roll out the feature to the shipping company and eventually the farmers, to cover the whole supply chain. In the future, the two companies want to expand to other blockchain-supported initiatives, like "Tip your farmer".[80]

One Look
Cymmetrik
China, 2023

Technology: Digital Watermarks
Level: Primary Packaging
Application field: Food
Solution aim: Logistics, Transport and Storage Optimization, Product Conditions and Quality Monitoring, Tracking and Traceability

Cymdicator® is able to accurately record instances of food exposure at above-par temperatures—that result in irreversible quality change—and present the record in a way that's accurate, intuitive, and easy-to-read. [81]

WarmMark
Warmmark®
USA, /

Technology: Time Temperature Indicators (TTIs)
Level: Primary Packaging
Application field: Food, Pharmaceuticals / Health
Solution aim: Logistics, Transport and Storage Optimization, Environmental Conditions Monitoring

WarmMark is a single-use, ascending time and temperature indicator that not only changes color when temperatures warm to a specified threshold, but also indicates whether exposure to that duration is brief, medium, or prolonged based on that sensor's specific temperature threshold.[82]

FreezeSafe Indicator
SpotSee
USA, /

Technology: Freeze Indicators
Level: Secondary Packaging, Tertiary Packaging
Application field: Food, Pharmaceuticals / Health
Solution aim: Logistics, Transport and Storage Optimization, Environmental Conditions Monitoring, Preserve the product during transport

The SpotSee FreezeSafe™ indicator provides accurate evidence if a product has experienced unacceptably low temperatures. This cost-effective solution allows you to add an indicator to every shipment or mount directly onto the product. [83]

ShockWatch 2 Impact Indicators
SpotSee
USA, /

Technology: Barcodes
Level: Tertiary Packaging
Application field: Indefinite sector
Solution aim: Product Impacts Information, Product Conditions and Quality Monitoring

ShockWatch® 2 impact indicators are single-use, go/no-go devices that determine if fragile products have been dropped during transit or in storage. The indicators are field-armable, tamperproof devices that turn bright red when an impact beyond a specific threshold has occurred. [84]

FreshTag Smart Labels
Insignia Technologies
UK, /

Technology: Freshness Indicators
Level: Primary Packaging
Application field: Food
Solution aim: Logistics, Transport and Storage Optimization, Product Conditions and Quality Monitoring, Counterfeiting Protection

A fully automated, customisable indicator designed to change colour over a pre-set time period and specified temperature range. Perfect for use in the supply chain.[85]

After Opening Timers
Insignia Technologies
UK, /

Technology: Time Temperature Indicators (TTIs)
Level: Primary Packaging
Application field: Food, Pharmaceuticals / Health
Solution aim: Logistics, Transport and Storage Optimization, Product Conditions and Quality Monitoring

The‘smart ink’ has been developed as an extension of our original smart label product, and provides consumers with a visual indication of how long a food packet has been open, encouraging them to use the product whilst at its optimum freshness and preventing food from being thrown away unnecessarily. [86]

Leak Detection Label
Insignia Technologies
UK, /

Technology: Gas Indicator / Gas Leakage Indicators
Level: Primary Packaging
Application field: Food
Solution aim: Product Conditions and Quality Monitoring

The leak detection label is applied to the outside of modified atmosphere packaged foods (containing CO_2) and gives a visual indication if a leak is present in the packaging.The label is a useful tool for identifying pin hole (very small) leakers and can be used to confirm packaging integrity. [87]

ESL SMARTpack
EBV Elektroink
UK, 2014

Technology: NFC Tags, Temperature Sensor / Thermochron
Level: Primary Packaging
Application field: Pharmaceuticals / Health
Solution aim: User Engagement, Gamification and Reward System, Tracking and Traceability, Theft Protection

The SMARTpack module is formed as a standard set of electronics that can be fitted to multiple housings for specific use-cases. The domiciliary care pack is operated by the patient, having been pre-programmed by the pharmacy or medication distribution centre using the EMap™.[88]

BAT-LYFT
SharpEnd
UK, 2021

Technology: NFC Tags
Level: Primary Packaging
Application field: Arts and Culture
Solution aim: User Engagement, Gamification and Reward System

Limited Edition products are a great way for brands to experiment with Connected Packaging and with a chip placed into the can lid, consumers were encouraged through marketing to 'Tap the Can' with their smartphone.[89]

Shazam x Bombay Sapphire
Bombay Sapphire
UK, 2018

Technology: AR/WebAR Codes
Level: Primary Packaging
Application field: Beverage
Solution aim: User Engagement, Gamification and Reward System, Brand System Information

Users were able to scan the label to reveal an immersive animation, representing the essence and character of Bombay Sapphire in augmented reality. Customers could then watch exclusive video content, showcasing different Bombay Sapphire recipes. And now you can have an equally immersive experience with WebAR. [90]

Christmas ARPackaging
The Good Crisp Company & Aircards
USA, 2020

Technology: AR/WebAR Codes
Level: Primary Packaging
Application field: Beverage
Solution aim: User Engagement, Gamification and Reward System, Brand System Information, Product Impacts Information

The Good Crisp Company, a new and better-for-you take on the classic canister chip, is launching a Web-based Augmented Reality (WebAR) feature on its packaging that will turn The Good Crisp Company canisters into a holiday-inspired winter wonderland, complete with Santa.[91]

Tostitos
Tostitos
USA, 2018

Technology: NFC Tags, Gas Sensor
Level: Primary Packaging
Application field: Beverage
Pharmaceuticals / Health, Consumer Electronics
Solution aim: User Engagement, Gamification and Reward System, Product Impacts Information

The Tostitos Party Bag is outfitted with sensors to detect alcohol on a person's breath. If you're in the clear, the bag turns green and you're free to go about your night. If alcohol is detected, the bag turns red with the message. [92]

AR Delivery Boxes
Amazon
USA, 2020

Technology: AR/WebAR Codes
Level: Secondary Packaging
Application field: Logistics, Shipping and Delivery
Solution aim: User Engagement, Gamification and Reward System

Amazon created AR delivery boxes that allow customers to access AR Halloween. Customers can scan an AR delivery box using an app, titled Amazon Augmented Reality. The app is available in both the App Store and Google Play. [93]

BlindSpotz™ Freeze Indicator for Vaccine
CTI
USA, /

Technology: QR-Codes, Temperature Sensor / Thermochromic Inks
Level: Primary Packaging
Application field: Pharmaceuticals / Health
Solution aim: Product Conditions and Quality Monitoring

BlindSpotzTM is an indicator of persistent freezing, thanks to the use of a particular ink that reasons at low temperatures, which indicates whether a pharmaceutical product is safe to use. This product allows you to monitor whether the product has been subjected to freezing temperatures during shipment. [94]

Reveal Impact
Ardagh Group
Luxembourg, 2017

Technology: Temperature Sensor / Thermochromic Inks
Level: Primary Packaging
Application field: Beverage
Solution aim: Product Conditions and Quality Monitoring, User Social and Environmental Awareness

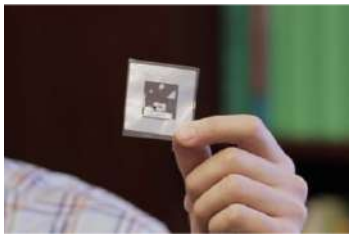
This solution for aluminium cans uses two different thermochromic inks, which both have the same colour when cooled down. Once the can gets warmer, one colour disappears quicker than the other, revealing a hidden message that inform the consumer about the impact on the planet. [95]

TempSafe Electrocard
Ynvisible in collaboration with SpotSee
Canada and USA, 2021

Technology: QR-Codes, Temperature Sensor / Thermochromic Inks
Level: Secondary Packaging
Application field: Logistics, Shipping and Delivery
Solution aim: Product Conditions and Quality Monitoring

TempSafe Electrocard is a low power calibrated temperature indication label for cold-chain and temperature-controlled shipment and storage of goods such as blood bags, premium foods, biomaterials, and medicines. [96]

Gas sensor
MIT University
USA, 2014



Technology: NFC Tags, Electronic / Conductive Inks
Level: Primary Packaging
Application field: Food, Logistics, Shipping and Delivery
Solution aim: Product Conditions and Quality Monitoring

This sensor detects dangerous gases or food deterioration. The reading of the detected information can be read from a smartphone thanks to NFC technology. [97]

Sneakers authenticity guarantee
EBay in collaboration with Sneaker Con
Germany, /

Technology: NFC Tags
Level: Primary Packaging
Application field: Fashion, Logistics, Shipping and Delivery
Solution aim: Counterfeiting Protection

eBay launchs his new Authenticity Guarantee program, guaranteeing a buying and a selling of sneakers safer. eBay offering proof of authentication by using NFC-enabled tag for selected footwear in partnership with Sneaker Con as its third-party authenticator, adding a key level of security to the buying process. [98]

Pepsi Super Bowl LV 2021 Cans
Pepsi
USA, 2021

Technology: AR/WebAR Codes
Level: Primary Packaging
Application field: Beverage
Solution aim: User Engagement, Gamification and Reward System

This contents are available by scanning a QR codes on the website or on specially marked cans of Pepsi with a smartphone camera to see an AR selfie lens in the photo-sharing app. [99]

Tuned Wines
DJ Jordi Ruz
Spain, /

Technology: NFC Tags
Level: Primary Packaging
Application field: Beverage
Solution aim: User Engagement, Gamification and Reward System

Using an NFC sticker tag, Wine Tuned using its bottles create a dynamic tasting and listening experience. After a purchase, the consumer tap the NFC sticker to launche a listening session and a host of other exclusive content. In this way, the consumer can thus try a multisensory and immersive experience.[100]

Moose Knuckles platform
Moose Knuckles
Canada, /

Technology: RFID Tags, NFC Tags
Level: -
Application field: Fashion
Solution aim: User Social and Environmental Awareness, Instructions for Use, Reuse and End-of-Life Management, Product Characteristics Information / Digital ID, Brand System Information, Product Impacts Information

It transform its garments into connected product embedding r-pac's new TWINTAG NFC/RFID tags into garments. The dual function, single chip tags combine NFC's close range frequency for consumer use with long range RFID functionality for supply chain tracking. [101]

BVLGARI platform
BVLGARI
Italy, 2023

Technology: NFC Tags
Level: -
Application field: Fashion
Solution aim: User Social and Environmental Awareness, Product Characteristics Information/ Digital ID, Brand System Information, Counterfeiting Protection

BVLGARI transformed their luxury products into a digital communication channel by embedding NFC tags inside the product that activate different experiences, depending on context, when users tapped their phones to the objects. [102]

Ocean Bottle
The Ocean Bottle Ltd
USA, 2019

Technology: NFC Tags
Level: -
Application field: Beverage
Solution aim: Product Characteristics Information/ Digital ID, Brand System Information, Product Impacts Information, User Social and Environmental Awareness

Ocean Battle is recyclable and part made from recycled ocean plastic. It comes embedded with an NFC enabled smart-chip, which allows owners to register the bottle to our Ocean Bottle Mobile App to further fund the collection of ocean-bound plastic each time a refill is registered. [103]

Napolina tomatoes can
Princes Group
Italy, 2020

Technology: QR-Codes
Level: Primary Packaging
Application field: Food
Solution aim: User Social and Environmental Awareness, Instructions for Use, Reuse and End-of-Life Management, Product Characteristics Information/Digital ID, Brand System Information, Product Impacts Information, Tracking and Traceability

On the can of Napolina brand is printed a QR codes which, when scanned, will provide consumers with information about supply chain sustainability. [104]

Mousline
Nestlé in collaboration with Carrefour
France, 2019

Technology: QR-Codes, Blockchain
Level: Primary Packaging
Application field: Food
Solution aim: User Social and Environmental Awareness, Instructions for Use, Reuse and End-of-Life Management, Brand System Information, Product Impacts Information, Tracking and Traceability

Nestlé and Carrefour gave consumers access to blockchain data for Mousline purée in France. Consumers, using their smartphone, can scan a QR code on the Mousline packaging. [105]

MedicalPrescription
Faller Packaging
Germany, /

Technology: Electronic / Conductive Inks, Display (LED, E-Paper)
Level: Primary Packaging
Application field: Pharmaceuticals / Health
Solution aim: User Accessibility Improvement, Instructions for Use, Reuse and End-of-Life Management

Medical Prescription is a digitised folding carton that help the patient with the drug intake. The drug box includes a small e-paper display and buttons, that counts down the tablets, reminds the patient of the correct time to take them and alerts the patient when it is time to order a new prescription. [106]

PluggyMed
Palladio Group
Italy, 2021

Technology: Electronic / Conductive Inks, IoT
Level: Primary Packaging
Application field: Pharmaceuticals / Health
Solution aim: User Accessibility Improvement, Instructions for Use, Reuse and End-of-Life Management

PluggyMed was developed in collaboration with the software house Omnys. It is a system that, thanks to the printing of conductive inks, allows the interaction between the blister of the drug and a smart device in order to monitor the observance of therapy by the patient. [107]

Farmison & Co Label
Farmison & Co
UK, 2023

Technology: QR-Codes
Level: Primary Packaging
Application field: Food
Solution aim: User Social and Environmental Awareness, Instructions for Use, Reuse and End-of-Life Management

Farmison & Co has embedded a QR code on its packaging, which can be scanned with your smartphone. This reveals more information about your product, see the farm through a video, find information about the breed and food miles [108]

SmartID
Fraunhofer
Germany, 2023

Technology: Barcodes
Level: Primary Packaging
Application field: Pharmaceuticals / Health
Solution aim: Counterfeiting Protection

This technology exploits the fact that every package possesses a unique, characteristic surface texture. When the smartphone scans the printed barcode, at the same time, it scan also the texture of the surface. The barcode already contains information about the texture. [109]

Digi-Cap Closure
Berry Global
USA, /

Technology: NFC Tags,Temperature Sensor/Thermochromic Inks
Level: Primary Packaging
Application field: Pharmaceuticals / Health
Solution aim: User Accessibility Improvement, Product Conditions and Quality Monitoring

Digi-Cap is a cap that guarantees child-resistant safety, but is also able to monitor a patient's behavior, especially in clinical trials, recording the data on the intake of the drug to check compliance with the indications provided and to obtain information on the effectiveness with respect to the indicated dosage. [110]

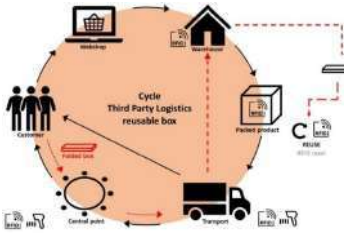
Coca-Cola® Christmas Pack with NaviLens

Coca Cola UK with NaviLens
UK, 2022

Technology: QR-Codes
Level: Primary Packaging
Application field: Beverage
Solution aim: User Accessibility Improvement

NaviLens allows blind or visually impaired people to access the information normally printed on the packaging.The system will provide information to recognize products, listen to their name, nutritional information and allergens. [111]

Sustainable HF RFID Assisted E-fulfilment Package



Hasselt University
Belgium, Germany, 2021

Technology: RFID Tags
Level: Tertiary Packaging
Application field: Waste Management
Solution aim: Waste Disposal Optimization, Tracking and Traceability

The integration of screen printed antennas and RFID chips as smart labels in reusable cardboard packaging could offer a solution. Functional RFID labels were integrated in cardboard packaging and its potential application as reusable smart box for third party logistics was tested.[112]

Fresh Label

Naoki Hirota
Japan, 2008

Technology: Barcodes, Freshness Indicators
Level: Primary Packaging
Application field: Food
Solution aim: Product Conditions and Quality, Monitoring

This label change color over time. Once the meat (or otherperishable product) ispastit's due, the label will have turned from white to blue, making the item unscannable. The label has one layer of info for the food with the barcode, and another on top with special, non-toxic and safe pigment from purple cabbages ink reactive to ammonia. [113]

HolyGrail 2.0
Greiner Packaging
Denmark, Germany, and France, 2022

Technology: Digital Watermarks
Level: Primary Packaging
Application field: Food, Beverage
Solution aim: Waste Disposal Optimization, User Social and Environmental Awareness

Greiner Packaging isable to integrate digital watermarks simply and invisiblyintovariousforms of decoration.When a used packaging item is collected and sent to a sorting system thatrecognizesitsdigital watermark. [114]

Ynap Digital ID for garment
Ynap
Italy, 2020

Technology: Digital ID, QR Code
Level: Primary Packaging
Application field: Fashion
Solution aim: Waste Disposal Optimization, Instructions for Use, Reuseand End-of-Life Management, Tracking and Traceability

Greiner Packaging isable to integrate digital watermarks simply and A digital ID card to trace the history of a garment by scanning the QR code sewn inside the garments. Customers will have access to various information such as the origin and design of the garment, instructions for its maintenance and style tips [115]

1.4 CASE ANALYSIS

In the modern market, Smart Packaging is rapidly becoming a critical area of innovation. Through an in-depth study of 116 smart packaging cases worldwide, these cases encompass the two main categories of Smart Packaging: Intelligent Packaging and Active Packaging. For these cases, we have summarized some comprehensive charts analyzing the distribution of smart packaging across different application fields and geographic regions, packaging levels and industries, as well as the relationships between the technologies used and their corresponding aims. The charts further categorize the specific application fields of various types of packaging, including beverages, food, pharmaceuticals, health products, cosmetics, and personal care products, and show the distribution of these applications in different countries and regions.

Case Analysis Framework:
To better understand and analyze these cases, we will summarize and discuss them based on the following three main classification criteria:

1. Level Packaging – Reference Sector – Place: We will analyze the cases based on the packaging levels (primary packaging, secondary packaging, tertiary packaging) and explore their application in different reference sectors and geographical regions.

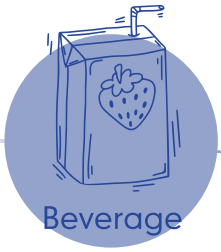
2.Intelligent Packaging – Technology – Aims: This section will delve into the technological applications of intelligent packaging, including sensor technology, information transmission, tracking, etc., and explore the specific aims of these technologies, such as enhancing product safety, extending shelf life, and increasing consumer interaction.

3.Active Packaging – Technology – Aims: We will explore the main technologies of active packaging, including desiccants, antimicrobial agents, etc., and the specific aims and effects of these technologies in extending product shelf life and improving product quality.

Through this systematic classification and analysis, we not only reveal the diversity and wide application of smart packaging in the global market but also deeply analyze its innovative potential and development trends in different fields. The following chapters will provide detailed summaries and analyses of these cases, discussing the unique advantages and future prospects of smart packaging in enhancing product value, extending shelf life, and improving consumer experience.

Smart Pa
Case An

12



11

11

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2

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Indefinite 1

1

3

UK
Italy
Switzerland
China
USA
France
Sweden
Japan
Spain
Denmark
India
Luxembourg
UK
France
USA
Singapore
USA
UK
Germany
Italy
Italy
Germany
USA
Germany
UK
USA
Canada
USA
USA
USA
USA
USA
France
Italy
Canada

39
Primary
Packaging

Secondary
Packaging

Tertiary
Packaging

Non related
to Packaging

Intelligent
Packaging

51
Cases

TABLE X: Packaging type - Level Pa

ackaging
nalysis 1

art
aging

Cases
65
Active Packaging

61
Primary Packaging

Tertiary ackaging

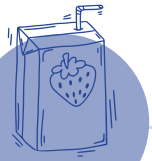
Non related to Packaging

26
Food

Australia
Japan
Switzerland
China
Russia
USA
UK
India
Spain
France

13
Pharmaceuticals / Health

USA
UK
Japan
France
India
Switzerland



10
Beverage

Denmark
Australia
Germany
Switzerland
Japan
Italy
UK
Korea

5
Gardening

UK
USA
Spain
India

4
Cosmetics / Personal Care

USA
Korea
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Main Application Areas of Smart Packaging

In our study of 116 smart packaging cases, primary packaging stands out as a significant category, accounting for a substantial portion of the applications. The analysis highlights that primary packaging is predominantly focused on three main sectors: food, beverage, and pharmaceuticals/health products. From the data presented, it is evident that among the 51 intelligent packaging cases, 39 are related to primary packaging, primarily concentrated in the food, beverage, and pharmaceuticals/health sectors. Similarly, among the 65 active packaging cases, 61 are related to primary packaging, with a similar concentration in these sectors.

The concentration of primary packaging in the food, beverage, and pharmaceuticals/health sectors indicates a strong market demand for intelligent and active packaging solutions in these areas. Innovations in smart packaging technologies in these fields significantly enhance product safety, extend shelf life, and improve consumer interaction. A systematic analysis based on packaging type and sector provides a comprehensive understanding of the current trends and future potential in the smart packaging industry.

Specifically, in the food industry, the application of intelligent packaging, through integrated sensors and real-time monitoring systems, helps ensure the freshness and safety of food products. This not only reduces food waste but also enhances consumer trust and satisfaction. In the beverage industry, intelligent packaging technologies such as RFID tags and smart seals enable product

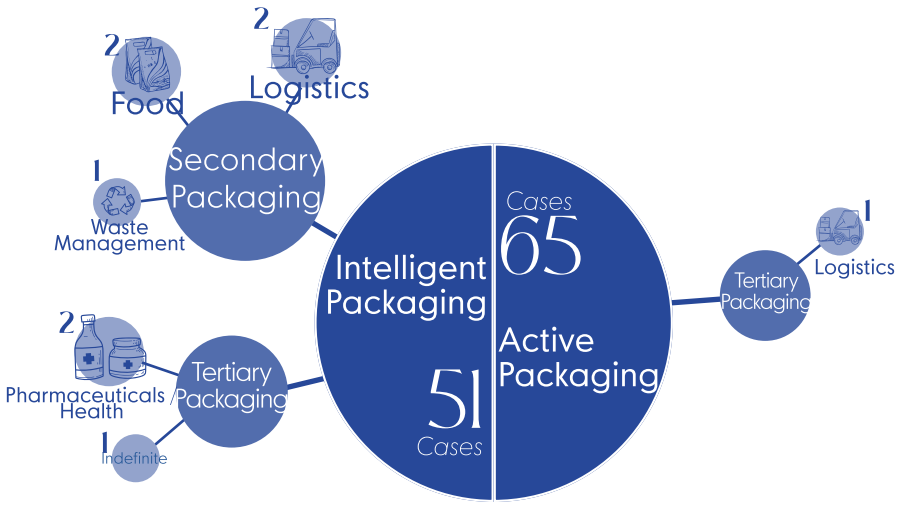
authentication and shelf-life monitoring, ensuring consumer safety. Additionally, in the pharmaceuticals and health products sector, intelligent packaging improves medication management accuracy, ensuring that patients take the correct dosage at the right time.

Active packaging technologies are equally important in these sectors. For example, active desiccants and antimicrobial agents in food packaging effectively extend product shelf life, maintaining freshness and nutritional value. In beverage packaging, active technologies prevent oxidation, preserving the taste and quality of the drinks. For pharmaceuticals and health products, active packaging provides additional protection, preventing drugs from being affected by external environmental factors during storage and transportation.

In summary, intelligent and active packaging technologies play a crucial role in enhancing product safety and extending shelf life, while also offering new opportunities and challenges through improved consumer interaction and product tracking. The widespread application and continuous innovation of these technologies will continue to drive the development of the smart packaging industry, meeting the growing market demands.

In the fashion and apparel industry, smart packaging also shows tremendous potential and innovation opportunities. The integration of smart tags, embedded chips, and augmented reality (AR) technologies can provide consumers with a personalized shopping experience. For instance, smart packaging can offer traceability information, material sources, care instructions, and more, increasing product transparency and credibility. Additionally, smart packaging can interact with mobile devices to offer virtual try-ons, styling suggestions, and other value-added services, enhancing the consumer's shopping experience.

Distribution of Smart Packaging Across Different Packaging Levels

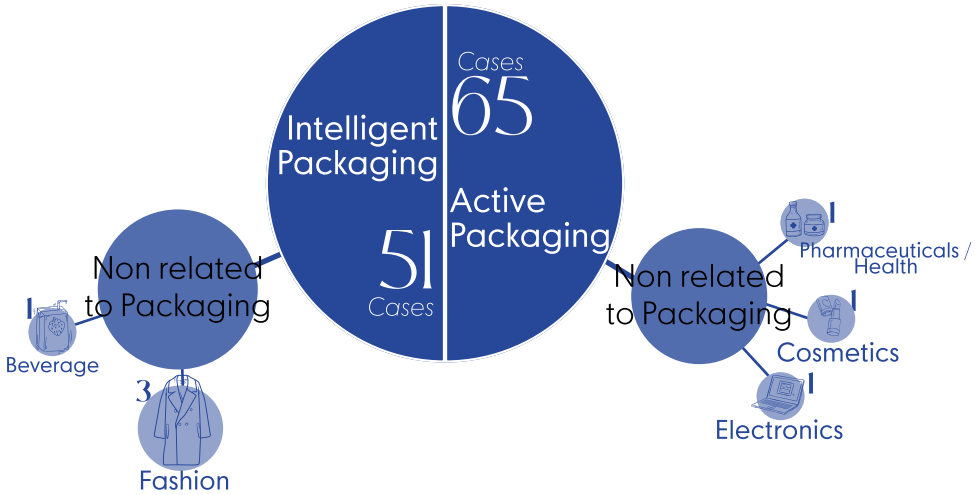


The chart illustrates the distribution of Intelligent Packaging and Active Packaging across different packaging levels. According to the chart, Intelligent Packaging is more likely to be found in Secondary Packaging and Tertiary Packaging, whereas Active Packaging is primarily concentrated in Primary Packaging.

This distribution trend indicates that the application of Intelligent Packaging is more widespread in Secondary and Tertiary Packaging. This is likely because Secondary and Tertiary Packaging typically involve more information transmission and monitoring needs, such as supply chain tracking, product authentication, and quality control, where Intelligent Packaging technologies have distinct advantages. In contrast, Active Packaging focuses more on extending product shelf life and protecting product quality, which is especially important in Primary Packaging. Therefore, its application is more concentrated in Primary Packaging.

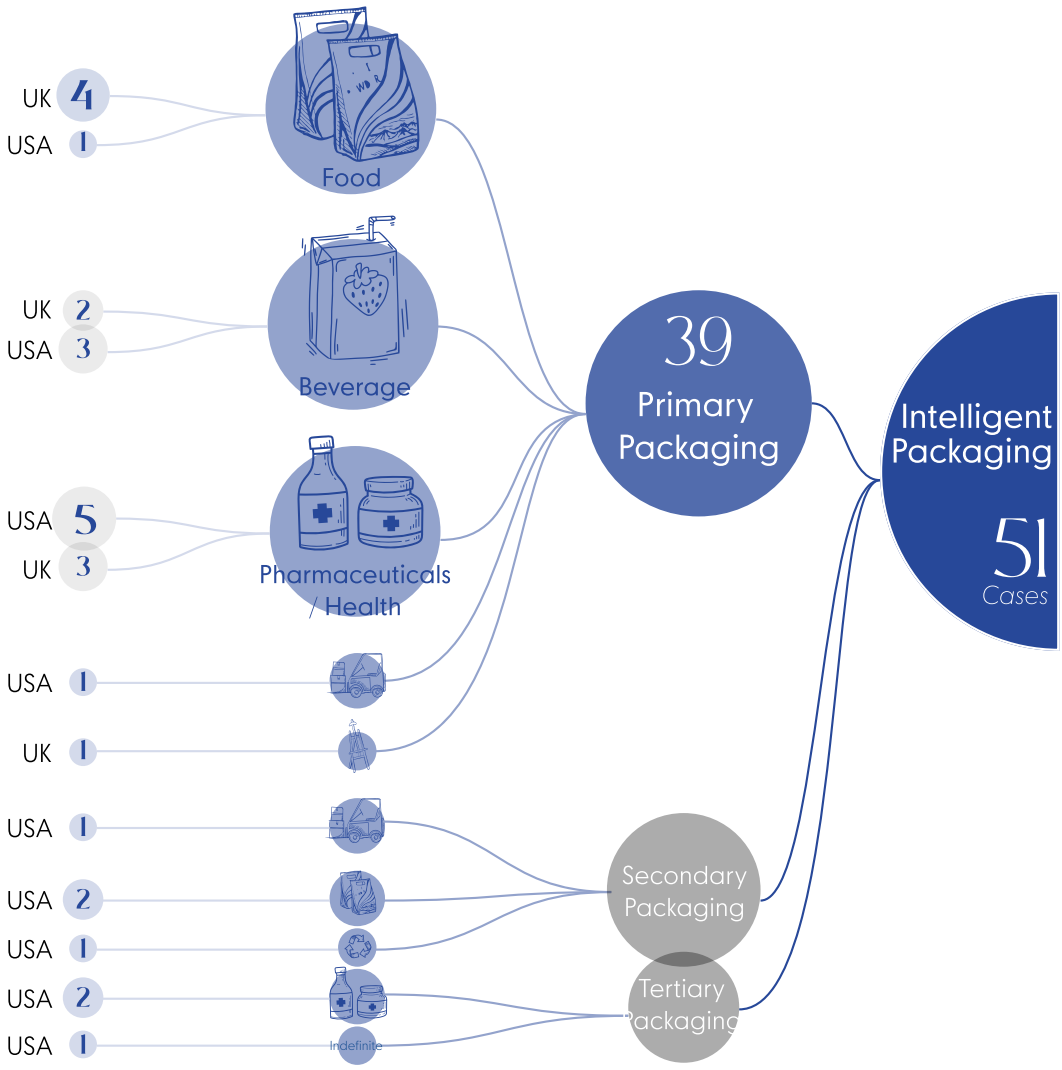
In conclusion, Intelligent Packaging technologies, due to their unique advantages in information transmission and monitoring, are more suitable for Secondary and Tertiary Packaging. On the other hand, Active Packaging is mainly applied in Primary Packaging, where there is a need to extend shelf life and protect product quality. This trend reveals the unique roles and application scenarios of different packaging technologies at various stages of the supply chain.

Summary of Non-Related to Packaging Cases



The chart highlights several instances where Intelligent Packaging and Active Packaging technologies are applied in areas not directly related to traditional packaging. These cases show that similar technologies are being used in various products beyond their conventional packaging roles. For Intelligent Packaging, applications are found in beverages and fashion, while Active Packaging technologies are seen in pharmaceuticals/health, cosmetics, and electronics. This demonstrates the versatility and broader potential of these smart packaging technologies in enhancing product value and functionality across different sectors.

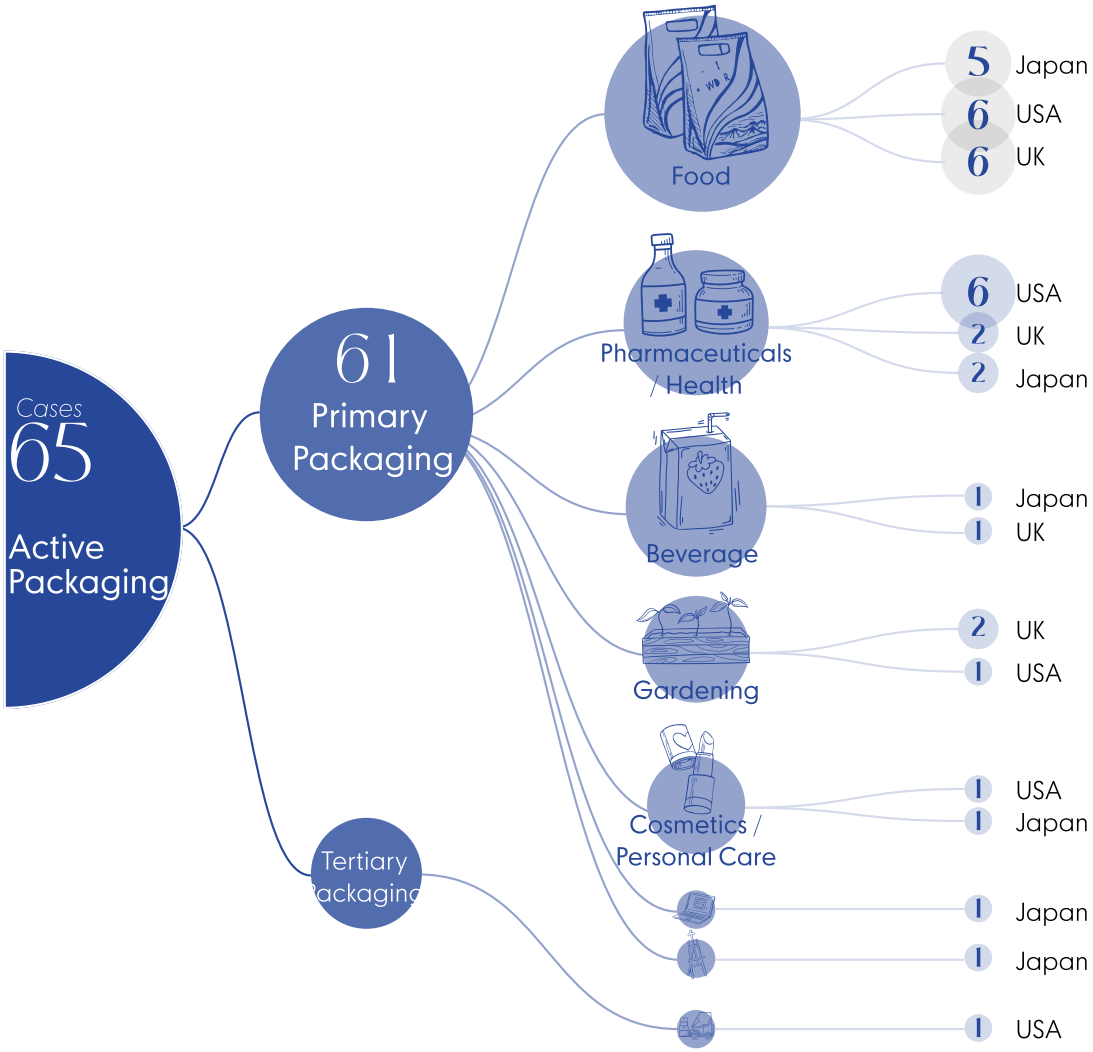
Current Regional Development Status of Intelligent Packaging



According to the statistical results, intelligent packaging cases are mainly concentrated in the USA and the UK. These two countries play a significant role in the application and development of intelligent packaging technologies, particularly in the fields of food, beverages, and pharmaceuticals/health products.

The USA and the UK are at the forefront of intelligent packaging technology application, reflecting their strong focus on product safety, quality control, and supply chain efficiency. The widespread application of intelligent packaging technologies in food, beverages, and pharmaceuticals/health products demonstrates their significant potential in enhancing product safety, extending shelf life, and improving consumer interaction.

Current Regional Development Status of Active Packaging



According to the statistical results, active packaging cases are primarily concentrated in three countries: the USA, Japan, and the UK. These three countries play a significant role in the application and development of active packaging technologies, particularly in several key areas.

Overall, the USA, Japan, and the UK are at the forefront of active packaging technology application and development. They demonstrate the great potential of these technologies in enhancing product safety, extending shelf life, and meeting market demands. The successful application of active packaging in these countries provides valuable experience and reference for other regions.

Comprehensive Analysis of Intelligent Packaging Technologies

The following diagram presents a case analysis of intelligent packaging, connecting various technologies, application fields, and purposes. Intelligent packaging technologies are categorized into different types, including NFC, QR codes, and AR codes, and are applied in various fields such as beverages, fashion, and food. Each technology has its specific uses, such as product condition and quality monitoring, user engagement and reward systems, logistics optimization, and brand system information. This diagram comprehensively illustrates the diverse applications and technological support of intelligent packaging in enhancing product quality, optimizing logistics, increasing user engagement, and promoting environmental awareness.

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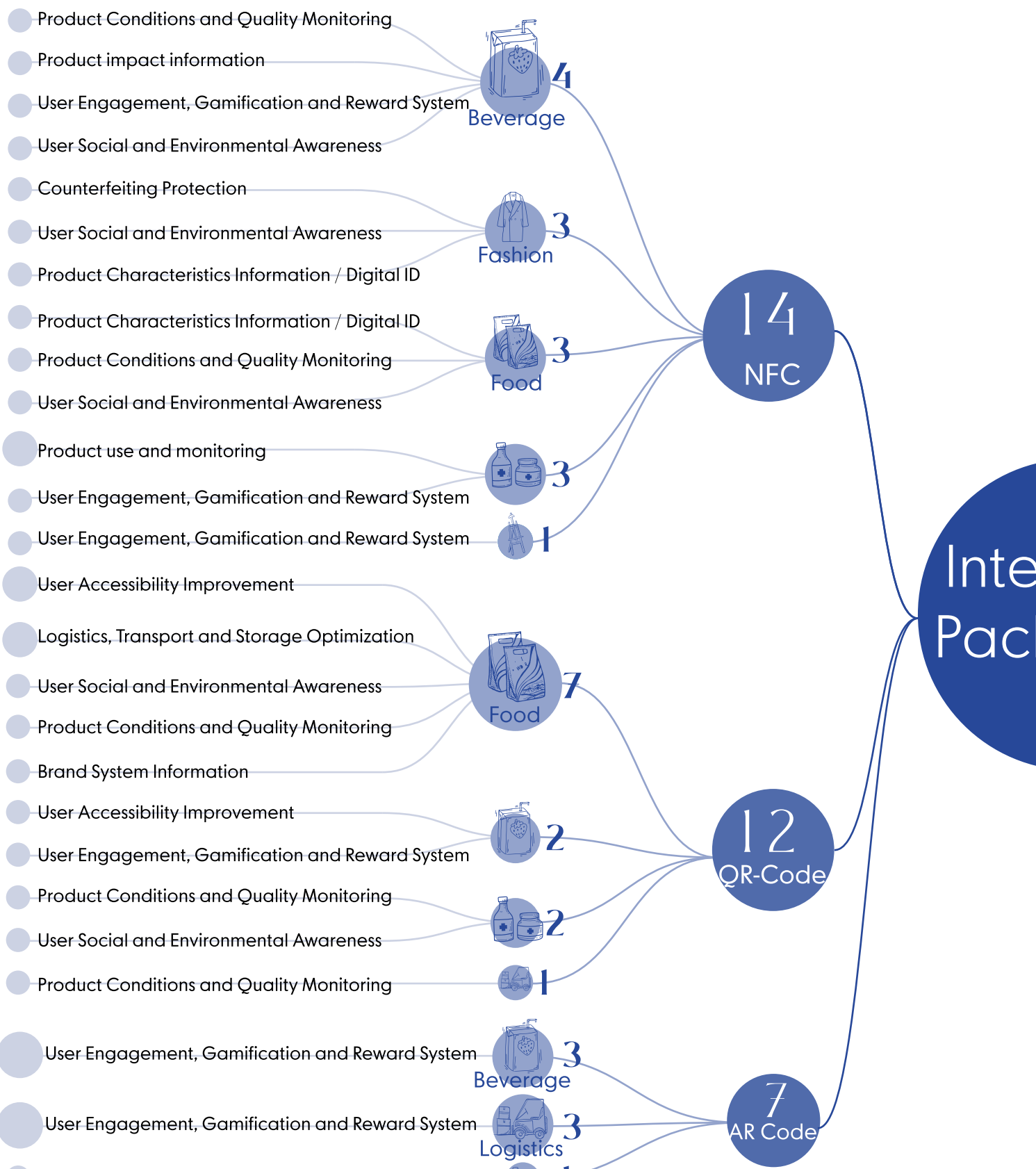

TABLE X: Intelligent Packaging - Tec

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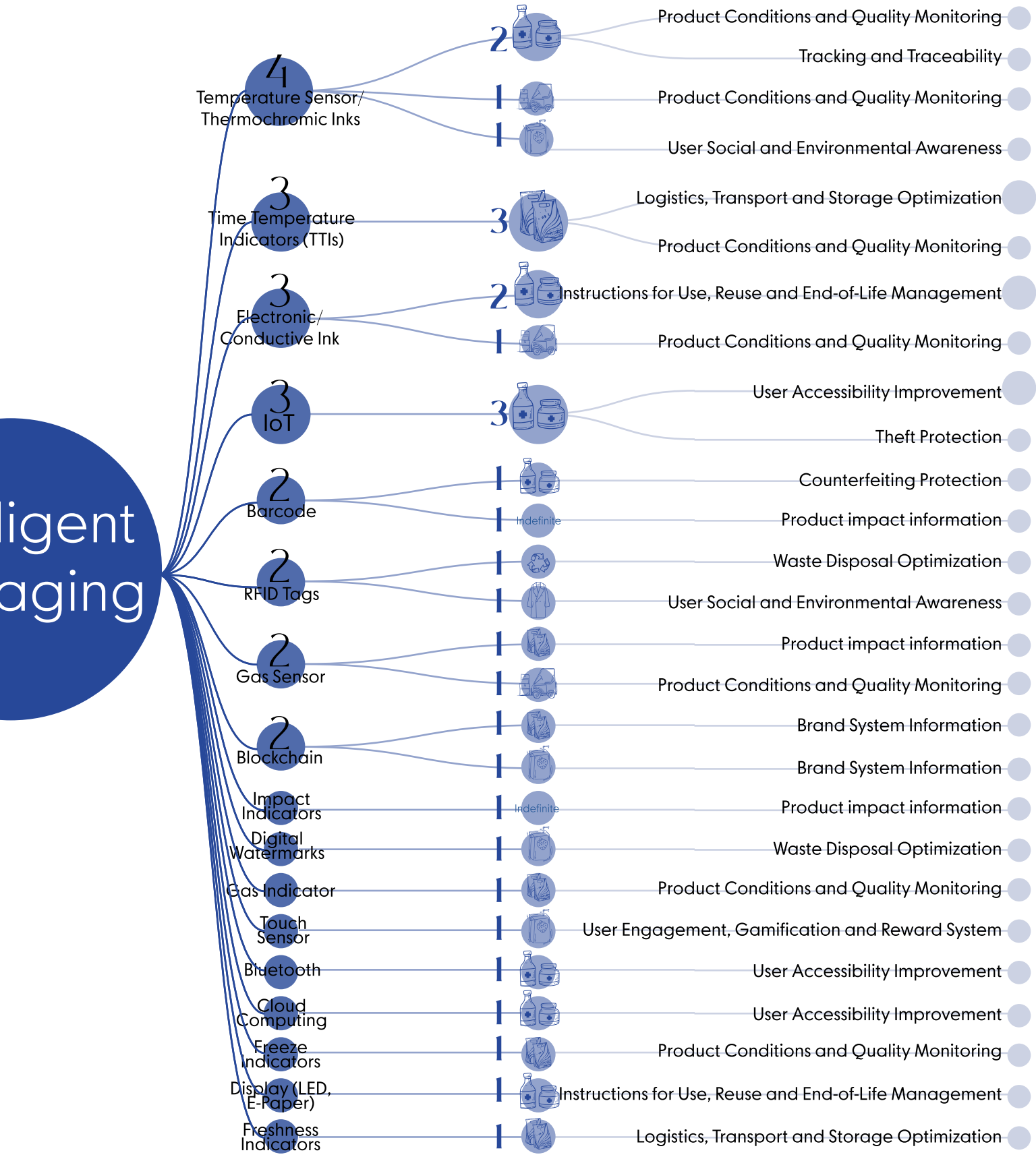
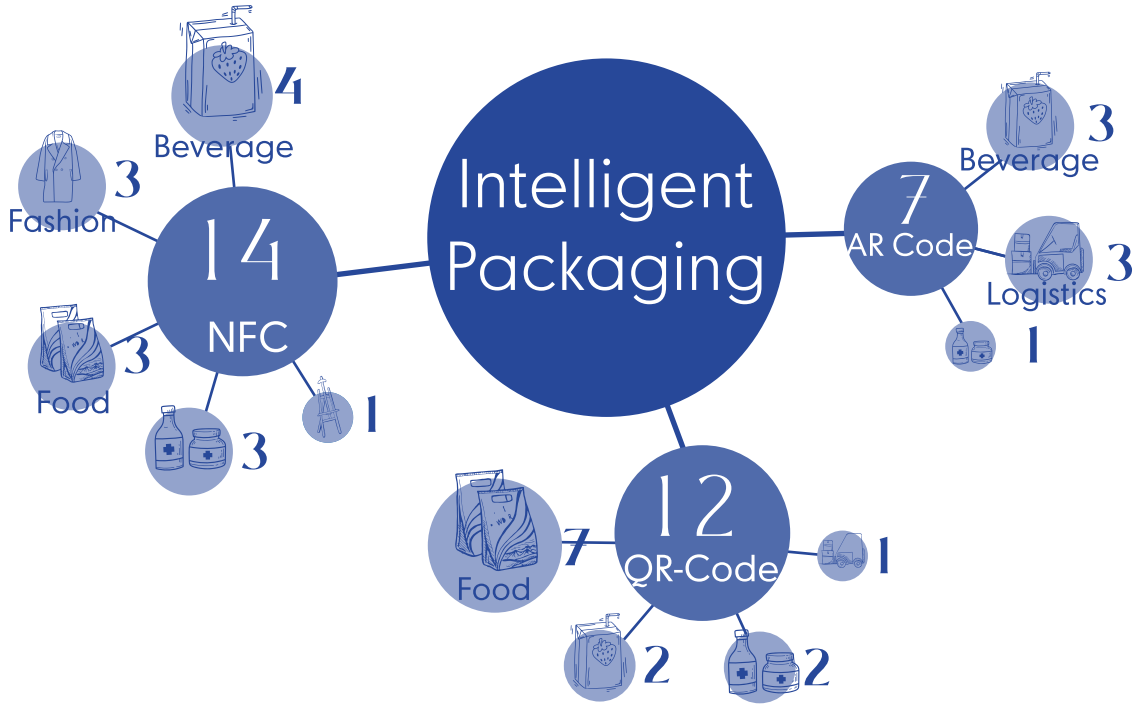


Most widely used technology



In the realm of intelligent packaging, three technologies have emerged as particularly prominent: NFC (Near Field Communication), QR codes, and AR (Augmented Reality) codes. Each of these technologies offers unique advantages and is predominantly utilized in specific sectors, highlighting their versatility and importance in modern packaging solutions.

NFC technology is extensively applied across various industries, notably in the beverage, fashion, and food sectors. The primary advantage of NFC is its ability to enable seamless, contactless communication between devices, which facilitates enhanced consumer engagement, authentication, and real-time data exchange. In the beverage industry, NFC tags are used to provide consumers with detailed product information, verify authenticity, and offer interactive experiences. Similarly, in the fashion sector, NFC tags help combat counterfeiting and enable personalized shopping experiences. The Italian fashion industry, renowned for its high-quality and luxury brands, can leverage NFC technology to protect brand integrity, verify product authenticity, and enhance the overall consumer experience by providing rich product histories and care instructions.

QR codes are another widely adopted technology in intelligent packaging, with significant usage in the food and beverage sectors. The simplicity and accessibility of QR codes make them an excellent tool for providing consumers with instant access to a wealth of information via their smartphones. In the food sector, QR codes are used to share nutritional information, recipes, and origin details, enhancing transparency and consumer trust. The beverage industry uses QR codes for marketing campaigns, loyalty programs, and to deliver rich media content such as videos and interactive advertisements. In the Italian fashion

industry, QR codes could be utilized to offer customers access to exclusive online content, such as virtual fashion shows, brand stories, and style guides, further enriching the consumer's interaction with the brand.

AR codes, though slightly less common than NFC and QR codes, are gaining traction, particularly in the beverage and logistics sectors. AR technology offers an immersive and interactive experience, allowing consumers to visualize products in a new dimension. In the beverage industry, AR codes can transform product packaging into engaging marketing platforms, where consumers can access interactive content and virtual experiences. In logistics, AR codes are used to streamline operations by providing real-time data on inventory, improving accuracy and efficiency in the supply chain. For the Italian fashion sector, AR codes present an innovative way to engage customers, offering virtual try-on experiences, interactive product catalogs, and augmented reality shopping experiences that blend the digital and physical worlds seamlessly.

These intelligent packaging technologies not only enhance consumer engagement and provide valuable information but also play a critical role in ensuring product authenticity, safety, and traceability. The integration of such advanced technologies in packaging demonstrates the industry's commitment to innovation and consumer satisfaction. In the context of the Italian fashion industry, these technologies support the preservation of brand heritage, enhance consumer trust, and offer new avenues for customer interaction, aligning with the industry's tradition of excellence and innovation.

Main purpose of intelligent packaging

The diagram highlights the main purposes for which intelligent packaging technologies are employed, focusing on user engagement, gamification, reward systems, social and environmental awareness, and product conditions and quality monitoring. These technologies, including NFC tags, QR codes, and AR codes, are crucial in various sectors, particularly in the fashion, food, and beverage industries.

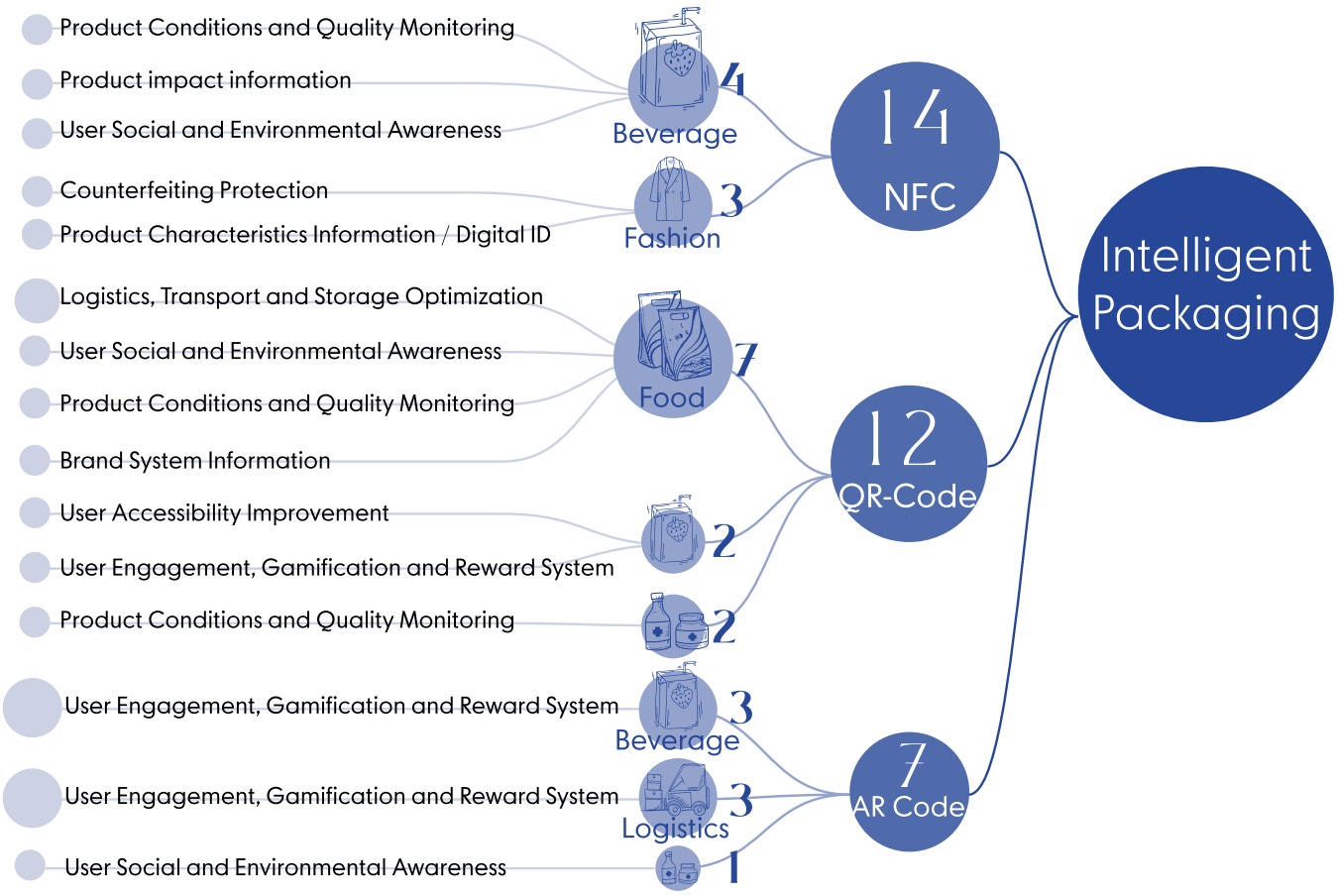
One of the primary purposes of intelligent packaging is to enhance user engagement, gamification, and reward systems. By integrating features like NFC tags and QR codes, brands can offer interactive and rewarding experiences. Consumers can access exclusive content, participate in loyalty programs, and engage in gamified marketing campaigns through these technologies. This not only boosts customer engagement but also fosters brand loyalty by providing a unique and memorable interaction with the brand.

Another significant purpose is to raise user social and environmental awareness. Intelligent packaging technologies enable companies to share detailed information about their sustainability practices and ethical sourcing. This transparency is facilitated through QR codes and NFC tags, allowing consumers to learn about the environmental and social impact of their purchases. For the Italian fashion industry, these technologies can highlight the use of sustainable materials, fair labor practices, and efforts to reduce environmental impact, thereby enhancing brand reputation and consumer trust.

Product conditions and quality monitoring is also a critical application of intelligent packaging technologies. Sensors such as temperature and gas indicators, along with NFC and QR codes, help monitor product conditions throughout the supply chain. This real-time monitoring ensures product integrity and reassures consumers about the freshness and safety of their purchases. In industries like food, beverages, and fashion, maintaining optimal product conditions is essential to prevent spoilage, damage, and counterfeiting, protecting both the brand and the consumer.

In summary, the diagram underscores the diverse applications and significant benefits of intelligent packaging technologies in enhancing consumer engagement, promoting social and environmental responsibility, and ensuring product quality. These technologies are pivotal in modern packaging solutions, particularly in the Italian fashion sector, supporting innovation and excellence while meeting contemporary consumer expectations.

Main solution aim related to entertain the user



The diagram showcases three main applications of intelligent packaging technologies: NFC tags, QR codes, and AR/WebAR codes, emphasizing their primary purposes in entertaining users and enhancing user engagement. These technologies play a crucial role in modern packaging solutions, particularly in increasing user interaction and brand experience.

Firstly, NFC tags are widely used in intelligent packaging. They provide seamless, contactless communication, allowing users to easily access detailed product information, verify product authenticity, and participate in interactive experiences.

QR codes are another widely used technology in intelligent packaging. Their simplicity and efficiency make them a convenient tool for consumers to access a wealth of information. In the fashion industry, QR codes can offer exclusive content such as virtual fashion shows, brand stories, and style guides, further enriching consumers' brand interaction experience.

The application of AR/WebAR codes in intelligent packaging is also increasing, especially in enhancing user interaction. AR technology provides immersive and interactive experiences, making product packaging not just a carrier of information but a platform for brand-consumer interaction.

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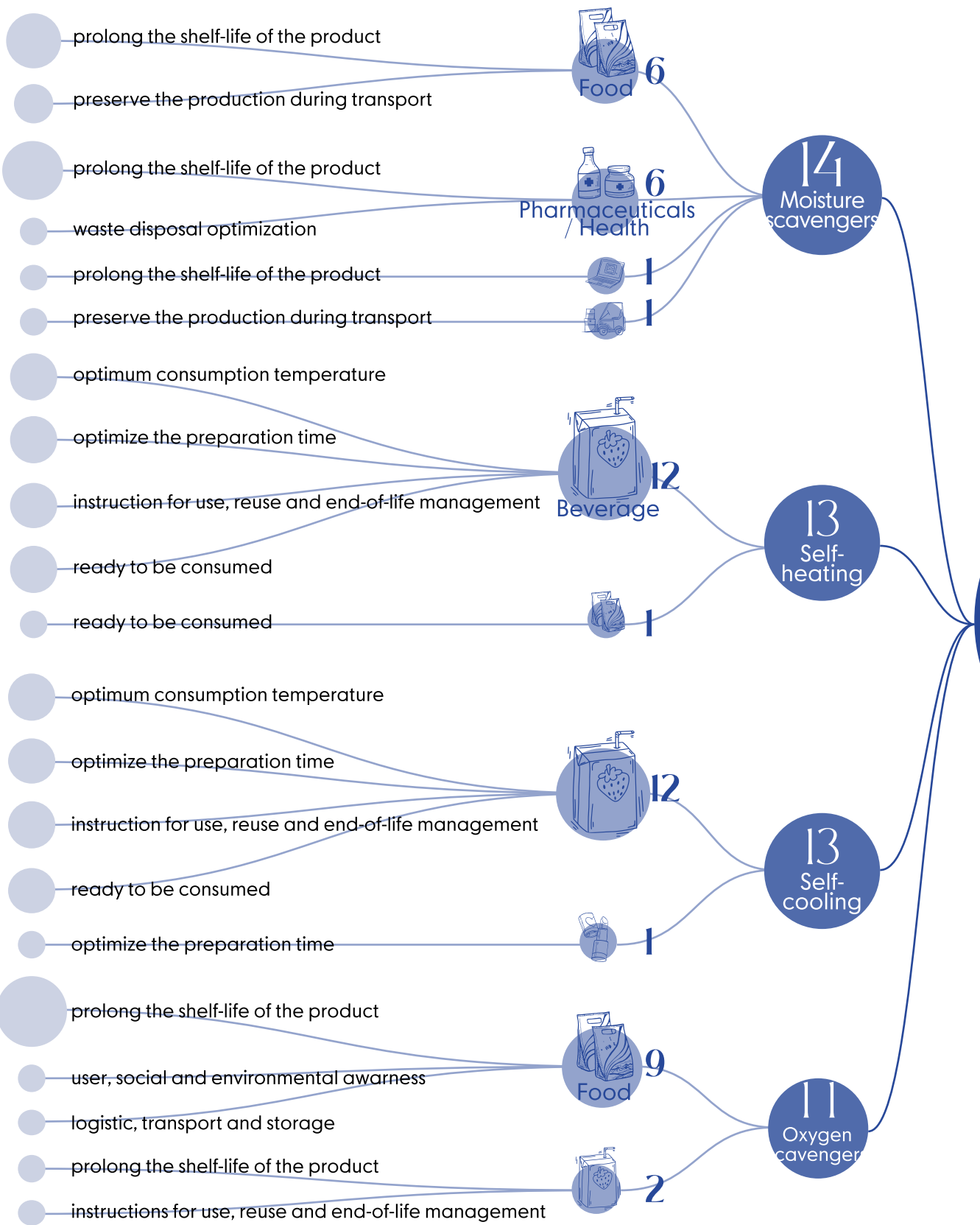

TABLE X: Active Packaging - Techno

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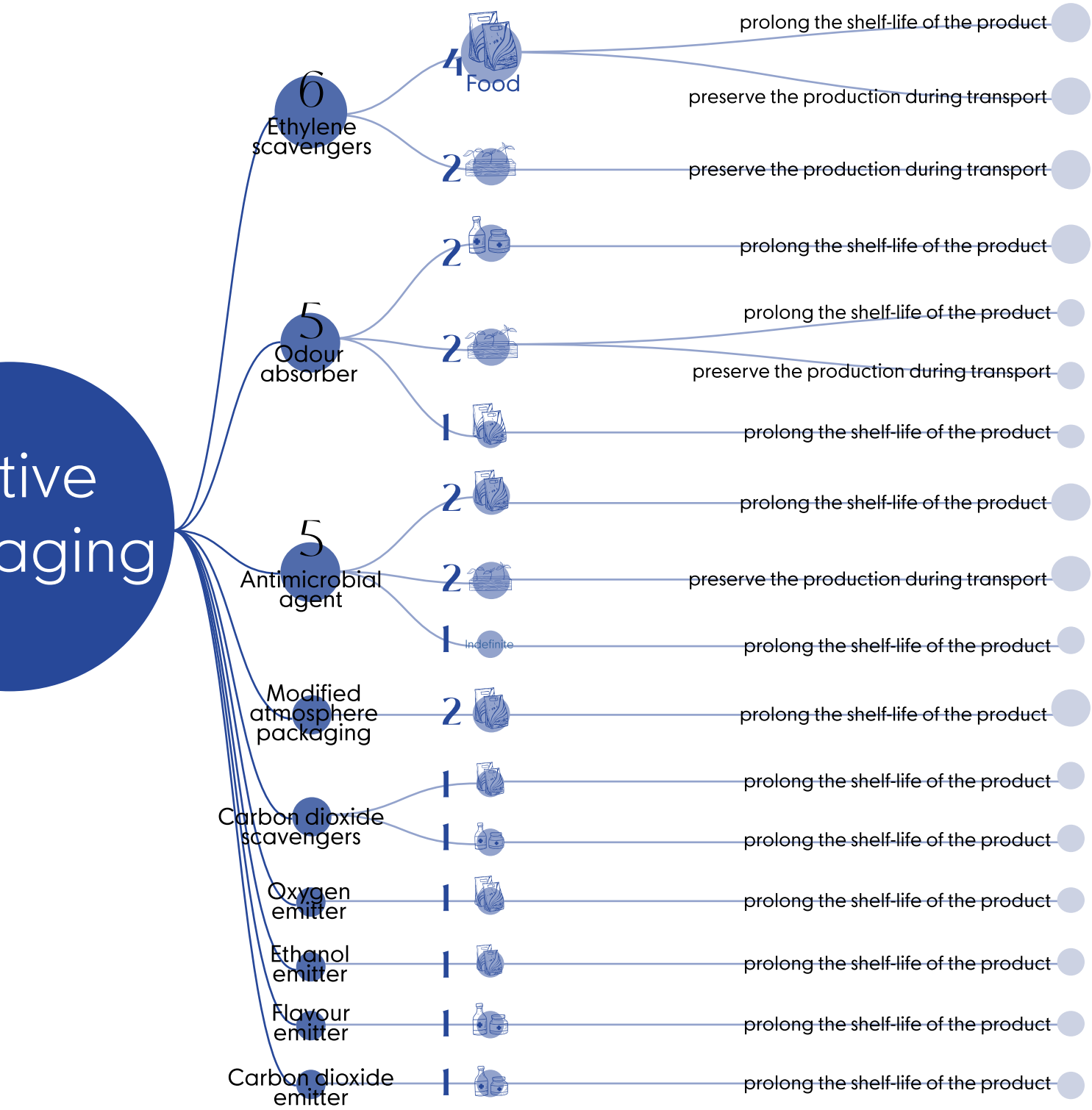


Most widely used technology

The diagram showcases several key technologies widely used in active packaging, including moisture scavengers, oxygen scavengers, self-heating, and self-cooling packaging. These technologies play a crucial role in various industries, particularly in extending product shelf life and ensuring product quality and safety.

Firstly, moisture scavengers are extensively used in active packaging, especially in the food and pharmaceutical/health industries. The primary function of moisture scavengers is to control humidity levels inside the packaging, preventing products from becoming damp and spoiling. In the food industry, moisture scavengers effectively extend the shelf life of products, maintaining their freshness and quality. In the pharmaceutical and health industries, these technologies help preserve the stability and efficacy of medications and health products, ensuring their quality and safety throughout the supply chain.

Oxygen scavengers are another commonly used technology in active packaging, primarily applied in the food and beverage industries. Oxygen scavengers remove oxygen from the packaging, preventing oxidation reactions and extending product shelf life. In the food industry, oxygen scavengers prevent the oxidation and spoilage of food, maintaining its freshness and nutritional value. In the beverage industry, these technologies ensure the quality and flavor of products, extending the shelf life of beverages.

Self-heating and self-cooling packaging are innovative technologies in active packaging, mainly used in the beverage and food industries. These technologies allow products to self-heat or self-cool without the need for external equipment, providing a convenient consumption experience. In the beverage industry, self-heating and self-cooling packaging enable consumers to enjoy drinks at the ideal temperature anytime, while in the food

industry, these technologies offer instant heating or cooling solutions, enhancing product convenience and appeal.

In summary, these active packaging technologies play a significant role in extending product shelf life, ensuring product quality, and enhancing consumer experience. By applying these technologies, various industries can not only improve the market competitiveness of their products but also meet the high demands of modern consumers for product quality and convenience. In the Italian fashion industry, these technologies can also be adopted and applied to ensure product quality during transportation and storage, enhancing brand value and customer satisfaction.

Main purpose of active packaging

The diagram highlights the main purposes of active packaging technologies, focusing on prolonging product shelf life and preserving products during transport. These technologies are essential across various industries for maintaining product quality and extending product lifespan.

Firstly, extending product shelf life is a key goal of active packaging. Technologies such as oxygen scavengers and moisture scavengers reduce oxygen and humidity levels inside packaging, preventing oxidation and spoilage. In the food and beverage industries, these technologies help maintain freshness and flavor. In the pharmaceutical industry, they ensure the stability and efficacy of medications and health products.

Secondly, active packaging technologies play a crucial role in protecting products during transport. Products face environmental challenges like temperature changes, humidity fluctuations, and physical impacts. Active packaging uses antimicrobial agents and ethylene scavengers to mitigate these factors, ensuring product quality and safety upon delivery. These technologies are widely used in the food and fashion industries to protect sensitive items like fresh produce and high-end fashion goods.

In summary, active packaging technologies are vital for extending shelf life and protecting products during transport. They enhance market competitiveness, meet consumer demands for quality and safety, and improve product lifespan, thereby boosting brand value and customer satisfaction.

FASHION SYSTEM IN ITALY

In this chapter we report the research we have done to understand what is Made in Italy and how the fashion system works in Italy. This step is in accordance with the first step of the systemic methodology that leads to analyze a system in a holistic way, then understand the system from different points of view such as historical, economic, productive, legislative and environmental. Following this scheme we have made an analysis to understand what is, at the legislative level, made in Italy and how it is defined. Then, we understood how production is organized in Italy, specifically we analyzed the districts present in the Italian territory with a greater focus on those related to the fashion world. Then we analyzed the history of fashion in Italy, the history of the districts and finally the history of the raw materials used in the fashion world. Following this historical overview of the fashion world we have analyzed the whole production process, going then to disentvisare in more detail each step of the process so as to have a clear understanding of it, from the procurement of the primary matrices to the end-user. Finally, we have analyzed the economic value that the fashion world represents for Italy and the monetary flows that import and export entail.

2.1 MADE IN ITALY

The term Made in Italy, today, is synonymous throughout the world with quality and excellence of which Italian products are carriers. Today it is almost associated with a real brand.
What is the "Made in Italy" brand?
The "Made in Italy" by definition is a mark of origin then an indication applied to a single product or a package that certifies the production in Italy to allow the consumer to recognize the national goods and distinguish them from those imported. Care must be taken, however, not to confuse the concept of origin with that of origin of a good. The origin indicates the place from which a good is shipped, while the origin indicates the place of production. [116]
The declaration of origin of a product has become compulsory since Italy acceded to the Madrid Agreement of 1981, which stipulates the obligation to "indicazione precisa ed in caratteri evidenti del paese o del luogo di fabbricazione o di produzione", then indicate in legible characters the country or place of manufacture or production.
In transposing this international agreement into Italian law, the D.P.R. n. 656/1958 introduced the administrative detention by the customs offices of goods for which there is a well-founded suspicion that they bear a false or false indication of origin.
In addition, in the event that there is an improper use of the "Made in Italy" origin mark, it is criminally sanctioned by art. 517 c.p., which establishes: "Chiunque pone in vendita o mette altrimenti in circolazione opere dell'ingegno o prodotti industriali, con nomi, marchi o segni distintivi nazionali o esteri, atti a indurre in inganno il compratore sull'origine, provenienza o qualità dell'opera o del prodotto, è punito, se il fatto non è preveduto come reato da altra disposizione di legge, con la reclusione fino a due anni e con la multa fino a ventimila euro", then anyone who sells or circulates goods with national names, marks or distinctive signs, which mislead consumers as to the origin of the goods, it is punishable by law both in civil and criminal law, with the payment of a fine and imprisonment. [117]

The affixing of the mark of origin "Made in Italy" should therefore mean that a good has been produced in Italy, thus protecting Italian excellence.
Unfortunately this is only partly true and often even products made almost entirely abroad can affix the brand "Made in Italy".
This is because, in order to determine the country of origin of a product, it is necessary to refer to the European legislation on non-preferential origin of the product. To determine the non-preferential customs origin of a product, the following two criteria, contained in art. 60 of Codice Doganale dell'Unione:

1) Criterion of goods wholly obtained
This criterion is only applicable when the entire manufacturing process has taken place in a single State. Art. 60 of CDU states that "le merci interamente

ottenute in un unico paese o territorio sono considerate originarie di tale paese o territorio".

2) Criterion of last substantial processing or working
Applicable for goods whose production two or more countries have cooperated, the criterion established by the second paragraph of art. 60 CDU: "Le merci alla cui produzione contribuiscono due o più paesi o territori sono considerate originarie del paese o territorio in cui hanno subito l'ultima trasformazione o lavorazione sostanziale ed economicamente giustificata, effettuata presso un'impresa attrezzata a tale scopo, che si sia conclusa con la fabbricazione di un prodotto nuovo o abbia rappresentato una fase importante del processo di fabbricazione", so the product is considered to originate in the country where the last substantial transformation took place. [118]

There is no clear definition of what is meant by "last substantial transformation". The European Court of Justice tried to clarify this concept in its judgment of 26 January 1977 C-49/76. The last substantial transformation "si verifica solamente nell'ipotesi in cui il prodotto che ne risulta abbia composizione e proprietà specifiche che non possedeva prima di essere sottoposto a tale trasformazione o lavorazione", that is if the product has a special composition and properties that it did not possess before being subjected to such transformation.
One tool that can overcome this uncertainty is Informazione Vincolante in materia di Origine (I.V.O.). I.V.O. is a tool that allows an entrepreneur to ask the Customs Agency to declare the origin of a product. Once the Information has been issued, it will be binding on Customs, both in the import and export phase, precluding subsequent disputes. [117] [119]

In 2009, Law No. 166/09 was passed, introducing a new origin mark: "100% Made in Italy". Only products for which the design, design, processing and packaging took place exclusively in Italy can be considered entirely Italian. Only these products can boast of such words as "100% Made in Italy", "100% Italia" (100% Italy) "tutto italiano" (all Italian) or similar.
This introduces a more restrictive mark of origin that stands out from the simple "Made in Italy". While the latter can boast all the products for which the last transformation or substantial processing took place in Italy, the "100% Made in Italy" is reserved for entirely Italian productions. [117]

In 2010, the Italian Parliament passed the law c.d. Reguzzoni-Versace-Calearo. This law provides for "Made in Italy" a particular legislation in the textile, leather goods, footwear, sofas and tanning products sectors.
For each product sector of reference, the specific processing phases are identified by law. The law provides that, in the sectors identified, they can indicate "Made in Italy" the products for which the processing phases have taken place mainly on the Italian territory and, in particular, if at least two processing phases have taken place in Italy. Although this law has been formally in force in Italy since 2010, it is not concretely applicable. The European Parliament has in fact expressed a negative opinion on the implementing decrees. [120]

2.1.1 THE DISTRICTS OF MADE IN ITALY

Industrial districts are composed primarily of small and medium-sized independent companies situated within a limited geographical area, historically connected by a common production purpose. These companies form an active economic and social network, offering specialized expertise and collaborating with local private and public entities.
The advantages of industrial districts are numerous:

- Enhanced cooperation between companies, leading to greater flexibility and efficiency in meeting market demands.
- The development of a subsidiary system that ensures high standards of quality, both in terms of professional expertise and product output.

"141 industrial districts have been identified by Istat on the basis of local labour systems (SLL) on the basis of the analysis of their productive specialization, as can be seen from the data of economic units collected in 2011 through the 9th General Census of Industry and Services. 2011. Regarding 2001, the number of industrial districts decreases of 40 units.

The population and economic size of the districts increases. Each district, on average, consists of 15 municipalities (13 in 2001), 94,513 people (67,828 in 2001) and 8,173 local units (6,103 in 2001) that absorb 34,663 employees (26,531 in 2001).

The districts of Made in Italy are 130, 92.2% of the industrial districts of the country; they are more present in the mechanical (27.0%), textile-clothing (22.7%), household goods (17.0%) and leather, leather and footwear (12.1%)."[121]

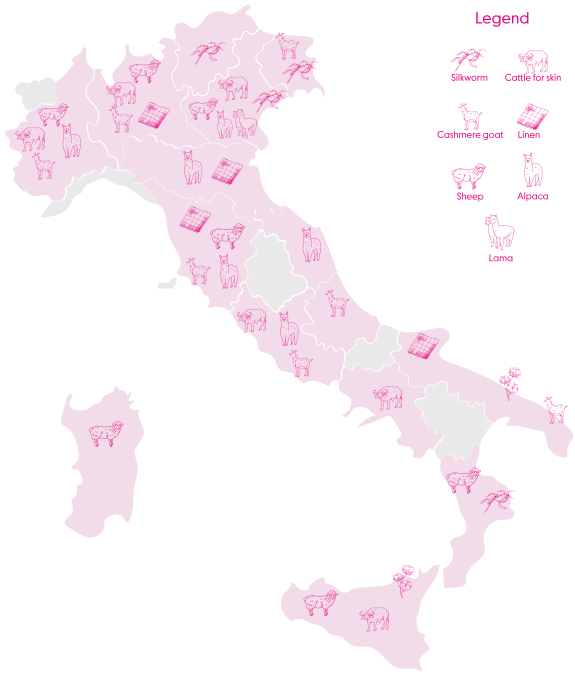
"Distretti industriali 2011" from Istat Data [121]

RAW MATERAIL PRODUCTION IN ITALY

Italy's diverse landscape supports a variety of raw material production districts, each specializing in different natural resources essential for various industries, particularly the textile and fashion sectors. These districts play a pivotal role in maintaining the quality and heritage of the "Made in Italy" brand, with each region contributing unique raw materials that are integral to various industries.

Silk production in Italy is predominantly found in Northern and Central regions. Despite its historical significance, silk production faces challenges such as high costs and ethical concerns, which have led to a decline in its prevalence. However, the existing producers focus on maintaining high standards, ensuring that Italian silk remains a luxury product sought after worldwide.

Linen cultivation has seen a resurgence in recent years, particularly in Central Italy. Reintroduced in 2022, linen production aims for excellence despite the limited areas of cultivation. This revival highlights Italy's commitment to traditional agricultural practices while adapting to modern demands for quality and sustainability.
Leather production, derived from cattle, is widespread across Central and Southern Italy. This sector, however, faces significant ethical issues that impact its production and market acceptance. Producers are increasingly seeking sustainable and ethical alternatives to address these concerns, aiming to maintain the high standards associated with Italian leather.



Row material production in italy

Wool production is concentrated in Northern and Central Italy, particularly in the Apennine regions. Despite the small size of farms, which restricts their ability to meet high global demand, these farms produce high-quality wool. This focus on quality over quantity supports Italy's reputation for premium textile products and sustains traditional sheep farming practices.

Cashmere goat farming is primarily located in the mountainous regions of Northern and Central Italy. The limited production of cashmere emphasizes quality, catering to a niche market that values the luxurious nature of this fiber. Similarly, alpaca and llama farming, though scattered and small-scale, contribute unique fibers for specialized textile products, supporting the diversity of Italy's raw material offerings. Sheep farming, widespread across Italy with significant concentrations in Sardinia and Central Italy, supports both the wool and meat industries.

This sector relies on traditional practices, ensuring that the products meet high standards of quality that Italian textiles are known for.

The reintroduction of cotton in Southern Italy in 2022 marks an experimental phase aimed at establishing sustainable production. This initiative reflects a broader trend of diversifying and reviving traditional agricultural practices to enhance the sustainability and quality of raw materials used in Italy's textile industry.

Overall, the geographical distribution and specialization of raw material production districts are crucial to the "Made in Italy" brand. These districts contribute to Italy's global reputation for excellence in fashion and textiles by focusing on quality and sustainability. The ongoing efforts to address ethical and environmental concerns further reinforce the country's commitment to responsible and high-quality production. This blend of tradition and innovation ensures that Italy remains a leader in the global textile industry.

TEXTILE INDUSTRIAL DISTRICTS IN ITALY

Italy's textile industry is renowned worldwide for its quality, craftsmanship, and tradition. The country's textile industrial districts are key contributors to this reputation, with each district specializing in various aspects of textile production. These districts, spread across the country, from the northern regions to the southern parts, bring unique contributions to the industry, ensuring that Italy maintains its prestigious position in the global textile market.

Textile Industrial Districts in Italy

In the northern region, Lombardy stands out as a major hub for textile production, leveraging its historical expertise and advanced technology to produce high-quality fabrics. Nearby, the Como region is synonymous with silk production, known for producing some of the finest silk fabrics in the world. This tradition dates back centuries, and the region continues to uphold its reputation for excellence in silk manufacturing. Vicenza, another northern district, is celebrated for its delicate lace and high-quality leather goods. The craftsmanship in these areas supports both the fashion and luxury goods sectors, enhancing Italy's global standing in these industries.

Moving to central Italy, Carpi is an important textile district renowned for its high-quality production and innovation in textile manufacturing processes. Tuscany, famous for its leather production, particularly in areas like Florence, also contributes significantly to textile production. The region combines traditional techniques with modern technology, ensuring that both its leather and textiles meet the highest standards. Additionally, Assisi is well-known for its intricate embroidery work, a craft perfected over generations. The embroidery from this region is highly valued in the fashion industry for its quality and artistic value.

In the southern part of Italy, the Campania region is notable for its contributions to both the textile and leather industries. The region focuses on maintaining high standards and traditional methods, ensuring that its products continue to be recognized for their excellence. Meanwhile, in Sicily, Bronte is known for its textile production, contributing to the diversity of Italy's textile industry with its unique regional characteristics.

Despite the industry's excellence, the Italian textile sector faces several environmental and ethical challenges. Linen and wool production are associated with environmental problems related to dyeing processes, while leather production faces not only environmental issues from dyeing and tanning but also ethical concerns and counterfeiting problems. Cotton production, reintroduced in some regions, also grapples with environmental challenges due to dyeing practices. These challenges highlight the need for the industry to adopt more sustainable and ethical production practices.

In conclusion, the textile industrial districts in Italy are integral to the country's reputation for high-quality fashion and textiles. Each district, with its specialized focus, contributes to a rich tapestry of products celebrated globally. While maintaining traditional craftsmanship, these districts are also navigating modern challenges, striving to adopt more sustainable and ethical production practices. This blend of tradition and innovation ensures that Italy remains a leader in the global textile industry, offering products that are not only beautiful and high-quality but also increasingly sustainable.

APPAREL INDUSTRIAL DISTRICTS IN ITALY

Italy is celebrated globally for its high-quality apparel, and much of this reputation is due to its specialized apparel industrial districts. These districts, scattered throughout the country, are each dedicated to specific aspects of clothing and accessory production, from shoes and hats to buttons and corsetry. The synergy of these districts ensures that Italy remains at the forefront of the fashion industry.

In the northern region of Italy, the Lombardy area is a significant player in the apparel sector, particularly known for its production of underwear and buttons. The meticulous craftsmanship and attention to detail in these products underscore the region's commitment to quality. Moving east, the Veneto region is distinguished by its production of glasses and clothing, integrating traditional techniques with modern design to cater to both local and international markets.

Central Italy, particularly Tuscany, is another powerhouse in the apparel industry. This region is renowned for its shoe production, with a focus on combining style and comfort. The Marche region, known for its hat production, adds another dimension to Italy's fashion offerings, providing high-quality, stylish headwear that is sought after worldwide. Assisi, famous for its embroidery, contributes intricate and artistic details to various apparel items, enhancing their aesthetic appeal and value.

Southern Italy also plays a crucial role in the country's apparel industry. The Molise region focuses on clothing production, maintaining high standards and traditional methods to produce

Apparel Industrial Districts in Italy

garments that are both durable and stylish. Further south, in Puglia, the production of shoes and corsetry is prominent. This region's dedication to excellence ensures that their products meet the rigorous demands of the fashion industry.
However, the apparel industry in Italy is not without its challenges. Environmental concerns, particularly regarding waste production and disposal, are significant issues that the industry must address. The production processes involved in creating high-quality apparel generate waste, and finding sustainable methods to manage and reduce this waste is crucial for the industry's future.

Italy's apparel industrial districts showcase the country's commitment to quality and innovation in fashion. Each district's expertise contributes to a globally respected industry. Despite environmental challenges, they uphold Italy's reputation for exceptional apparel, blending traditional craftsmanship with modern design.

The following is a specific list of industrial districts.[122]

Basilicata
Distretto della corsetteria di Lavello

Campania
Distretto conciario di Solofra
Distretto tessile di Sant'Agata dei Goti - Casapulla
Distretto tessile di San Marco dei Cavoti
Distretto tessile di San Giuseppe Vesuviano
Distretto calzaturiero di Grumo Nevano – Aversa – Trentola Ducenta
Distretto tessile di Calitri

Emilia-Romagna
Distretto calzaturiero di San Mauro in Pascoli
Distretto calzaturiero di Fusignano e Bagnacavallo
Distretto tessile di Carpi

Molise
Distretto dell'abbigliamento di Trivento e Riccia

Piemonte
Distretto laniero di Biella
Distretto tessile di Chieri - Cocconato
Distretto tessile di Oleggio – Varallo Pombia

Puglia
Distretto calzaturiero di Barletta
Distretto calzaturiero di Casarano

Sicilia
Distretto tessile di Bronte

Campania
Distretto orafo di Marcianise

Toscana
Distretto orafo di Arezzo

Lazio
Distretto dell'abbigliamento della valle del Liri

Lombardia
Distretto del bottone di Grumello del Monte
Distretto tessile della val Seriana
Distretto tessile lecchese
Distretto della calzetteria di Castel Goffredo
Distretto serico comasco
Metadistretto del design
Metadistretto della moda
Distretto meccano-calzaturiero di Vigevano
Distretto dell'abbigliamento gallaratese
Distretto del tessile intimo in Valle Camonica

Marche
Distretto del cappello
Distretto calzaturiero di Fermo e di Macerata

Toscana
Distretto della pelle, cuoio e calzature di Castelfiorentino
Distretto conciario e calzaturiero di Santa Croce sull'Arno
Distretto calzaturiero di Valdinievole
Distretto tessile di Prato
Distretto calzaturiero di Lucca
Distretto della pelle, cuoio e calzature di Valdarno superior
Distretto dell'abbigliamento di Empoli

Umbria
Distretto del ricamo di Assisi

Veneto
Distretto sistema moda
Distretto dell'abbigliamento
Distretto calzaturiero del Brenta
Distretto vicentino della concia
Distretto calzaturiero veronese
Distretto dell'occhiale di Belluno
Distretto argentiero
Distretto orafo vicentino

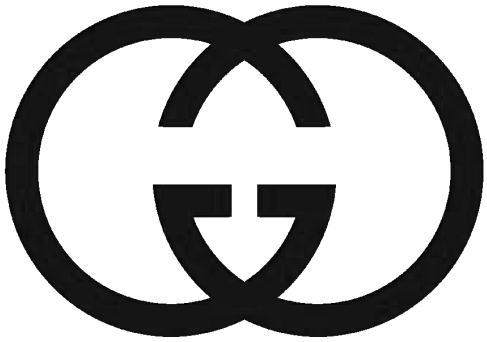
2.2 ITALY FASHION

In this section we will report the historical research performed, to understand the evolution of Italian fashion and the birth of the concept Made in Italy not from a legislative point of view, as we analyzed in the previous section, but of the perception of it by foreign consumers and what this has meant for Italy. We will discuss the evolution of the realization of clothes, firstly the clothes were made by tailors and made to measure but following the advent of the standardization of sizes and mass production of clothes there was a complete outclass of the fashion boutique with clothes prêt-à-porter and then the birth of the figure of the designer and the great brands that Italy can boast of.
Later we report the history and evolution of textile districts, the reasons that led to their birth, their development and sometimes even their decline.
Finally, we report the history of the production of raw materials, all not originating in the Italian territory but which have nevertheless represented the basis for the creation of what is now a brand that evokes quality, refinement and good realization such as Made in Italy.

2.2.1 HISTORY OF FASHION

When you think about what Italy represents, the first words that come to mind are food and fashion. After all, Italy includes names such as Gucci, Ferragamo, Versace, all great haute couture who have made and continue to make school. But this almost integral "identity" of Italy is relatively recent. Of course, there was already a certain notoriety for textile production but we could not yet talk about Italian fashion. At the beginning of the 20th century clothes were made to measure by tailors. This entailed a high price of realization, long times of realization, but the fact of being realized by hand and custom was synonymous with uniqueness.
On the other hand, at the beginning of the '30s, also because of the recently concluded World War I and the high industrial development, in northern Italy, and in particular in Turin and Milan, very advanced in the packaging of uniforms, was born the desire to focus on a new way of making clothes: to pack ready-made clothes. In the wake of this desire, in 1930 the Gruppo Finanziario Tessile (GFT) was founded in Turin thanks to the union between the Turin-based company Donato Levi and the Biella-based Lanifici Rivetti. Two years later, in 1932, the Gruppo Finanziario Tessile founded, again in Turin, the brand Facis (Fabrica Abiti Confezionati In Serie)that is, the creation of a factory of mass-produced clothes. Always in Turin, in those years the Gruppo Finanziario Tessile opened the chain of stores Marus (Magazzini Abbigliamento Ragazzo Uomo Signora). They were a chain of stores that sold ready-to-wearmade. With the advent of the fascist party and, always present, will to create a national fashion, in 1935 was established the Ente Nazionale Moda, founded by the fascist party based in Turin. This body had the aim of driving this nascent industry of ready-made.
Around the same time, however, even big names in the fashion boutique expanded their market. One example is the Gucci fashion house, founded in 1921 by Guccio Gucci in Florence, which opened its first store in Rome. The Gucci atelier originally produced travel suitcases, based on the traditional craftsmanship of the Tuscan manufacture, famous for the processing of leather.

GUCCI



House of Gucci logo [123]

Despite the advent of the World WarII, in 1945 another name of the fashion boutique opened its boutique in Veneto. Roberta di Camerino began to produce her line of bags and fashion accessories.
After the World War II and the fall of the fascist party the Ente Nazionale Moda was dissolved but the idea at the base had remained alive then in October 1945 was refounded, this time chaired by Count Dino Lora Totino of Cervinia, known for his collaboration in the construction of the Mont Blanc tunnel, which came from an ancient family of Biella lanieri and therefore was very familiar with textile production, in collaboration with Giovanni Roveda, the then mayor of Turin, with base still Turin. This body, however, unlike the fascist one, had not been constituted by the State and had not yet been recognized as official by the State. To try to obtain this recognition, one of the first actions that the newborn Agency did was to organize in Turin, in the halls of the Palazzo Reale, the first Esposizione Nazionale delle arti della moda. The exhibition aimed to emphasize the link between the textile industry and fashion. Turin was therefore the ideal place to represent this connection thanks to the notoriety of the textile industry, which was one of the main Italian economic forces.
Despite the rising production of ready-made clothes and this desire to intensify the collaboration between the textile industry and fashion, in 1946 90% of the demand for clothes was satisfied by tailors.

In 1949, in Milan, another well-known industrial center, the Centro Italiano della Moda was born. Its birth had the objective to assume the legacy of the fascist entity but in doing so, Milan did not recognize the role of Turin in the nascent world of fashion. This act led to the birth of a rivalry between the two cities, about who would "take" fashion, starting to challenge each other by organizing exhibitions and parades. On 2 April 1949, the international exhibition of textile and clothing art was organized in Turin. This exhibition was commissioned by the president of the Ente Moda, Count Filippo Giordano delle Lanze, an important exponent of the wool factory. The then mayor of Turin, Domenico Coggiola, the Minister of Industry Ivan Matteo Lombardo, expressed the recognition of Turin as the capital of Italian fashion. In the same period, however, on April 4, 1949, the Centro italiano della moda in Milan had organized at the Teatro dell'Opera in Rome a show in which clothes made by fashion houses in Milan, Rome and Florence were presented. It is not necessary to underline that no fashion houses from these cities participated in the Turin exhibition and that Turin fashion houses were not invited to the Rome exhibition.
Still in 1949, the International Centro Interazionale delle Arti e del Costume (CIAC) was founded. Its base was at Palazzo Grassi, in Venice, it was equipped with an important collection of period clothes and it was published the magazine "Arte e Costume" in which they were called to write some of the major Italian art historians. Venice, too, wanted to enter the world of fashion and in 1950 the Festival della Moda was organized. This fashion show was, since the first year, one of the most luxurious events of Italian fashion.

On January 28, 1949, Linda Christian married Tyrone Power, an American actor. Their wedding was celebrated in Rome, the wedding dress was designed for the bride by the Fontana sisters, a Roman fashion house founded in 1943, while the groom's dress was designed by the Sartoria Caraceni. This event brought the Atelier Romani under the spotlight of Hollywood, giving a great boost to the nascent Made in Italy and the notoriety of Italian fashion abroad. Riding this wave of notoriety in May 1949 the Rome Chamber of Commerce organized the first national conference of fashion. On November 5 of the same year, the Comitato della Moda was established in Rome. It was not very successful, however, antagonizing the Turin committee and alliances in a not very profitable with the Ente di Milano, ending up not being able to achieve the objectives he had set himself.

Linda Christian and Tyrone Power Marriage [124]

In the wake of the notoriety that Italian fashion had received thanks to the marriage between the two Hollywood celebrities, and taking advantage of the new market opportunities that America constituted, the first Italian haute couture show was organized on February 12, 1951. This fashion show was organized by Count Giovan Battista Giorgini, a well-known Tuscan entrepreneur who was the promoter of Italian fashion and who can almost be called the father of Made in Italy. The parade was organized in Florence with the aim of presenting Italian clothes and accessories to American buyers. This event was followed by a second parade in July of the same year. Giorgini encouraged, in his first parades organized in Florence, the participation of Roman and Milanese houses but did not invite any high fashion house in Turin, simply inviting Mirsa, the name of the marquise Olga di Grésy, noblewoman, entrepreneur and designer, as a fashion boutique. This makes clear the great rivalry that still existed between the cities. In the same year, however, the Ente Nazionale Moda of Turin obtained recognition by the government and changed its name to Ente Italiano Moda. In 1953, after the official recognition of the Ente Italiano Moda of Turin by the State, an agreement was reached between the latter and Giorgini. From then on, the Florence fashion shows were formally held under the patronage of Turin. This fact contributed to the removal of Roman fashion houses from Florentine fashion shows. Thus, in 1953 the Sindacato Italiano Alta Moda (SIAM) was founded by Roman fashion houses, this led to a total detachment from the fashion shows organized by Giorgini. In 1954, Giorgini founded the Centro di

Firenze per la Moda Italiana (CFMI), whose main objective was to organize fashion shows at Palazzo Pitti, Florence. In the mid-1950s, the four cities laid the groundwork for a sort of division of labour that would become increasingly defined in later years. Rome would be dedicated to high fashion, Florence at the fashion boutique while Turin and Milan at the dress made.

While in Italy this new dynamic was established, the fashion boutique gained great recognition in America. In 1953, the Marquise de Grésy won the Neiman Marcus award. This award is an American award, also known as the Oscar of Fashion. This was the recognition of how important was the fashion-boutique, based on small craft workshops, for the American market.

While the battle between cities for the exclusivity of the world of haute couture raged, the evolution of ready-made clothes took a further step forward. In 1952, the Rivetti brothers, Italian entrepreneurs who were familiar with the reality of American industry, developed a complete system of measures for packaged clothes. This was the result of a vast operation of anthropometric survey of the Italians by sellers and shopkeepers, so as to create a standardized size system. This system had already been adopted during the First World War by the American industry, from which the Rivetti brothers had taken inspiration, to make the uniforms of the soldiers sent to fight in Europe.

Even outside Piedmont, following this great milestone achieved by the prêt-à-porter industry were launched brands that dealt with ready-made clothes including the launch of the brand Fuso d'Oro by the wool mill Marzotto di Valgano, Vicenza or in 1955 the birth of the brand Vestebene, founded by Albene Miroglio, which began to produce women's underwear, first using raion fiber and later developing a new synthetic fiber, polyester, which allowed to reduce production costs. This new type of production took more and more foot, in fact in 1955, 78% of the demand for clothes was satisfied by tailors. This shows how, in just ten years, the figure of the tailor was diminishing. Ready-to-wear clothing on the market had a high success and spread in southern Italy. In 1955 the first edition of Samia (Salone Mercato Internazionale dell'Abbigliamento), "Mostra Mercato di Moda" was held in Turin. This salon was entirely dedicated to ready-made clothes. The aim of this salon was to try to detach itself from haute couture to develop its own aesthetic code. Many great names were invited for the occasion, including the Milanese Biki and Jole Veneziani, the Roman sisters Fontana and Antonelli. All these big names proposed different collections for the foreign market. Samia gained great international prestige and soon the two annual editions became one of the world's leading events in the clothing industry. In 1957 the first edition of the Mitam (Mercato Internazionale del Tessile per l'Abbigliamento e l'Arredamento) was held in Milan. Although this market depended on the Milan Committee, the organization of the Mitam was largely entrusted to the EIM, so much so that Rossini, the director of Samia was simultaneously also director of the Mitam.

In addition to the success abroad of the Italian ready-made, the fashion boutique continued to conquer the American market. In 1956 Roberta Camerino won the Neiman Marcus award.

Roberta di Camerino wins Neiman Marcus award [125]

In 1958, the Rivetti brothers, after revolutionizing the world of ready-made launched their brand dedicated to a female audience: Cori (Confezioni Rivetti).
In the same year another important event happened, something that still brings many tourists and famous people from all over the world. Milan Fashion Week was established.
In the same year the Chamber of Mayors of Italian Fashion was founded in Rome. This room was commissioned by the high fashion center of Rome and Florence. Their goal was to coordinate the different sectors of Italian fashion, unfortunately failed its intent within a few years.

The 1960s brought a turning point in the field of fashion. We are in the years of student protests, attacks on American presidents, hippie and feminist movements and the "One small step for a man, one giant leap for mankind".
As an opening to the new decade, in 1960 he opened the fashion house Valentino, by Valentino Garavani in Rome. This fashion house can be defined as a first step from the fashion boutique, which had characterized the previous years, to the birth of a new type of fashion, Haute Couture. There is still no mention of the figure of the "Stilisti", the designer, this figure has not yet been recognized but there is an increasing desire to detach from that niche world that represented the fashion boutique. In fact, in a social and cultural context in which the '60s were found there was an increasing desire, even by the middle class to "dress in fashion". This was possible thanks to the economic boom in which Italy was located, therefore, even the middle class had more money to spend and invested them in the "dress". This huge spread of prêt-à-porter was also due to the improvement in the manufacture of clothes, there was more attention to style and higher quality fabrics were used. In 1965 56% of the demand for clothes was met by ready-made clothes.

In 1961, to celebrate the centenary of the Unification of Italy, Giovanni Battista Pininfarina, Italian entrepreneur and coachbuilder, founder of the current car company Pininfarina, organized in

Turin the fashion show called Moda. Style. Costume inviting the major fashion brands of the era.
In the same year, also abroad there was a desire to detach from the world of fashion boutiques and in France, another great name of today's fashion, Yves Saint Laurent, opened his fashion house. His intention was to propose a break from the fashion of the previous decade, giving a greater spread through prêt-à-porter.
On 29 September 1962, the National Chamber of Fashion was established, which was joined by the Milanese fashion houses. In 1965, the National Chamber of Fashion divided the fashion shows into two cities: Rome would have the Haute Couture while Florence would have the fashion shows dedicated to ready-to-wear. This allows us to understand how important prêt-à-porter had become.

The market was constantly expanding at that time, which even fashion houses like Salvatore Ferragamo expanded their production. The fashion house Salvatore Ferragamo was founded by Salvatore Ferragamo in 1927 in Florence, which after achieving notoriety in America in the production of shoes also earning the nickname "Shoemaker of the stars" because he had worked in a shoe shop in Hollywood. Salvatore Ferragamo originally produced shoes but in 1965 expanded its production to bags and clothing.

Salvatore Ferragamo

Salvatore Ferragamo logo [126]

The connection between Italian fashion and the American market was getting closer and closer so that in 1967 Valentino won the Neiman Marcus Award, the third won by a great Italian name. So famous that he dressed Jackie Kennedy, wife of the late American president JFK, whose life had been attentive in 1963, with Aristotle Onassis, Greek entrepreneur, strengthening even more the notoriety of Italian fashion abroad.

Lydia di Roma, Giancarlo Venturini, Valentino, Emilio Pucci and Stanley Marcus at the Neiman Marcus Awards. [127]

Jackie Kennedy and Aristotle Onassis marriage [128]

Until that moment there was not a great attention to fashion dedicated to young people, to the expression of themselves through the way of dressing. A major breakthrough was the opening by Mary Quant of a store in London, launching the miniskirt trend. Thanks to this, new and revolutionary for the time, garment, London became the true European capital of youth fashion.

Mary Quant and the miniskirt [129]

Even in Italy, more attention was paid to youth fashion, so that, in 1965, Gilberto Benetton founded the Benetton Group in Treviso and a year later opened the first store dedicated to youth clothing in Belluno. Three years later, in 1969, Benetton also expanded abroad by opening its first store in Paris.

Benetton logo [130]

Fashion was changing and so were the shops, an example was the opening of the first Fiorucci store in Milan, the store, since furniture, was inspired by the style of Pop Art, passing through a transgressive space that represented the youth movement of that time.

Fiorucci Pop Art shop [131]

There was on the part of young people, almost a willingness to go against fashion and a brand took this new trend in full. The birth of the brand Robe di Kappa, a brand of Maglificio Calzificio Torino played a central role in transferring the youthful trend of "antimoda" in a more casual sphere and sports clothes.

Robe di Kappa logo [132]

In 1969, since they had seen themselves excluded from the "division of tasks" by the National Chamber of Fashion, Turin and Milan founded new fairs dedicated to luxury industrial production: Modasezione and Milanovendemoda. The first was dedicated to a type of customers who were looking for clothes that represent a middle way between the Fashion Boutique and large-scale packaged. This was Turin's way of becoming a fashion hub. But this attempt, as history has shown, has not come true above all because of the fact that Milan, another city to aspire to the same result had on its side the fashion magazines that then advertised more the Milanese signatures than the others.

The atmosphere that reigned in the 70s was different from that that had characterized the previous decade, we talk about years that saw the birth of Queen, famous British rockband, the victory by ABBA, Swedish music group, the Eurovision Song Contest, the release of iconic films like Star Wars and Saturday Night Fever and the election of Margaret Thatcher as the first British Prime Minister. But at the same time Italy had collapsed in the Lead Years, in which there was an extreme political dialectic that produced violence in the streets, armed struggle and terrorism that culminated in the kidnapping and killing of Aldo Moro.
In this period characterized by violence and lightheartedness the fashion environment could not help but be influenced. In 1974 Modasezione closed and a year later Mitam also closed. In 1977 closed the EIM and Samia. A year later Modit (Moda Italiana) was founded in Milan by Modenese. It became the main grandstand of the nascent Made in Italy, together with Milanovendemoda and then Milano Moda Donna and Milano Moda Uomo. This sudden disappearance of bodies and associations was due to the emergence of a new figure in the fashion world: "Stilista".
In this decade, in fact, we began to introduce the concept of "Stilista" whose task was to offer a sort of preventive expression of taste. It, therefore, was a very distinct figure from the company in which he worked. Albini was a great example of this new figure, almost detached from the manufacturers because, in a fashion show had designed clothes for four different houses but giving a unique imprint. With the designers not only a new fashion system was born, but fashion itself was transformed into a cultural industry, halfway between the classical manufacturing enterprise and the intellectual industry.

At that time the main fashion houses arose that still today shape the fashion scene. In 1970, Roberto Cavalli opened his eponymous fashion house in Sesto Fiorentino, in 1978 Gianni Versace opened in Milan the fashion house Versace, Miuccia Prada became the owner of the Prada fashion house that was founded in 1913 in Milan by the brothers Mario and Martino Prada under the name Fratelli Prada.

One of the great examples of the connection of the fashion market and Made in Italy and with the American market is the history of the fashion house Armani. The fashion house Giorgio Armani was opened in 1975 by Giorgio Armani in Milan.

The take-off of this new brand reached the red carpet when, in 1978, Diane Keaton wore an Armani dress when she won the Academy Award for Best Actress. This event was really important for the launch of Made in Italy in America. A year later Armani won the Neiman Marcus award and in 1980 he released the film America Gigolò, whose protagonist played by Richard Gere, dressed only clothes by Armani.

GIORGIO ARMANI

Giorgio Armani logo [136]

PRADA

roberto cavalli

VERSACE

Prada [133], Roberto Cavalli [134] and Versace [135] logo

Diane Keaton wear Armani dress for the Oscar Night [137]

Richard Gere in American Gigolò wearing Armani [138]

The 80s saw the rise of other important fashion houses such as the Moschino fashion house, founded by Franco Moschino in Milan and the fashion house Dolce & Gabbana founded by Domenico Dolce and Stefano Gabbana in Legnano. This fashion boom gained a huge recognition by the then president of the republic Francesco Cossiga who gave several honors to the seven major Italian designers. Armani were awarded, Versace, Ferré, Valentino, Paola Fendi, Krizia and Wanda Ferragamo. These winners were among the protagonists of the made in Italy that had made fashion the second sector of the Italian economy after tourism. In 1986 the event Donna Sotto le Stelle was organized. This event was held on the staircase of the Trinità dei Monti. For the occasion twenty of the most important Italian designers paraded. This event was broadcast live in Eurovision.

Not only the American market had been conquered by Italian designers, but also the British monarchy. In 1991, Lady Diana wore a Versace dress for a photo shoot. He wore a long blue dress studded with applications, which immediately became iconic. After the publication of the photo shoot, Lady Diana and Gianni Versace became friends and the princess's wardrobe was enriched with many pieces of the designer. In the same year Sophia Loren won the Oscar wearing a black sequin dress signed Valentino. The following year, Lady Diana attended McCartney's concert wearing a red velvet dress by Valentino. In 1994 Elizabeth Hurley wore Versace's black dress held by pins along her right side when she accompanied Hugh Grant to the premiere of the film four weddings and a funeral. Italian designers had become the official escorts of celebrities.

Lady Diana photoshoot wearing Versace [141]

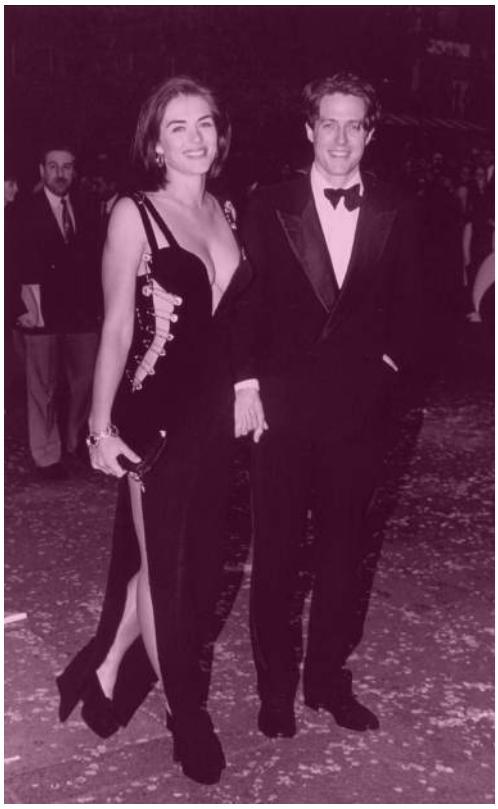
MOSCHINO

D&G
DOLCE & GABBANA

Moschino [139] and Dolce & Gabbana [140] logo

Sophia Loren wear Valentino for Oscar Night [142]

Lady Diana wear Valentino at Paul McCarthney concert [143]



Elizabeth Hurley dresses Versace at the premier of Four weddings and a funeral [144]

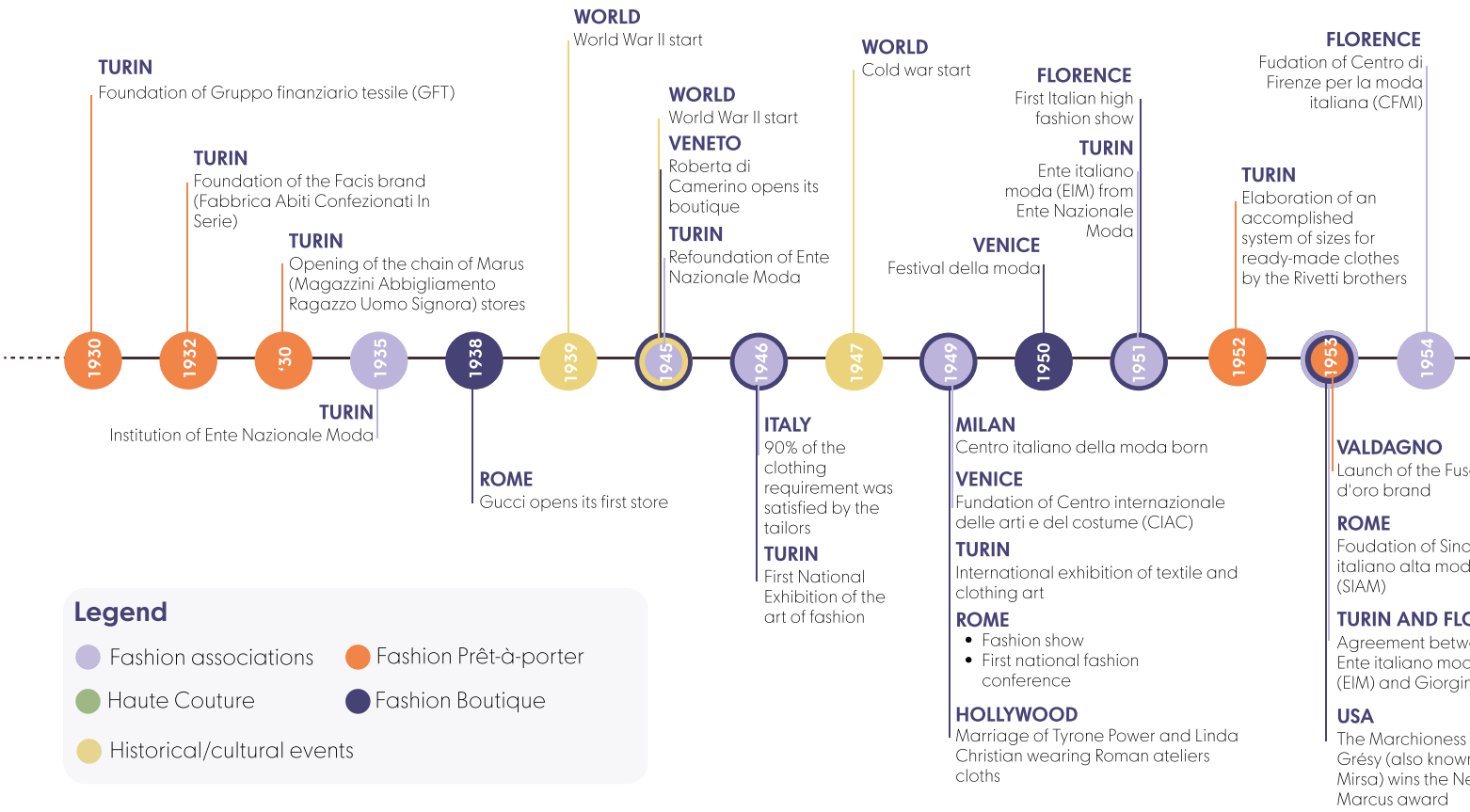
In 1993 he opened in Florence the fashion house Patrizia Pepe by Patrizia Bambi and Claudio Orrea. The world of Italian fashion was on everyone's lips. But this decade was not characterized only by successes and creations of clothes become iconic. In 1995 Maurizio Gucci was killed by Patrizia Reggiani, his ex-wife. In 1997, Gianni Versace was killed by serial killer Andrew Cunanan. The second half of the 1990s was a time of mourning for the fashion world. In 1999, following the murder four years earlier, the Gucci fashion house was bought by Kering S. A. an international luxury group based in Paris.
With the advent of the new century, there was a new wave of celebrities who showed off at major public events iconic clothes designed by major Italian designers. In the 2000s the iconic Versace Jungle Dress worn by Jennifer Lopez, American pop star, at the Grammy Awards night, or in 2001 the dress worn by Julia Roberts on Oscar night when she won the statuette as best actress, showing off a dress signed Valentino. In 2012, Carey Mulligan wore Prada's iconic sequined dress for the Met Gala.
In 2009 Milan was considered the capital of fashion surpassing cities such as New York, Paris, Rome and London.
In the same year Patrizia Pepe clothes became available for purchase online. This was a great turning point, changing the way of buying clothes, even Haute Couture. In 2016 another historic fashion house also chose to use the online sales channel for its clothes: Prada through a portal called Net-a-Porte and MyTheresa. Today buying clothes online, even big brands has become normal but these are the pioneers of this new way of selling their products.

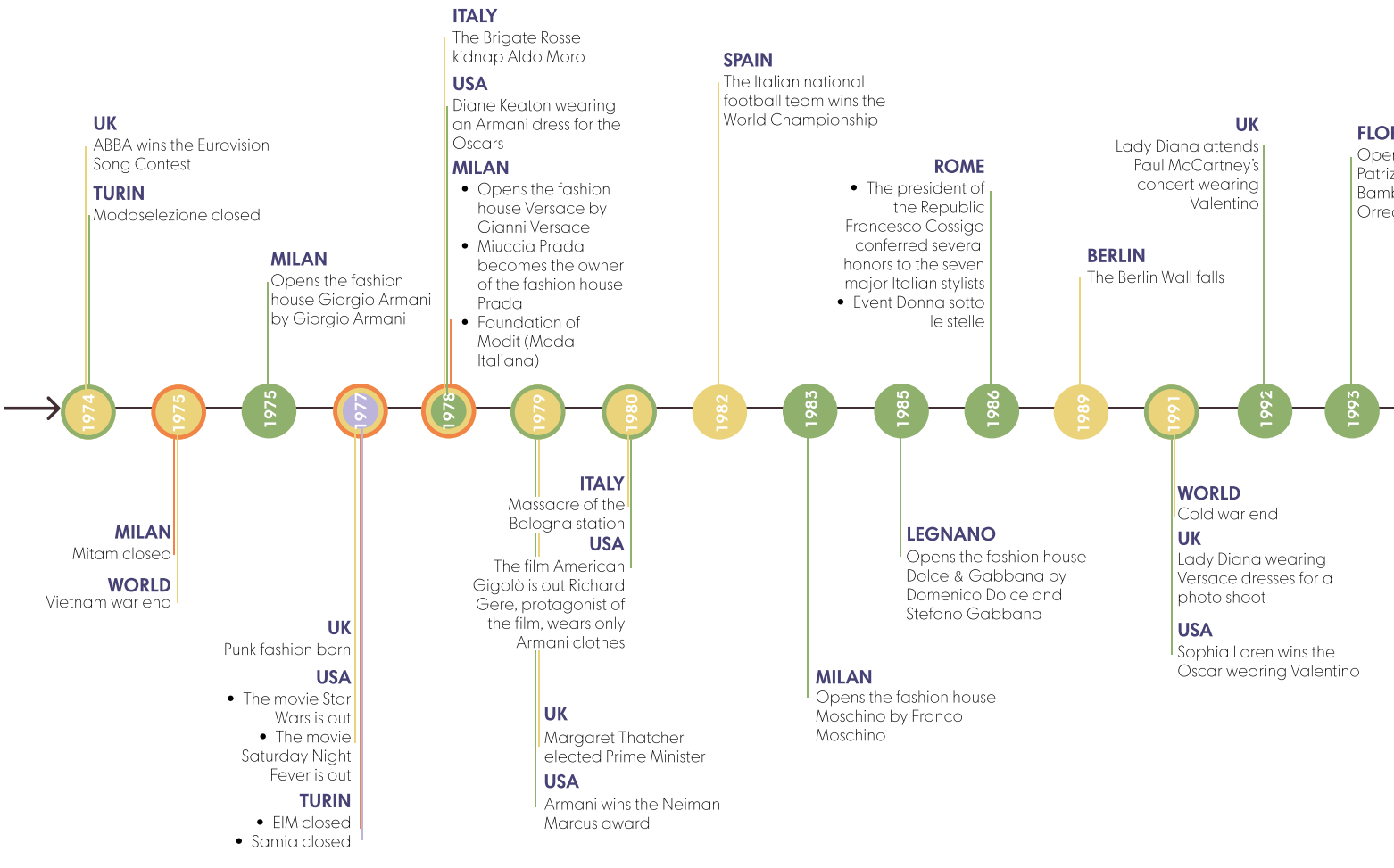
In 2012, the Valentino brand was sold to Mayhoola for Investments, a Quatar company. In 2018, the Versace brand was sold to Michael Kors Limited, and in 2019, Versace joined Capri Holdings Limited group to create a new luxury group with Michael Kors and Jimmy Choo, holding Donatella Versace in charge as creative designers. In 2019, the Roberto Cavalli brand was purchased by Dubai millionaire Hussain Sajwani.
Although the companies are no longer legally Italian, the spirit and creativity still reflect the original. It almost seems that nothing has changed, and that yesterday's beauties continue to fascinate the world today. An example was, in 2019, when Jennifer Lopez wore again the Jungle Dress designed by Versace for Milan Fashion Week. [147] [148] [149] [150] [151]
Fashion fascinates us, it represents us, with its oddities, its class, its extravagance and its normality, and Italy and Made in Italy are still today the driving force of this sector.

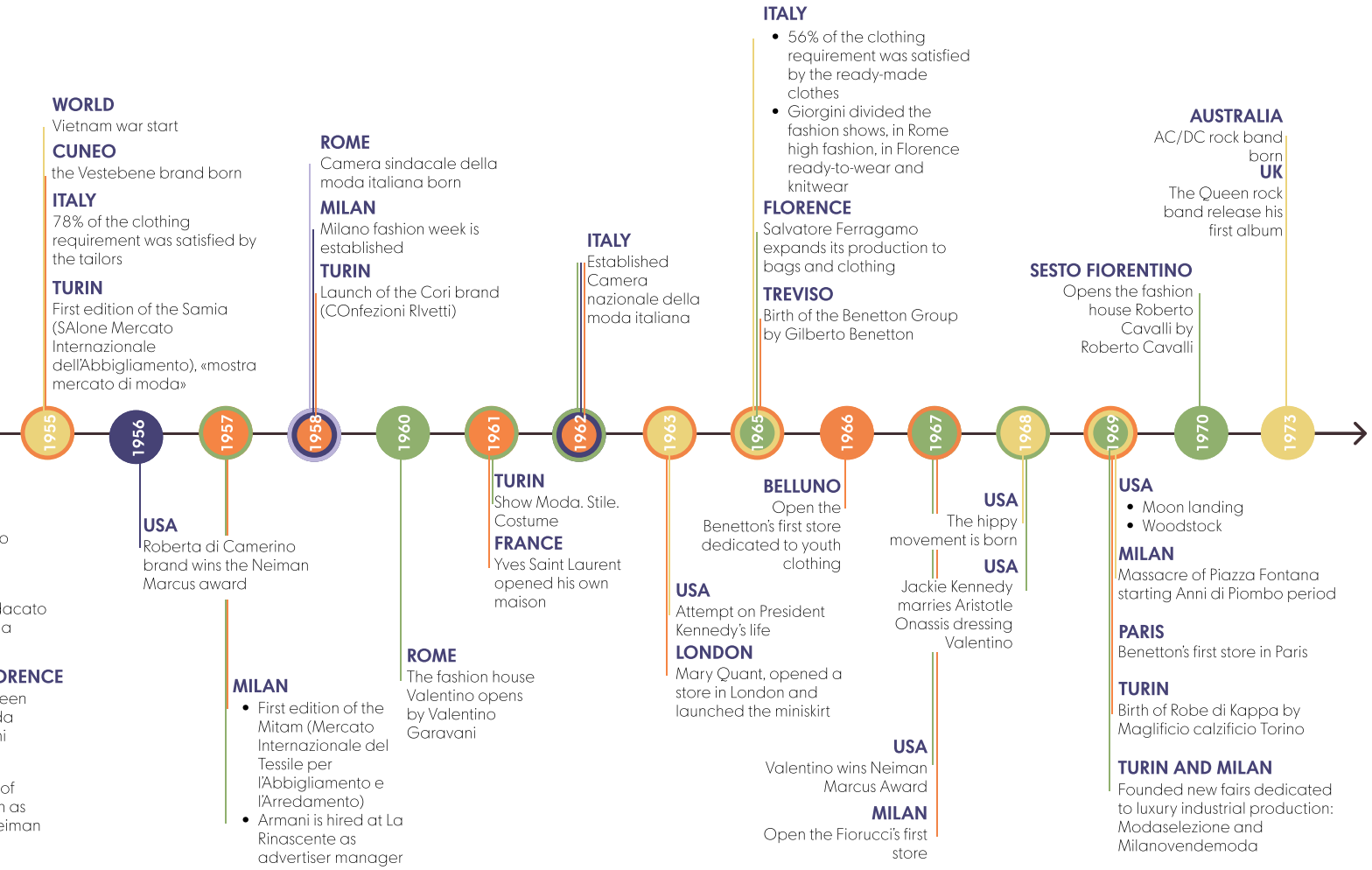
Julia Roberts wear Valentino dress for the Oscar Night [145]

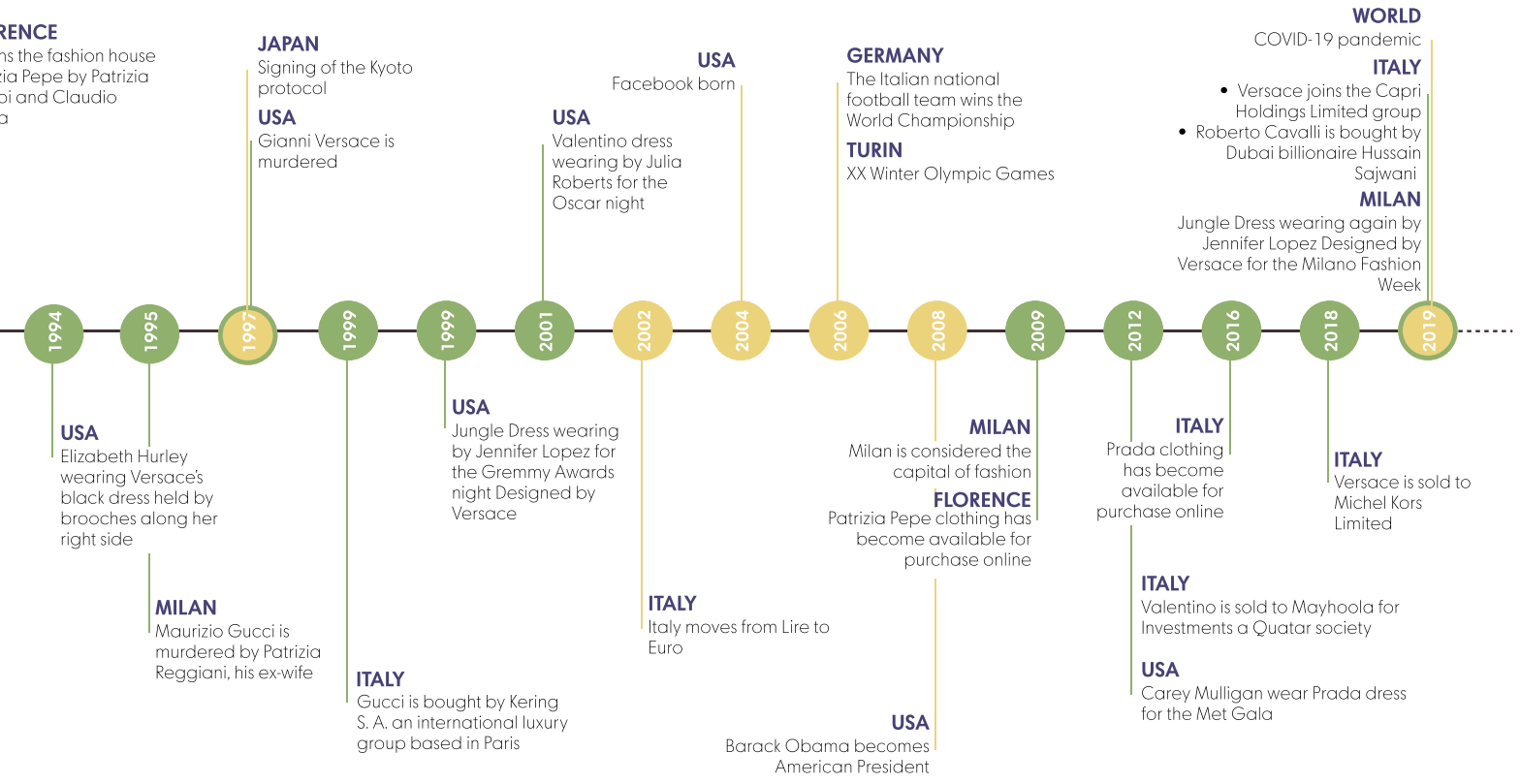
Jennifer Lopez wear Versace Junle Dress in 1999 and 2019 [146]

HISTORY OF FASHION IN ITALY






1955
WORLD
Vietnam war start
CUNEO
the Vestebene brand born
ITALY
78% of the clothing requirement was satisfied by the tailors
TURIN
First edition of the Samia (SAlone Mercato Internazionale dell'Abbigliamento), «mostra mercato di moda»
1956
USA
Roberta di Camerino brand wins the Neiman Marcus award
1957
MILAN
First edition of the Mitam (Mercato Internazionale del Tessile per l'Abbigliamento e l'Arredamento)
Armani is hired at La Rinascente as advertiser manager
1958
ROME
Camera sindacale della moda italiana born
MILAN
Milano fashion week is established
TURIN
Launch of the Cori brand (COnfezioni RIvetti)
1960
ROME
The fashion house Valentino opens by Valentino Garavani
1961
TURIN
Show Moda. Stile. Costume
FRANCE
Yves Saint Laurent opened his own maison
1962
ITALY
Established Camera nazionale della moda italiana
1963
USA
Attempt on President Kennedy's life
LONDON
Mary Quant, opened a store in London and launched the miniskirt
1965
ITALY
56% of the clothing requirement was satisfied by the ready-made clothes
Giorgini divided the fashion shows, in Rome high fashion, in Florence ready-to-wear and knitwear
FLORENCE
Salvatore Ferragamo expands its production to bags and clothing
TREVISO
Birth of the Benetton Group by Gilberto Benetton
1966
BELLUNO
Open the Benetton's first store dedicated to youth clothing
1967
USA
The hippy movement is born
USA
Jackie Kennedy marries Aristotle Onassis dressing Valentino
USA
Valentino wins Neiman Marcus Award
MILAN
Open the Fiorucci's first store
1968
USA
1969
USA
Moon landing
Woodstock
MILAN
Massacre of Piazza Fontana starting Anni di Piombo period
PARIS
Benetton's first store in Paris
TURIN
Birth of Robe di Kappa by Maglificio calzificio Torino
TURIN AND MILAN
Founded new fairs dedicated to luxury industrial production: Modaselezione and Milanovendemoda
1970
SESTO FIORENTINO
Opens the fashion house Roberto Cavalli by Roberto Cavalli
1973
AUSTRALIA
AC/DC rock band born
UK
The Queen rock band release his first album


1994
USA
Elizabeth Hurley wearing Versace's black dress held by brooches along her right side
1995
MILAN
Maurizio Gucci is murdered by Patrizia Reggiani, his ex-wife
1997
JAPAN
Signing of the Kyoto protocol
USA
Gianni Versace is murdered
1999
ITALY
Gucci is bought by Kering S. A. an international luxury group based in Paris
1999
USA
Jungle Dress wearing by Jennifer Lopez for the Gremmy Awards night Designed by Versace
2001
USA
Valentino dress wearing by Julia Roberts for the Oscar night
2002
ITALY
Italy moves from Lire to Euro
2004
USA
Facebook born
2006
GERMANY
The Italian national football team wins the World Championship
TURIN
XX Winter Olympic Games
2008
USA
Barack Obama becomes American President
MILAN
Milan is considered the capital of fashion
FLORENCE
Patrizia Pepe clothing has become available for purchase online
2009
2012
ITALY
Prada clothing has become available for purchase online
ITALY
Valentino is sold to Mayhoola for Investments a Quatar society
USA
Carey Mulligan wear Prada dress for the Met Gala
2016
ITALY
2018
ITALY
Versace is sold to Michel Kors Limited
2019
WORLD
COVID-19 pandemic
ITALY
Versace joins the Capri Holdings Limited group
Roberto Cavalli is bought by Dubai billionaire Hussain Sajwani
MILAN
Jungle Dress wearing again by Jennifer Lopez Designed by Versace for the Milano Fashion Week

2.2.2 HISTORY OF THE FASHION DISTRICTS

In the previous section we analyzed the relatively recent evolution of Italian fashion, the birth of "Stylists" and the change from tailor-made to ready-made. In this section we will see why many fashion houses have arisen in specific places, such as Milan, Florence and Turin going to reconstruct the history of Italian districts related to the world of textiles.

The establishment of the districts as a fabric production system dates back to the Middle Ages. The first draft of the present districts came with the rise of the Guilds from the 12th century. They were associations whose purpose was to regulate and protect the activities of producers belonging to the same professional category. They were based on an oath that committed their members to mutual assistance and the defence of common interests.

With the beginning of the Crusades in Palestine in 1095, there was strong political and economic instability in the East. The East had a long history of producing fabrics and silks. Exploiting this instability, the Italian merchants decided to establish silk industries in Tuscany, especially in the cities of Lucca and Florence and Liguria, in Genoa. Thanks to this, in the fourteenth century those who dictated the rules of luxury no longer came from the east but had moved to Flanders as for woolen fabrics and from Tuscany for those in silk. At that time, raw silk was imported from the countries of the Far East, it was necessary to wait until the early 1600s for the introduction of silkworm farming in Lombardy. Many peasant families were engaged in the cultivation of mulberry trees and in the production of silk cocoons also dealing with the processing of silk thread.

Lombardy, at that time, was not only concerned with the production of silk fabrics but also became the center of production of cotton fabrics. In the seventeenth century, there was a period of crisis for the medieval textile guilds in many cities of Lombardy but, despite this, Cremona, Monza and Busto Arsizio continued to be the hundred of production of cotton fabrics. At the same time, even in areas outside the control of corporations, such as Bologna in Emilia-Romagna, Chieri in Piedmont, Pistoia and Prato in Tuscany, and Milan became new proto-industrial centers. Proto-industry was a mode of organizing production processes that developed mainly in rural areas due to the availability of unoccupied labor in some seasons of the year. This type of production involved a merchant-entrepreneur who owned raw materials and looms and who entrusted to the peasant families bales of cotton, hemp and linen to be transformed into yarns. In this way the peasant families, especially during the periods when the agricultural work slowed down, could integrate the proceeds of the work of the fields with that of the spinning wheel or the loom. For this reason, cotton merchants organized work in rural areas, such as the mountain plains and the Lombard

valleys, where the land was generally arid, but there was a large abundance of water resources, necessary for processing cotton.

Italy at that time boasted not only a large production of silk and cotton but also a high production of wool. In 1670 Schio and Valdagno in Veneto, Biella in Piedmont and Prato became centers of wool production. In Schio was used local wool cheap. The production specialized in imitating woollen fabrics produced in Verviers, present-day Belgium and Wiltshire, England, as well as in medium quality carded wool garments. Biella instead, became the main Italian center for the production of a type of thick cloth of mixed wool of low quality. Prato, on the other hand, was famous for its red berets to the Levantine, of which Vincenzo Mazzoni had begun the production in 1788. Prato produced linen and pure wool fabrics of low quality that were highly sought after for their economy. Each city, therefore, had its own specialization.

In the middle of 1700, the proto-factories of Schio and Verona, used for the production of cotton yarns, began to use large looms with flying fuse for the production of more precious fabrics. Instead, domestic production of woollen cloths and mixed fabrics of low quality continued to be carried out within peasant families. These two production realities, domestic and centralized production, continued to coexist during the 18th and early 19th centuries.
In 1800 Biella was the first center of production of wool fabrics, followed by Schio and Prato. The Lanificio Piacenza, which was founded in 1733 by the Piacenza family in Biella, launched on the market patterned fabrics with colored patterns thanks to which it was established, as totally revolutionary compared to the simple fabrics that until then were produced. This contributed much to the success of the city as a center for the production of woolen fabrics.

This success did not extend to the processing of other raw materials. We are at the beginning of the industrial revolution and in Italy, textile production had not progressed as much as that of foreign countries, in fact, in the early 800 the processing of cotton was reduced due to the competition moved by the most advanced European industries. The 800, however, also brought great innovations in the textile industry.

In 1813 the Scotsman Benjamin Law invented the fraying machine, which made it possible to recover the fibers from pre-existing fabrics, which in the 1840s was the success of Prato. Italy tried to modernize itself, to keep up with other European industries. In 1917 Pietro Sella of the Lanificio Maurizio Sella, introduced in Biella the first automated machinery for processing wool he had purchased in Verviers.

Also in those years was founded the Lanificio Rossi in Schio by Francesco Rossi, who had bought the machinery from Gelmi & Bosio, a textile company in Gandino that was the first to adopt the first carding machinery and spinning machines for processing wool in 1808. All the companies of the time tried to modernize by buying these new machines that allowed to increase productivity and reduce costs.

In 1820 Giovan Battista Mazzoni, a manufacturer of textile machinery in Prato, made the mechanization of cotton and wool processing by applying technologies from foreign countries, such as carding and spinning cotton, textile fibres produced from a wider range of raw materials. In 1820 he adapted some machinery for spinning cotton to spinning wool. He began to use hydraulic energy as the driving force of machines and also developed other technological aspects of textile production such as dyeing, gauging and cotton cutting. In the thirties of the nineteenth century. he designed a machine for shaving the fabric, built a Jacquard loom and opened a foundry for the production of the components of his machines. These new inventions gave a huge boost to textile production.

In 1840, Prato obtained the frayed machines and the city gradually became the most important center for the collection and classification of wool rags and in 1850 Prato began to produce recycled wool fabrics from rags.

In 1840 in Biella, the Lanificio Maurizio Sella began to use chemical dyes and specialized in the production of high quality fabrics thanks to the use of spinning mules. In the mid-800 the Lanificio Piacenza of Biella included in its system steam boilers and built a large factory with residences for workers. Following this industrial adjustment, 80% of all cotton spindles in Italy were already concentrated in the provinces of Milan and Como.
The Unification of Italy, in 1861, was a great opportunity for market expansion for textile production centers, especially those located in northern Italy.
This drive to modernize production did not affect all types of raw materials. One example is Como, in which silk producers produced this fabric with obsolete looms, but despite this, they met a season of great prosperity. This happened because of the Franco-Prussian War that began in 1870, which forced Lyon, then a great power in the production of silk fabrics, to lose control over the market.
Prato, on the contrary, seemed unstoppable during this period of modernization, so much so that in this city was installed the first mechanical loom for wool processing. The notoriety of Prato had also reached abroad so much that in 1888, the Austrian company Kössler & Mayer founded the Fabbricone, the largest local factory of that time. Also in Prato, Lanificio Calamai installed the first mechanical spinning plant. The factory began to carry out the chemical carbonization of rags and drying of fabrics with machines. The regenerated fabric rivaled that of Yorkshire, although Prato's production, unlike the others, was mostly based on hand weaving.

At the end of the 19th century, the silk industry also experienced a profound development both at a technical and commercial level. The sector started a mechanization process seeing the number of frames increased. The wool industry also continued its modernization process and adopted a vertically integrated production cycle becoming one of the largest Italian industries in terms of both employment and production. This was possible also thanks to the imposition of protective duties of up to 40% between 1887 and

1965 by the state.
In the early 1900s, the Como silk industry began a rapid mechanization of production and, with the adoption of electricity, factories were moved to the plains and urban areas. This was not the only change that the silk industry of Como undertook, in fact it began to produce a new variant of silk, managing to create dyed fabric, based on the fabrics produced in Lyon. This step allowed the industries of Como to enter the high fashion market. Although their goal was to create new dyed fabrics, the dyeing and finishing industries of Como could not adapt technologically to the transition from vegetable dyes to chemical dyes.

With the outbreak of WWI there was a restriction of foreign trade. This led industrialists to invest in the manufacture of those products and machinery that were previously imported from more industrialized foreign countries but that now was no longer impossible to import. This forced Italy to undergo further industrial development. There was also an economic development because, both in the domestic and foreign markets, the silk and textile industries in general benefited from the withdrawal of French, German and Austrian competitors from the market. The industry of Prato, during the war received considerable commissions from the Italian army, especially for the production of fabrics for blankets and uniforms. The period of the Great War was therefore a period of prosperity for the textile industry.

Things changed in the post-war period. After 1918, artificial fibres were progressively introduced in Italy. SNIA Viscosa (Società Navigazione Industriale Applicazione Viscosa) was born in Turin, this company played an important role in bringing the production of artificial fibers to a good economic level sustainable- These new fibers were often used in combination with natural fibers, especially combined with wool.
In the same period the textile production of Prato focused on traditional carded and combed fabrics such as Melton, plaid, velvet, lining fabrics, double-sided wool, flannels, Cheviot and fabrics for men's and women's clothing.

In 1920, with the end of the boom that had been unleashed by the war, the textile industry suffered a deep crisis, but despite this it managed to regain prosperity after 1922 when important innovations made their way in this sector. Thanks to the development of man-made fibres such as raion, it was combined with silk to create a cheaper mix of silk and artificial fibres. Artificial fibres were imported from Belgium and Switzerland. In the same period Como tried to penetrate a new market niche such as the production of silk ties and shawls. These technological innovations and the increase in production due to mechanization, were not of great benefit. In 1926, large factories were in difficulty due to increased costs and overcapacity. Fewer and fewer people were buying silk clothing. The Great Depression of 1929 was a further blow to the silk industry and many silk industries faced bankruptcy or were absorbed by other industries.
This great crisis of silk fabrics was also due to the increasing growth of the production of artificial fibers. In 1935, Italy produced 15% of all artificial fibres

in Europe, making it the third largest producer in the world after the United States and Japan.
In 1936 even the wool industry of Prato began to use artificial fibers such as raion. In 1937 the National Textile Exhibition was held in Rome. This was an opportunity to promote synergy between the artificial fiber industries and the fashion industries.
The WWII outbreak was not as successful as the WWI outbreak. Because of the use of aeronautics bombing production centers to dampen the economy. During this period, the city of Prato suffered multiple damages.

Following the end of the war, the European recovery program began in 1948. Italian industries went through a process of modernization and "americanization" through the supply of goods (raw materials, in particular cotton), services (training and apprenticeship in America) and funding that allowed them to import advanced machinery from the United States.
In the 1950s, Italy, recovering from the post-war period, distinguished itself as the largest importer of textile waste from the United States, France, Netherland and West Germany. Prato became the largest center of regenerated wool, thanks to the development of procedures for the sorting of waste, which allowed producers to select and sort the items. At that time there was, in Italy, a strong migration of people from the south to northern Italy. In Prato, Most of the workforce came from the Mezzogiorno.

In the 50s there was an increasing affirmation of the fashion world and in 1950 wool fabric manufacturers and fashion designers collaborated in a fashion show themed 'Italian tailors and wool industries parade together' in which Biki (Elvira Leonardi Bouyeure), Vita Noberasko, the sisters Fontana and the company Rivella used wool fabrics from Marzotto, Rossi, Schio, Mabu, Zignone, Fila and several companies of Biella. In 1951, the first fashion show that presented Italian fashion, involving various sectors of clothing and fabrics, was organized. It was organized by Giovanni Battista Giorgini. Journalists and North American buyers participated in the most important department stores. Giorgini invited some emerging creators of Italian fashion with the result that high fashion houses such as Carosa, Simonetta, Schuberth and Fontana in Rome, Veneziani, Vanna, Noberasko and Marucelli in Milan and fashion-boutique, including Emilio Pucci and Tessitrice di Capri decided to attend the event.
Fashion manufacturers, however, were often dissatisfied with the quality and/or designs of Italian cotton and wool fabrics, as opposed to silks, traditionally used in high fashion. For this reason, Italian textile companies soon improved the quality of their products, as they considered collaboration with Italian fashion creators an extremely effective and low-cost advertising. In the mid-1950s, "Stilisti", that is, designers began to play a key role in textile design and clothing creation. In those years and in subsequent years, Italian designers such as Carosa, Germana Marucelli, sisters Fontana, Jole Veneziani, Krizia (Mariuccia Mandelli), Gianni Versace, Franco Moschino and Enrico Coveri, but also American designers such as Ken Scott, who had

inaugurated their own centers of creation in Paris and Milan, collaborated with the textile companies of Como, including Costa, Tondani, Clerici Tessuto, Bedetti Pedraglio, Giuseppe Scacchi and Ravasi. It was especially in the silk sector that Italian textile companies collaborated more often and more closely with fashion professionals.

In 1959, customs duties and import restrictions in the European Economic Community (EEC) were gradually abolished. This led, in addition to the great success that Italian fashion was enjoying, to an increase in exports to the United States by relaunching the Italian textile sector, especially in America. At that time, Italian clothing companies had been designing costumes for Hollywood actors since the late 1950s, effectively promoting their products to audiences around the world through films, actors and actresses.

In 1960 the textile factory in Como began exporting its fabrics to the USA. Luxury silk had become one of the main markets for Italian products. The success abroad of Italian silk meant that some Parisian designers, such as Jean Dessès, Madeleine de Rauch, Christian Dior, Jacques Fath and Hubert de Givenchy bought their silks in Como.

In the 1960s, established designers dedicated themselves to creating fabrics that were then used exclusively for their collections. In these cases, most textile companies were not allowed to label fabrics used in designer collections, and those who bought clothes judged the value of fabrics not on the basis of the textile company, but of the designer who designed the dress or used that fabric. As the clothing market became increasingly subject to the influence of fashion, the design, production and distribution of textiles were not organized by textile companies, but by processing companies, which had links with textile design studios, fashion designers and clothing factories.

With the spread of prêt-à-porter, textile companies were involved in the production of products for industrial clothing companies, which bought a much larger amount of materials and sold clothing under their own brand. The textile companies were no longer recognisable for the quality of the products because they could not differentiate them from those of competition by labelling. As was also the case with the use of fabrics by designers, the workforce of the textile industries went into the background, without having an official recognition.

The beginning of the recession in Italy in 1963 caused serious damage to industry, particularly in Biella, which was more dependent on the domestic market.

In 1969, the silk market, on the contrary, was very prosperous. The United States, France and Germany absorb 66% of the fabrics produced in Como for export.

In the 1970s, the production of regenerated fabrics decreased as much cheaper virgin wool fabrics from developing countries began to arrive. At that time, the textile industry underwent restructuring through state subsidies. This led to the fragmentation

of large integrated factories that produced standardized products in a network of small specialized enterprises. At that time the large vertically integrated Italian companies adopted two adaptation strategies: on the one hand there were companies that implemented a process of gradual decentralization of some stages of the production cycle by entrusting them to specialized and complementary companies, on the other hand, other large companies further integrated key functions vertically or horizontally by making strong investments in the creation of new plants and sales subsidiaries abroad or by acquiring other companies to develop new products and technologies of process thus expanding the product range. Some of these companies extended their activities to ready-to-wear clothing and its distribution.
Textile companies began to make a direct sale of their products to consumers. In this way, the textile companies that had begun to penetrate the clothing industry were able to highlight their identity with clothing collections made with their own fabrics, which was impossible when they were selling their fabrics to wholesalers or collaborating with ready-to-wear clothing companies.

At that time, the textile companies of Como had to compete with a fiercer international competition from emerging countries. For this reason they specialized in the production of very high quality silks so as to distance themselves more from those of medium quality made by emerging countries.
In Prato many textile companies managed to effectively restructure their organization and the range of products offered, collaborating with emerging Italian designers and moving from the production of regenerated fabrics and blankets for the bed to that of a wide variety of fabrics for high fashion, especially for women's clothing, using different raw materials, the production of fancy craft yarns and the implementation of very sophisticated finishing technologies. Some of these companies have entered the knitting yarn industry.

In 1971, Walter Albini brought together in a single collection items from different companies, such as Basile jackets, Callaghan knitwear and Mister Fox evening dresses labeling products as 'Walter Albini per' (trad. Walter Albini for), followed by the name of each company. This was perhaps one of the greatest examples of how the figure of the "Stilista" was completely detached from the manufacturer. Subsequently, Albini moved the promotion office to Milan. Like Albini, also the young generation of Italian designers, including Krizia, Ottavio Missoni, Versace, Gianfranco Ferré and Giorgio Armani, understood that the industrial and commercial infrastructure of Milan was a more congenial base than the Roman and Florentine. The Milanese collection had a huge impact on the world market of ready-to-wear and Italian textile companies, collaborating with these designers, also benefited from the subsequent boom of Italian fashion in the eighties.

In the 1980s, Italian textile production centres benefited from the boom in Italian fashion, and in this situation small companies exhibited their products at international trade fairs and made promotional trips to the fashion

capitals. At the same time, joint efforts by small independent local entrepreneurs to promote research and development, technical training and collective bargaining have begun to emerge, all the elements that have improved the competitiveness of the local industry. For example. each industrial city has opened its fair, as Ideacomo (Como), Ideabiella (Biella) and PratoExpo (Prato).

In the 90s, fashion changed drastically and the situation of the seterie of Como worsened, because, on the wave of minimalism, which had replaced the opulent taste of the eighties, began to circulate cheap printed silk from the Far East and viscose became one of the most used fabrics in the fashion industry. This crisis also spread to other sectors such as wool and some textile companies to combat the crisis and be more competitive on the market, decentralized production, both in different Italian regions and abroad.

This decentralization of production continues today even if there is a growing tendency to bring production back to Italian territories, both for a qualitative factor but also for the ever increasing interest, by consumers of a more sustainable production and an increasing attention to the exploitation of workers in poor countries, where generally fabrics are produced at a very low cost of labour. [152] [153]

HISTORY OF THE TEXTILE INDUS

1000

TUSCANY
From the time of the Crusades, sources of political instability and economic decline in the Eastern world, Italian merchants established silk industries in Lucca, Genoa and Florence

1095

PALESTINE
Beginning of the Crusades

1300

TUSCANY
Luxury no longer came from the East, but rather from Flanders for woolen fabrics and Tuscany for silks

early 1600

LOMBARDY
Many peasant families were engaged in the cultivation of mulberry trees, silk cocoons production and silk thread processing

1600

LOMBARDY
Even after the crisis of the medieval textile guilds of the cities, some towns in Lombardy, including Cremona, Monza and Busto Arsizio, continued to be centers of production of cotton fabrics

NORTHEN ITALY
Areas outside the control of corporations, such as Bologna, Chieri, Pistoia, Prato and Milan, became new proto-industrial centers

1670

PRATO, SCHIO, BIELLA
Became to prominence as manufacturing centers for wool

half 1700

SCHIO, VERONA
The protofactories of Schio and Verona had begun to use large looms with flying fuse for the production of fine fabrics

ITALY
Domestic production of woollen cloths and mixed fabrics of low quality was carried out within the peasant families. Domestic and centralized production coexisted during the 18th and early 19th centuries

1733

BIELLA
Foundation of the Lanificio Piacenza by the Piacenza family

1800

BIELLA
The Lanificio Piacenza launched on the market patterned fabrics with colored patterns thanks to which it established itself in a market dominated, until that time, by plain fabrics

PRATO
Prato established itself as the third centre for the production of woollen fabrics after Biella and Schio

early 1800

SCHIO, VERONA
The protofactories of Schio and Verona had begun to use large looms with flying fuse for the production of fine fabrics

1813

SCOTLAND
Benjamin Law invented the fraying machine

1817

BIELLA
Pietro Sella, c
introduced to
machinery he

SCHIO
Foundation c
acquiring the
textile compa
adopted the
carding and

Legend

- Synthetic fibers
- Historical events
- Cotton
- Wool
- Silk
- Fashion industry +Textile industry

1914

WORLD
World War I Startedt

ITALY
- There was a limitation of international trade that led industrialists to invest in the realization of those products and machines
- Both on the domestic and foreign markets, the silk industry and the Italian mechanical-textile industry benefited from the withdrawal of competitors

PRATO
During the WWI, the textile industry received considerable commissions from the Italian army, especially fabric for military blankets and uniforms

1918

WORLD
World War I Ended

after 1918

ITALY
Progressively introduced in Italy and often combined with natural ones, especially wool

TURIN
PSNIA Viscosa (Società Navigazione Industriale Applicazione Viscosa) played an important role in bringing the production of artificial fibres to a level of good economic sustainability

PRATO
Production Prato focused on traditional carded and combed fabrics such as Melton, plaid, velvets, fabrics for fabrics for men's and women's clothing

1920

ITALY
The silk industry suffered a deep crisis

1922

ITALY
Important innovations occurred in the silk textile industry: the development of artificial fibers such as raion and their combination with silk allowed the industry to achieve the cheapest mixed silks

COMO
Como tried to penetrate new niche markets such as silk for ties and shawls

1926

ITALY
The big silk industries were in difficulty because of the increase of the costs and the productive overcapacity

1929

USA
Great Depression

ITALY
Large silk companies faced bankruptcy, or absorption by other industries

1935

ITALY
Italy produced 15% of all artificial materials in Europe and was the third largest producer in the world after the United States and Japan

1936

PRATO
The wool industry of Prato began to use artificial fibers such as raion

1937

ROME
The National Textile Exhibition, held in Rome was an opportunity to promote synergy between the artificial fibres industry and the fashion industry

1939

WORLD
World War II Started

PRATO
The city of Prato was severely damaged during World War II

1945

WORLD
World War II

ITALY
Italy was world's largest importer of recycled textile waste. Main center for the regeneration of wool, Prato developed a procedure for sorting textile waste that allowed manufacturers to select and classify them

PRATO
Most of the workforce came from the Mezzogiorno

Wool fabric mar
fashion designers coll
fashion show themed
and wool industries pa
in which Biki, Vita
Fontana sisters
company used wo
Marzotto, Rossi, Schio, M
Fila and several c

STRY IN ITALY

of Lanificio Maurizio Sella,
o Biella the first automated
e had purchased in Verviers

of Lanificio Rossi by Francesco Rossi,
e machinery from Gelmi & Bosio, a
any from Gandino that had
use of the first machines for
spinning in 1808

BIELLA
Lanificio Maurizio Sella began to use chemical dyes and specialized in the production of high quality fabrics with spinning mules

PRATO
In Prato came the fraying machines and the city gradually became the most important center for the collection and classification of rags

PRATO
Prato began to produce recycled wool fabrics from used rags

ITALY
- Unification of Italy.
- There is a great opportunity for market expansion for textile production centres, especially in northern areas

FRANCE
Franco-prussian war. Lyon is stripped of control of the market and caused the interruption of production on the Rhine

COMO
Season of great prosperity despite most of the production of silk in rural industries with obsolete looms

PRATO
The first mechanical frame is installed in Prato

COMO
- Undertook a rapid mechanization of production and, with the adoption of electricity, the factories were transferred to the plains and urban areas
- Factories went on to produce new varieties of silk inspired by those products from Lyon, which allowed them to enter the high fashion market
- The dyeing and finishing industries found some problems in the transition from vegetable to chemical dyes

1820 · 1823 · 1830 · 1840 · 1850 · half 1800 · 1860 · 1861 · 1870 · 1888 · end 1800 · early 1900

PRATO
Giovan Battista Mazzoni made machinery for spinning cotton

PRATO
Giovan Battista Mazzoni adapts cotton spinning machines to wool spinning

PRATO
Giovan Battista Mazzoni designed a machine for shaving the fabric, built a Jacquard loom and opened a foundry for the production of the components of his machines

BIELLA
Lanificio Piacenza included in its system steam boilers and built a large factory with residences for workers

ITALY
As a result of this industrial adjustment, in the provinces of Milan and Como alone 80% of all cotton spindles in Italy were concentrated

PRATO
- The Austrian company Kössler & Mayer founded in the Tuscan city the Fabbricone, the largest local factory of the time
- Lanificio Calamai installed the first mechanical spinning plant in Prato, and the factory began to carry out the chemical carbonization of rags and drying of fabrics with machines

ITALY
- The silk industry experienced profound developments at both technical and commercial level; the sector underwent a mechanization process and saw the increase in the number of looms
- The Italian wool industry entered a phase of modernization and adopted vertically integrated production cycles, becoming one of the largest Italian industries in terms of both employment and production

ITALY
- Designers began to take on a key role in textile design as well as in the creation of clothing
- Italian designers such as Carosa, Germana Marucelli, the Sisters Fontana, Jole Veneziani, Krizia, Gianni Versace, Franco Moschino and Enrico Coveri, but also American fashion designers such as Ken Scott collaborated with the textile companies of silk.

ITALY
- Beginning of the recession in Italy
- This caused significant damage to the industry, in particular to Biella, which was most dependent on the domestic market

EUROPE
Progressive abolition of customs duties and restrictions on imports within the European Economic Community (EEC)

ITALY
- Increase in exports to the USA relaunching the Italian textile sector
- The Italian textile companies linked to the clothing sector had been designing costumes for Hollywood actors

ITALY
- Walter Albini brought together articles from different companies in a single collection labeling products as 'Walter Albini for', followed by the name of each company
- Albini moved the promotion office in Milan such as Krizia, Ottavio Missoni, Versace, Gianfranco Ferré and Giorgio Armani

ITALY
- Silk companies met problems because of fashion change and the cheaper printed silk from the Far East and viscose.
- Some textile companies to combat the crisis and be more competitive on the market decentralized production, both in different Italian regions and abroad

'50 · 1950 · 1951 · half '50 · 1959 · 1960 · '60 · 1963 · 1963 · '70 · 1971 · '80 · '90

Ended

ITALY
ufacturers and
aborated on a
d 'Italian tailors
rade together'
Noberasko, the
and the Rivella
olen fabrics by
Mabu, Zignone,
ompanies from
Biella

FLORENCE
The first fashion show that presented Italian fashion and that involved different sectors of clothing and fabrics was organized by Giovanni Battista Giorgini. It was attended by North American journalists and buyers, some emerging creators of Italian fashion and haute couture houses and fashion-boutiques

ITALY
Italian textile companies improved the quality of their products, as they considered collaboration with Italian fashion creators an extremely effective and low-cost advertising

COMO
The US, France and Germany absorbed 66% of the fabrics produced in Como for export

COMO
- Designers started to create fabrics exclusively used for their collections and the textile companies weren't allowed to label the fabrics. Same things in the prêt-à-porter production
- Fashion, textile design, production and distribution were organized by processing companies

COMO
- The textile factory started to export their fabrics to the USA. That of luxury silk became one of the main markets for Italian products
- Some Parisian designers, such as Jean Dessès, Madeleine de Rauch, Christian Dior, Jacques Fath and Hubert de Givenchy, bought their silks in Como

ITALY
- The production of regenerated fabrics decreased because of cheaper virgin wool textiles from developing countries
- Textile companies highlighted their identity selling clothing collections by their own to consumers
- Como specialized in the production of very high quality silks
- Textile companies restructured their organization and collaborate with emerging Italian designers

ITALY
Italian textile production centres benefited from the boom in Italian fashion, and at this juncture the smaller companies exhibited their products at international fairs and made promotional trips to the fashion capitals, each industrial city opened its own fair, such as Ideacomo (Como), Ideabiella (Biella) and PratoExpo (Prato)

2.2.3 HISTORY OF THE RAW MATERIALS

In the previous section we analyzed the evolution of textile districts and how they influenced the development of fashion houses. In this section we will explore the reasons that have led to the specialization of some regions and cities in the processing of raw materials that are not native to the Italian territory. In this section we have reconstructed the history of the three main raw materials that do not originate historically in Italy, which are linen, silk and cotton. Wool, on the contrary, coming from the shearing of sheep, is a kind of raw material that, on the contrary, is widespread in Italy.

As mentioned, the raw materials we are going to reconstruct now all originate outside the Italian territory. Flax began to be processed in 4000 A.C. in Mesopotamia. Cotton began to be processed in 3000 A.C. by the Egyptians and at about the same time silk began to be processed in China. In 3700 A.C. linen began to be processed by the Egyptians to make bandages in which they wrapped the bodies for mummification. In 2000 A.C. cotton began to be processed also in India and Peru, other places where the climatic conditions were optimal for its cultivation.

With the conquest of Egypt by Alexander the Great in 332 A.C. the knowledge and use of fabrics such as cotton and linen spread in the Greek way. In 300 A.C. Alexander the Great made Alexandria the most important sorting center for Europe of high quality Indian cotton. With the conquest of Egypt by the Romans in 30 A.C. the Romans introduced the cultivation of linen and its processing throughout the empire. Following this diffusion, the flax found optimal soil for its cultivation in the Po Valley and soon there it was widely cultivated.

A very important fact happened in 550 when monks returned from a trip to China, reported, hidden in the hollow of a stick silkworm eggs in Europe for the first time, specifically in the city of Constantinople where the emperor of the Eastern Roman Empire resided. Until that time, silks were imported, already in the form of fabrics from China and their creation was shrouded in mystery.

In 700, following the conquest by the Arabs of Spain, the cultivation of cotton and the processing of clothes was introduced into those terrors. A century later the same fate fell to Sicily.
In the year 1000 cotton threads and fabrics were imported into the ports of Venice, Genoa and Pisa.

Also thanks to the expansion of the Arab world, in 1100 silk production arrived in Italy and in particular in Sicily. At the same time in the north of Italy were developing cotton industries, in particular in Milan, Venice, Verona, Arezzo and Bologna thanks to easy access to raw cotton and the acquisition of productive skills thanks to the historic craftsmanship of Italian wool. In 1125 Italy began to import raw cotton from the Middle East.

In 1200 the production of linen fabrics spread to Flanders, England and Germany.
In 1400 the production of silk expanded also in Tuscany and Veneto. In the same year there were the first signs of decline in the processing and trade of cotton in Italy due to the lack of control over the production of raw cotton that took place in distant countries and the strength of Germany in the cotton market thanks to a system more favorable than the Italian one.
In 1500 the production of silk extended also in Lombardy thanks to the intervention of Ludovico Sforza who planted mulberry trees that were the basis of feeding and therefore of the breeding of silkworms. In that period was born the district Serico Comasco that is still active today.
A stain that cotton carries is slavery. In 1500 began the trade of human beings, with the deportation of slaves from Africa destined for the cultivation of American cotton.
In 1600 Italy and France competed for the primacy in the production of silk mainly due to the arrival of artisans from Catanzaro in Lyon who taught their art.

Despite the employment of slaves in the plantations, therefore great labor force to low cost, in 1600 the world center of the production of the cotton still resided in India and China. The 1600s saw the birth of important trading partners, including the British East India Company, which began spinning and weaving cotton in England thanks to the amount of raw materials imported from the Far East. In 1602 the Dutch East India Company was founded in the Netherlands, with the same purpose and so in 1616 in Denmark the Danish East India Company, in 1664 in France the French East India Company. In Spain, in 1609 the cultivation and processing of cotton was ended following the expulsion of the Moors. Following the revocation in 1682 of the Edict of Nantes, which was a provision issued by Henry IV of France to regulate the position of the French Huguenots and thus end the wars of religion. French linen artisans moved in large numbers to Ireland and Scotland.

In 1700 the cultivation and processing of cotton for the most part was concentrated in Asia and Africa. In Europe, policies were implemented to supplant the production of Indian fabrics with those produced in European countries. Venezi abolished the import of Indian fabrics in Italy. In the same vein, in 1701, the British parliament declared it illegal to import clothes produced in India. These prohibitions greatly favored the domestic production of individual nations. By the end of the 1700s, British exports accounted for 61% of all textiles produced in the nation, surpassing all European competitors. The competition, in fact, had less and less space in this trade thanks to the inventions occurred in previous years in England that shortened the processing time of cotton.
In 1800 America became the largest supplier of cotton to Europe, especially England. This was made possible by slavery, which drastically reduced labour costs.

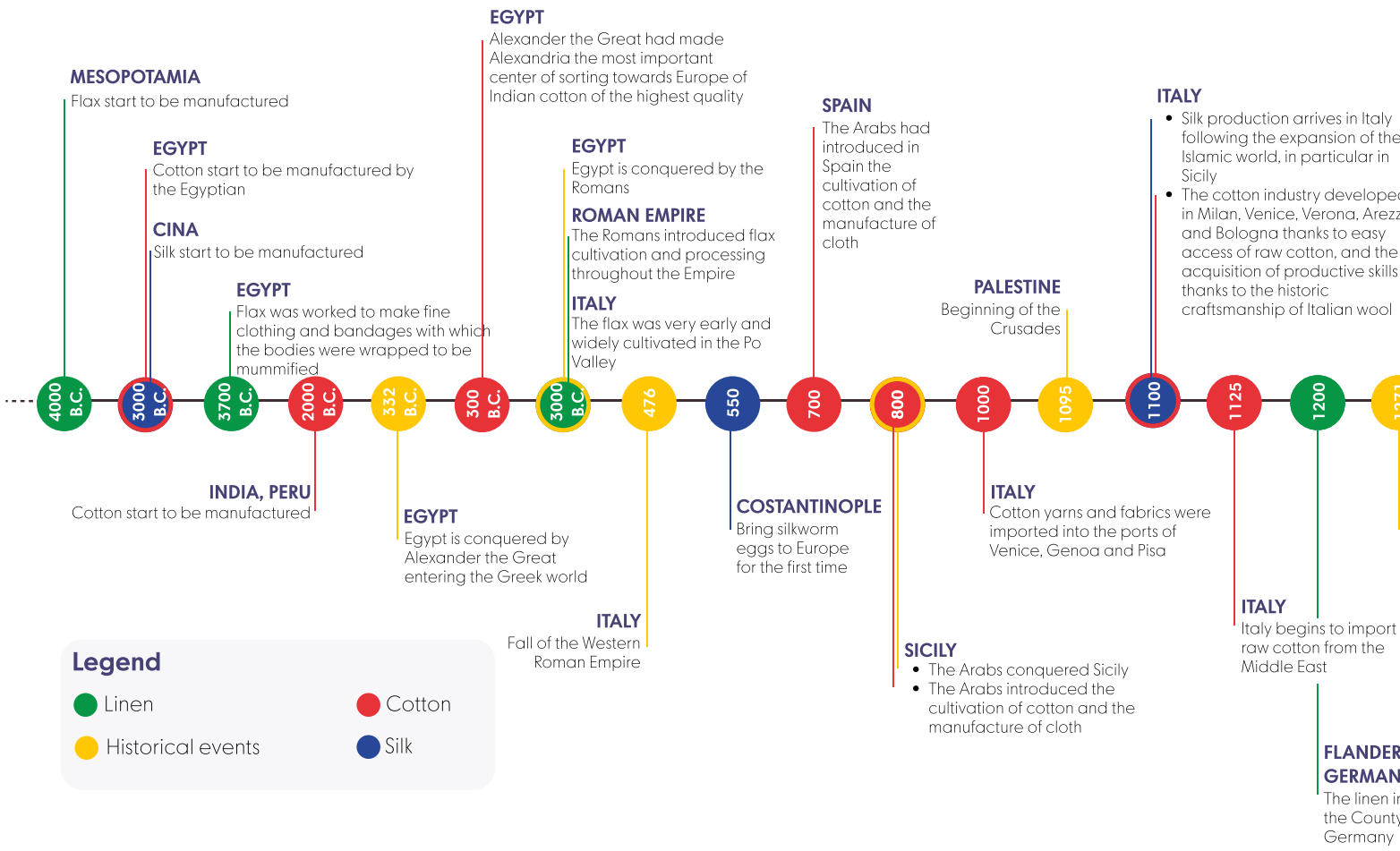
Also in the 1800s Japan modernized its method for silk production and soon supplied a large portion of the world of silk production.

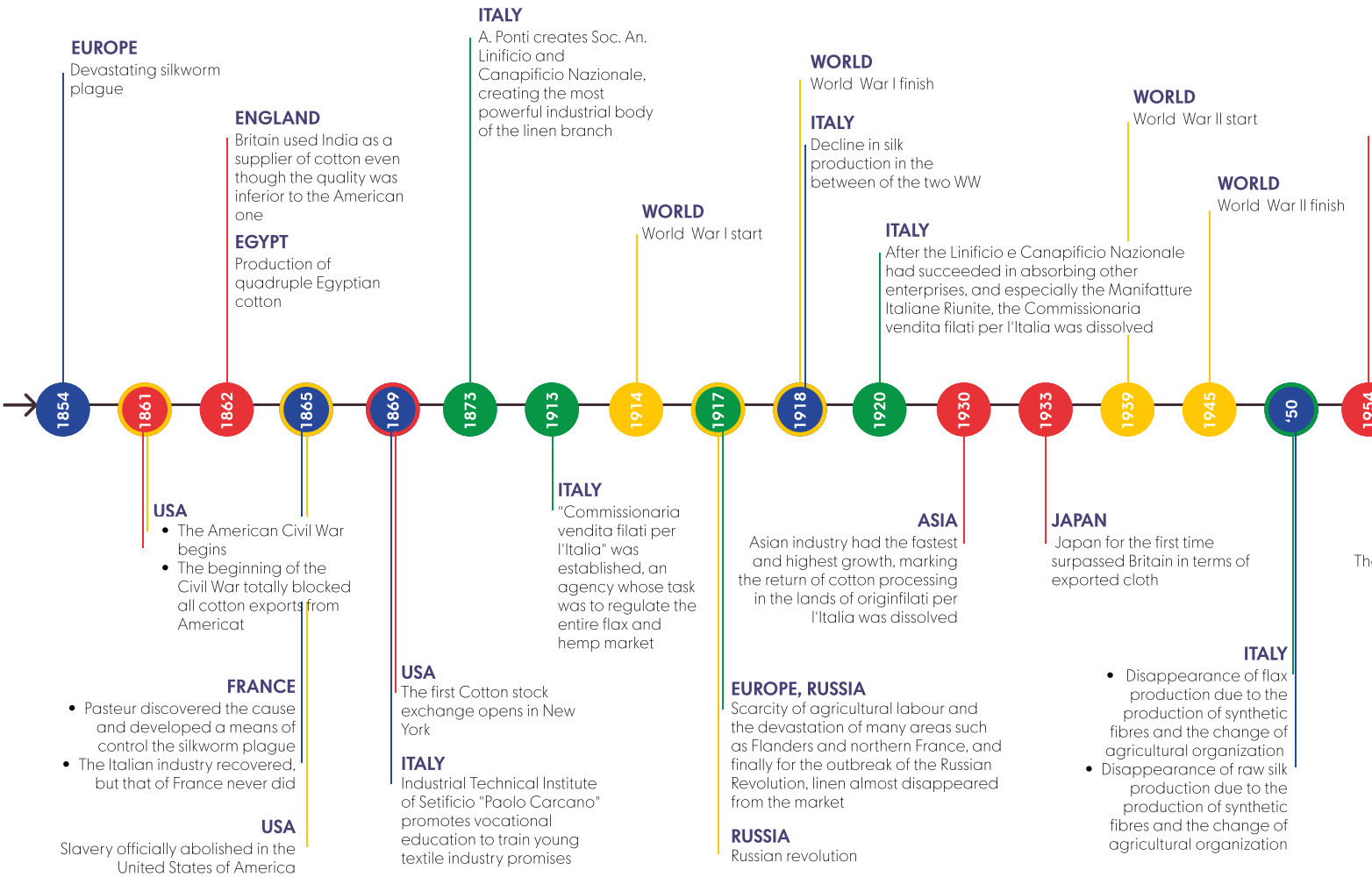
The 20th century was a period of great innovation by industry. In 1811 Philippe de Girard a nobleman from Provence made a linen spinning machine following the launch of a competition by Napoleon I. The introduction of mechanized processes in the linen industry mitigated the effects of competition with cotton. In 1840, mechanized linen factories were established at Villa d'Almè and Cassano d'Adda.
In 1854 a devastating plague struck silkworms in Europe. In 1865 Pasteur discovered the causes and developed a way to control the spread of the plague. The Italian industries managed to recover from this crisis but the French industries failed.
With the beginning of the American Civil War, there was a total blockade of cotton exports from America. This led, in 1862, the British to use India as a supplier of cotton even though the quality was lower than that produced in America. In Egypt, cotton production quadrupled.
In 1865, slavery was officially abolished in the United States, this was a big change for cotton production because the plantations had lost their labor force.
The value of cotton was so high that in 1869 he opened the first cotton bag in New York.

In 1869, the Setificio Industrial Technical Institute "Paolo Carcano" was established in Italy to promote vocational training for young people in the textile industry.
In 1873 Andrea Ponti, an entrepreneur, founded the Linificio e Canapificio Nazionale, creating the most powerful industrial body in the linen sector.
In 1913 the Yarn Sales Commission for Italy was founded, an agency whose task was to regulate the entire flax and hemp market.
Following the outbreak of WWI there was scarcity of agricultural work and the devastation of many areas such as Flanders and northern France and then with the outbreak of the Russian Revolution, linen practically disappeared from the market.
Between the two World Wars there was also a decline in silk production.
In 1920, after the Lanificio e Canapificio Nazionale was successful and absorbed other companies, in particular the Manifatture Italiane Riunite, the Commissaria Vendita Filati for Italy was dissolved.
In 1930, the Asian industry had the fastest and most enormous growth bringing the return of cotton processing to its homeland. In 1933 Japan, for the first time overtook England in terms of clothing export.
After the Second World War, in the 50s there was a total disappearance of the production of linen and raw silk in Italy due to the production of synthetic fibres and the change of the agricultural organization. During the 50s there was a strong migration of people from the countryside to the cities and this drastically reduced agricultural labour.
In 1954 the cotton industries also encountered a period of crisis that led to a progressive closure of the cotton industries in Italy. Consequently, the cultivation of cotton, which in 1957 covered a total area of 350000 hectares in Sicily, was also reduced. In 1982, cotton-growing areas amounted to only 2100 hectares in Sicily, and thus decreased until they disappeared completely in the 2000s. This continued decline led to the closure of the English cotton market in 1962.

On the contrary, in Italy, the production of silk had an exponential increase. In 1972, Como reached the record for silk production surpassing China and Japan. This was made possible, despite the competitive disappearance of sericulture in the Italian peninsula, thanks to the purchase of cheap raw silk from China. Between 1985 and 1989 there was an increase in export by the district Serico Comasco that reached 90%. In the 1990s, the spread of low silk items from Asia, and especially from China, caused a fall in the image of silk as an indicator of status, because, being accessible with more affordable prices also to the middle class made this product less exclusive. The growing competition of Chinese products led to the end of the uniqueness of products from Como, resulting in a market reduction for the district Serico Comasco. Strangely, because of the Black Friday of 1992 which led to a devaluation of the pound and the lira contributed to a decisive increase in the export of the district Serico Comasco and the temporary defense of employment in textile factories. Between 1996 and 2007, As a result of this crisis in the silk sector, employment and local units operating in the province of Como suffered severe contractions. Following the financial crisis of 2008, there was a further reduction in domestic demand for silk products.[154] [155] [156] [157] [158] [159] [160] [161] [162] [163] [164] [165]Almost ten years after this deep period of crisis for the silk sector, initiatives were started to reintroduce silkworm breeding in Italy with the aim of rediscovering knowledge that once belonged to certain territories.
In 2015, a project started to reintroduce sericulture in Veneto thanks to the collaboration with Crea, a non-profit organization that promotes initiatives aimed at spreading a culture of solidarity and respect, in collaboration with public and private bodies. [166] In 2019 a project led by the fashion house Gucci in collaboration with Nido di Seta to reintroduce sericulture in Calabria. [167] [168] In 2020, the cultivation of mulberry trees and the related sericulture and also textile factories in Trentino-Alto Adige stopped. In the same year the Northern Trentino Silk District was born. [169]
In 2022 the Linificio e Canapificio Nazionale relaunched the linen industry in Italy. [170] In the same year a collaboration between the clothing brand OVS and the farm Santiva reintroduced the cultivation of cotton in Sicily. [171] Also in 2022 began a silk project dedicated to the food industry of silkworms and aimed at relaunching the cultivation of mulberry and silkworm in Friuli-Venezia Giulia. [172] In this activity of reintroduction of the cultivation of raw materials, in 2023 great Haute Couture brands such as Gucci and Armani joined. The agricultural cooperative of San Floro in Calabria has signed an agreement with the maison Gucci for the production of silk. Meanwhile, the Puglia Regenerative Cotton Project by Giorgio Armani and the Fashion Task Force of the Sustainable Markets Initiative founded by King Charles III aims to introduce the cultivation of cotton in Puglia. [173]
Currently, the production resulting from these projects is not sufficient to meet the huge demand for raw materials that the fashion industry requires, but if this trend were to continue in the future and the Italian fashion houses invested, it could be possible to have an Italian production, from raw materials to the finished product.

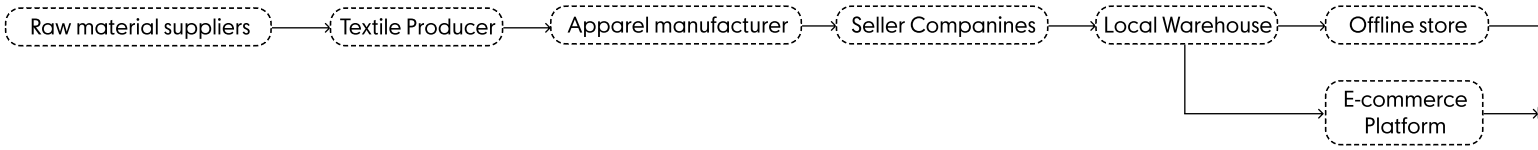
HISTORY OF FASHION FABRICS






ITALY
• Silk production expands in Tuscany and Veneto
• The signs of decay for the processing and trade of cotton in Italy due to the lack of control over the production of raw cotton in countries far from the strength of Germany in the cotton market
ITALY
• Silk production expands in Lombardy thanks to Ludovico Sforza that planted Mulberry tree
• Birth of the district Serico Comasco
AMERICA
The deportation of slaves from Africa to America to cultivate cotton
SPAIN
• Expulsion of the Moors from Spain
• The cultivation and cotton making ended in Spain
HOLLAND
Foundation of the Dutch East India Company
FRANCE
Revocation of the Edict of Nantes
IRELAND, SCOTLAND
The linen artisans of France moved in great numbers to Ireland and Scotland
ENGLAND
The English exports represented 61% of all the cloths produced in the nation surpassing all the European competitors thanks also to the inventions occurred in previous years in England that have shortened the processing time of cotton
ENGLAND
The English parliament declared the import illegal of cotton cloth printed in India
FRANCE
Philippe de Girard, Provençal nobleman realizes a machine for spinning linen on competition launched by Napoleon I
EUROPE
The introduction of mechanical processing in the linen industry mitigated the effects of cotton competition
1100
1453
1492
1500
1600
1602
1609
1616
1664
1682
1700
1701
end 1700
1800
1811
1840
ITALY
Marco Polo's trip to China starts
COSTANTINOPLE
Fall of the Eastern Roman Empire
AMERICA
Discovery of America by Christopher Columbus
ITALY, FRANCE
Italy and France compete for the record in the production of silk thanks to the arrival of artisans from Catanzaro in Lyon
ASIA
The centers of world cotton production were still India and China
ENGLAND
• Foundation of the British East India Company
• England began to spin and weave cotton
DENMARK
Foundation of the Danish East India Company
FRANCE
Foundation of the French East India Company
ASIA, AFRICA
The cultivation and processing of cotton for the most part was concentrated in Asia and Africa
EUROPE
Europe implements policies to replace the production of Indian fabrics with those produced nationally
ITALY
Venice abolished the import of Indian fabrics
USA
America became the world's leading supplier of cotton to Europe, especially to England, thanks to slavery that reduced labor costs
JAPAN
Japan was modernizing its methods of sericulture, and soon it was supplying a large portion of the world's raw silk
ITALY
Establishment of mechanical factories in Villa d'Almè and Cassano d'Adda
RS, ENGLAND,
IY
ndustry extended to
y of Flanders, England,
ITALY
Progressive closure of the cotton industry
ITALY
Cotton was grown on a total area of almost 350,000 hectares in Sicily
ITALY
The area cultivated with cotton amounted to only 2,100 hectares in Sicily
ITALY
The increase of the exports of the district Serico Comasco exceeded 90%
ITALY, UK
• Black Wednesday with a consequent devaluation of the pound and the lira
• The devaluation of the lira contributed to a decisive increase of the exports of the district Serico Comasco and to the temporary defense of the occupation in the factories textile
ITALY
Reintroduction of silkworm cultivation in Veneto with the collaboration of Crea
ITALY
• Linificio e Canapificio Nazionale (LCN) relaunches the linen industry in Italy
• OVS and Santiva reintroduced cotton conversion in Sicily
• Silk project dedicated to the agri-food supply chain of silkworms and aimed at relaunching mulberry and silkworm cultivation in Friuli-Venezia Giulia
1957
1962
1972
1982
1985
'90
1992
2000
2007
2008
2015
2019
2020
2022
2023
UK
e English Cotton stock exchange closed
ITALY
• Como achieved the absolute record in the production of silk surpassing China and Japan
• Raw silk was bought cheap in China
WORLD
• The diffusion of Asian (especially Chinese) silk articles at low prices causes a fall in the image of silk as a status asset
• The up-grading of Asian (Chinese) competition means the end of the uniqueness of the product from Como
ITALY
Decrease of the volume of transactions for the district Serico Comascoo
ITALY
Cotton is no longer cultivated in Sicily
ITALY
Employment and local units active in the province of Como suffered strong contractions
USA
Financial crisis
ITALY
Resulting in a decrease in domestic demand for silk products
ITALY
Reintroduction of silkworm cultivation in Calabria
ITALY
• Reintroduction of mulberry and related silkworm cultivation and also tissue factories in Trentino Alto Adige
• The Silk District of Lower Trentino is born
ITALY
• The agricultural cooperative of San Floro (Calabria) has signed an agreement with the fashion house Gucci for the production of silk
• Apulia Regenerative Cotton Project by Giorgio Armani and Fashion Task Force of the Sustainable Markets Initiative founded by King Carlo III to introduced cotton conversion in Puglia

2.3 THE SUPPLY CHAIN OF FASHION



The fashion industry operates through a complex and interconnected supply chain that starts from raw material suppliers and ends with the end user. This intricate system ensures that high-quality apparel reaches consumers efficiently while addressing various logistical, environmental, and ethical challenges along the way.

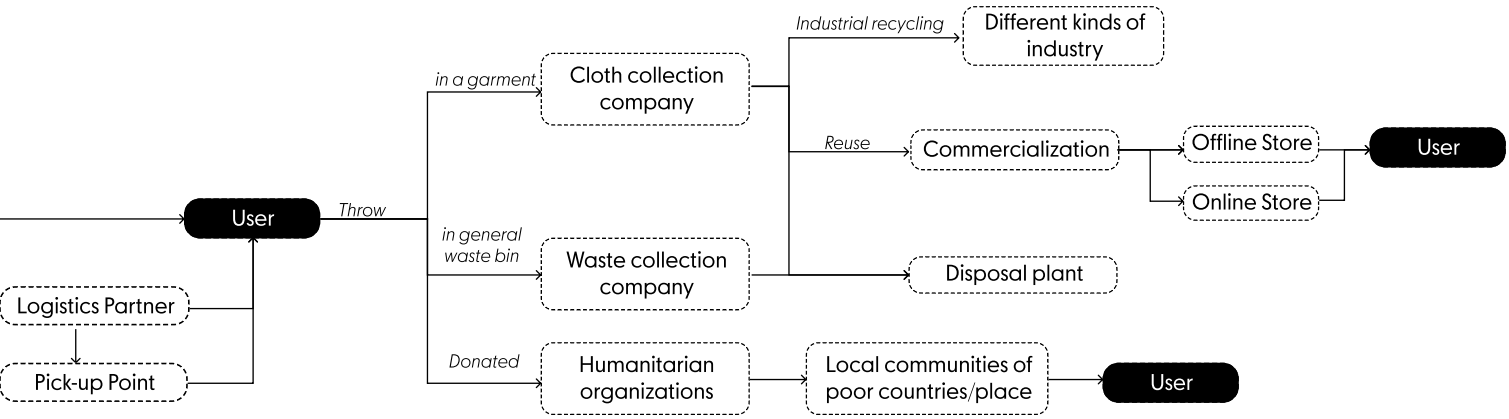
At the beginning of the supply chain, raw material suppliers provide the essential resources needed for textile production. These raw materials, ranging from natural fibers like cotton and wool to synthetic alternatives, are then processed by textile producers. These producers play a critical role in transforming raw materials into usable fabrics, utilizing both traditional techniques and modern technologies to maintain quality and efficiency.

Once the textiles are produced, they move to apparel manufacturers who craft the fabrics into finished clothing items. This stage is where design, craftsmanship, and innovation converge to create apparel that meets market demands.

Apparel manufacturers must balance creativity with practicality, ensuring that their products are not only stylish but also functional and durable.

The finished apparel is then distributed to seller companies, which handle the commercial aspects of the fashion industry. These companies work closely with local warehouses to manage inventory and ensure that products are readily available for retail. The distribution network includes both offline stores and e-commerce platforms, catering to diverse consumer preferences and expanding the market reach.

As products reach the consumer, the supply chain doesn't end. Users play a pivotal role in the lifecycle of fashion items, determining the fate of their garments once they are no longer wanted. Clothes can be thrown away, collected by waste management companies, or donated to humanitarian organizations. The latter option promotes sustainability and social responsibility, giving a second life to used clothing through reuse and



recycling initiatives.

Garments that are collected by cloth collection companies may be industrially recycled, entering different kinds of industries as raw materials for new products. Others may be commercialized again, either through offline or online stores, offering affordable fashion to new users. Items that cannot be reused or recycled are sent to disposal plants, where they are managed to minimize environmental impact.

Local communities, particularly in poorer regions, benefit from the donation of used clothing. These donations help to address clothing shortages and support community development. However, the disposal and recycling processes present environmental challenges that the fashion industry must continuously address. Waste products and the disposal of non-recyclable items contribute to environmental degradation, necessitating the adoption of more sustainable practices throughout the supply chain.

In summary, the supply chain of fashion is a dynamic and multifaceted system that extends from raw material procurement to the end user's disposal or reuse of garments. Each stage of the supply chain is interdependent, highlighting the importance of collaboration and innovation to ensure sustainability and efficiency. The industry's ongoing efforts to address environmental and ethical issues are crucial for maintaining its long-term viability and positive impact on society.

Next, we will detail each link in the supply chain, emphasizing its importance. Smooth operations are vital, impacting product quality, costs, and timely delivery from supplier selection and procurement to production scheduling and logistics. By exploring best practices and challenges, we aim to optimize efficiency, reduce costs, and enhance the fashion supply chain system. Throughout the project, we will use a systematic design methodology to identify and address issues effectively.

2.4 RAW MATERIARL IN ITALY

As seen in the previous section, the first step to create a dress are the raw materials. In this section we analyze in detail the main raw materials used by the fashion world.
The raw materials used in the fashion world are divided into two categories: natural origin and chemical origin. Natural fibres are those fibres that originate from animals, such as wool, silk and leather, or that originate from plants, such as linen and cotton. Chemical fibres, on the other hand, can be of plant or petrochemical origin and are classified as artificial and synthetic. Artificial yarns, such as acetate and viscose, are made from cellulose in the wood pulp or from fluff, a layer of short fibres adhering to the surface of the cotton seed. Synthetic fibres, on the other hand, are produced using petrochemical products as raw materials. The most widely used are polyester, nylon, polyamide trade name, acrylic and lycra, also known as elastane. [174]

2.4.1 WOOL

Wool is a fabric made through the sheared hair of various animals. It is a natural fiber that has very ancient origins. This type of fabric was widely used in the Middle East and North Africa, mainly in very warm locations, in particular by the Bedouin nomads of the Arabian Peninsula. This wide use of this fabric was due to its insulating properties that are still used today to make outerwear and curtains.
The particular performance characteristics that wool possesses derive from its own structure. The wool has a thin core around the hair, surrounded by an outer layer of microscopic overlapping keratin scales. Each wool fiber is therefore an elastic and wavy tube that can bend over 200 thousand times and maintain both the high elasticity and the internal tone.
The main features that this particular fiber has are, as mentioned, the high insulation capacity. This material is able to maintain its insulating properties even when wet. The wool, in fact, is naturally resistant to water, thanks to the presence of keratin on the animal's hair. Wool fabrics also have a high moisture absorption capacity. This is allowed by the star structure of the fibers that helps keep the water absorbed on the outer layer of the fabric. It also has a certain resistance to odors and antimicrobial ability. Finally, it has a high fireproof capacity. It is highly resistant to fire because it has a very high melting temperature. [175]

TYPES

There are many types of wool on the market, the main difference is from the hair of which animal they are derived. The main and most used is virgin wool. It is also known as lamb's wool, it is a very soft type of wool and is taken from the shearing of a sheep that is about seven months old. At that age, the animal's fur is the softest it will produce in its life. However, when referring to virgin wool, this particular type of wool is not always understood but this term is also used to indicate those types of fibers that have not undergone any processing procedure. Wool of this type is a very thin wool, with hypoallergenic properties, whose fibers are very thin and elastic.
Merino wool owes its name to the sheep from which the wool is made. In fact, it is taken exclusively from merino sheep. This sheep breed is native to Spain but is also widely spread in Australia. Merino sheep also produce a higher percentage of lanolin than other sheep, which results in a high removal process of much of the oil naturally in the hair. For this reason merino wool is more expensive than other types of wool.
Cashmere wool is a type of soft and delicate wool comes from the cashmere goat breed, whose fibers are made from the goat's neck.
Shetland wool is a type of thick and shiny wool. These sheep are a primitive breed native to the Scottish Shetland Islands that produce an unusual type of

wool as the sheep's fleece is not always uniform. In fact, a single sheep of this breed can have a fine wool on the neck and a thicker one on the hips. Shetland sheep's external hair is long and rough, usually used for durable rugs and fabrics, while the inner ones are used to make garments that need softness.
Not all types of wool come from sheep, some are obtained from camelids including alpaca, camel, vicuna and llama.
The alpaca is an animal native to South America, but now it has spread all over the world. The type of wool produced by this animal is very soft and with unique shades, in spite of its more rough and itchy appearance. It is a type of rare and precious wool that is often worked by hand.
Camel wool has a resistant, fine, light and very soft fiber. Camel wool is often obtained from camels living in cold regions such as Mongolia, northern China and Russia.
Vicuña are a type of wild alpaca. They are extremely rare animals, so much so that the Peruvian government, to preserve the species limits the frequency with which it is possible to catch them for obtaining their hair. The shearing of this animal dates back to the Inca Empire and the making of garments with this fiber was reserved for royalty. Today a garment made with this type of wool is highly expensive, precisely because of the rarity of the animal from which it is made.
The blade produces a rougher type of wool that sometimes cannot be worn in contact with the skin, for this reason it is mostly used to make carpets or blankets.
Wool can also be obtained from the fleece of a particular breed of goat, the Angora goat. It is not to be confused with the wool made from the hair of the rabbit that has the same name. For this reason the name Mohair is used to indicate goat wool. This breed of goat has a very thick hair that gives the wool obtained softness and protection. In addition, compared to that of sheep, it has fibers with scales not too pronounced, and this prevents tangling and shrinkage of the fibers.
Finally, there is the wool of Qiviut. This type of wool is obtained from the undercoat of the Arctic musk ox that is bred in Canada and Alaska. To obtain the hair of this animal it is necessary to wait until spring, when the animal naturally releases the undercoat, because it is not possible to shear it. The obtained hair is very fine, soft and strong and extremely warm as well as water resistant. [175]

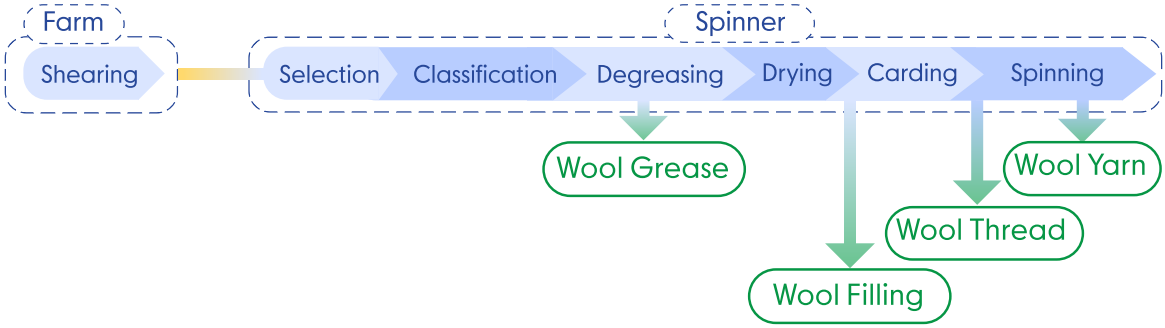
PRODUCTIVE PROCES

The process that must be undertaken to obtain wool yarn starts from the farms. The shearing of the sheep takes place at specific times of the year and must be carried out regardless of the use that will be made of the removed lava, as it affects the health of the animal. The shearing is carried out by a highly qualified workforce as it must be carried out quickly and without causing harm to the animal. The shearing process involves controlling the sheep, using scissors to remove the fleece in one piece, and then packing the wool for shipment.

Then the different wools are sent to the yarns. In this place the velli are selected and classified on the basis of the quality, color and length of the fibers. The selection phase is very important to determine the value and quality of the wool that will be made. The classification is based on the diameter of the fibres, the length of the flakes, the resistance and the curling and the overall quality. Then the degreasing process takes place. At this stage the fleece undergoes a cleaning process, in which dirt, grease and impurities are removed.

This process involves immersing the fleece in warm water and detergents followed by several rinses. After this step the wool is pressed to extract excess water and then dried. Next, the carding process aligns and separates the wool fibers, removing any remaining short fibers. This process takes place by means of carders containing belts or rollers covered with thin teeth or metal pins. The purpose of these teeth is to untangle the fibers by placing them in a continuous network, like the fibers put in parallel. After the carding phase, the spinning phase begins. The carded wool is then spun into wire using spinning machines. After the carding phase, the spinning phase begins. The carded wool is then spun into wire using spinning machines. At this stage the fibers are pieced together to create a continuous thread that is then dyed. During the dyeing process, chemical dyes are usually used to impart color. After being dyed, the yarn can be sold in balls or fabric to make garments. This phase involves the use of frames or frames to create the desired texture and pattern.

The output of this process can be skeins of wool or fabrics ready to be molded. [176] [177]



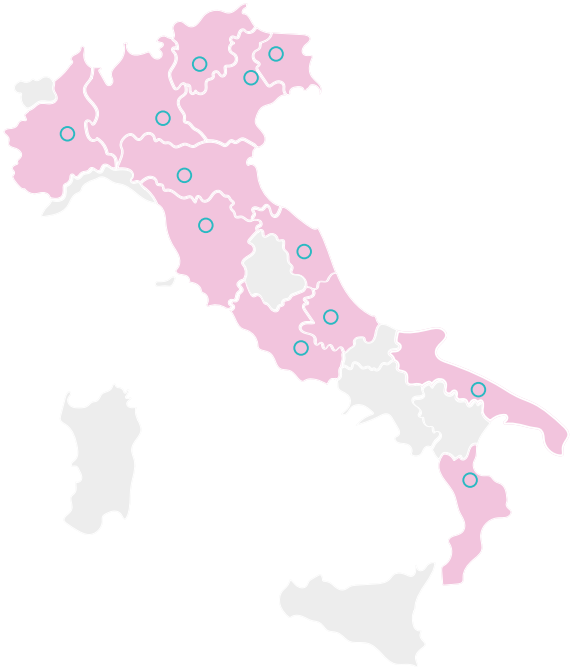
Schema of wool productive process

ORIGIN OF RAW MATERIALS IN ITALY AND PROCESSING DISTRICTS

The main sheep farms in the area are not intended for the production of wool to create clothing but are intended to produce food or milk. On the Italian territory various types of animals are bred for wool: sheep for virgin wool, Merinos sheep for merino wool, cashmere goats, for cashmere wool, Mohair sheep, for mohair wool, Brogna sheep, Alpaca Huacaya and Suri for alpaca wool and llama for llama wool. Below is a map showing the regions where these animals are reared. [178] [179] [180]

Looking at the map you could guess that there is a high production of wool destined for the realization of garments but in reality the farms are small and many only at amateur level. This means that there is not enough wool production to meet the high demand that the world of clothing requires.

Biella, in Piedmont is the only territory that houses a district entirely dedicated to wool processing. Even the textile district of Prato is very famous in wool processing, but its specialization is in working and treating regenerated wool, then wool recovered from waste clothes. Below is the mapping of the wool districts. [122] [181]



Map of farms

Map of wool district

LEGISLATURE

At the legislative level, wool is considered a by-product. The European regulation EC 1069/2009 defines the wool resulting from periodic shearing not as a raw material but as a by-product that must be treated in order to circulate on the market by lowering the load of pathogenic bacteria.
The legislation therefore states that wool can only be used in specialized processing plants and then transformed into "technical products" or wool intended for spinning. The fact that wool is defined as a by-product involving health risks means that its reworking has very high costs.
At the same time, however, CE Regulation 510/2006 makes wool one of the "agricultural products" that can therefore be protected by a PGI or PDO certification.
Moreover, the Italian Civil Code, in article 2135, defines the activity of wool production as connected to the agricultural one, therefore, wool turns out to be an agricultural product. [182] [183] [184]
These two different definitions of the same good do not give a clear idea of what it is at the level of laws and this leads to problems.
In Italy there are many sheep farms, but most are bred to produce meat and cheese; therefore, wool quality is not the main goal. However, the wool obtained from shearing, which is compulsory for the welfare of the animal, according to European legislation is considered a by-product and therefore not raw material and for this reason must be cleaned and disinfected before it can be sold and spun. In Italy, however, there are no large structures that can handle the huge amount of wool produced per year. Biella is the only place where they wash the juicy wool.
In addition, shearing is a job that requires highly qualified workers and the know-how of this practice has been increasingly lost. Nowadays, workers from New Zealand are hired to shear sheep.
The combination of these two aspects, the hiring of seasonal workers for shearing and the treatment of the proceeds as special waste makes shearing a highly expensive process for farmers who cannot absorb it. In addition, even if you wanted to burn the wool to avoid the large amount that it has that can not be used in the fashion world because not of high quality lowers the solution of energy recovery, that is, through incinerators, Burning waste for energy is just as difficult for the flame retardant qualities of the material; therefore, more cycles are needed to burn it completely.

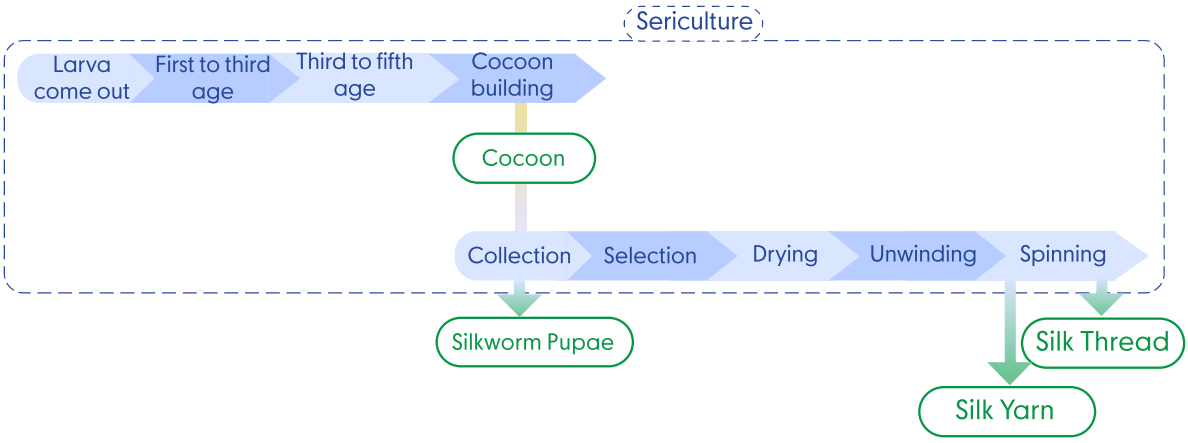
2.4.2 SILK

Silk is a natural fiber of animal origin, specifically is a long continuous thread produced by the silkworm, a moth belonging to the bombicide family, in the final phase of its larval life, when it closes inside the cocoon, inside which it will transform, first into chrysalis and then into butterfly. The fabrics made with this particular fiber are very light and hypoallergenic. In addition, they have a low coefficient of thermal conductivity, which means that silk fabrics are warm in winter and cool in summer. [185]

PRODUCTIVE PROCESS

Silkworm cultivation could not exist without mulberry cultivation. The main source of nourishment for the silkworm, in fact, are mulberry leaves. The production process of silk is divided into two parts, the first concerns the care of the silkworm until the formation of the cocoon, then there is the processing of the thread.
After the larva has come out of the egg, it goes through five stages of growth in which it is fed with mulberry leaves daily. Breeding from the first to the third age of the larva takes place in dedicated structures.
The larvae of old age nourish of the mulberry leaves up to the fifth age, about for two weeks. Then the instinct leads them to reach an elevated position where to create the cocoon. This event is called "climb to the woods". At that moment the breeder installs plastic structures that serve to provide a foothold for the construction of the cocoon, an activity that covers about two, three days.

After about a week from the creation of the cocoon, the operator collects the cocoons that are cleaned from the silk threads that the worm makes to anchor the cocoon to the branches of the trees or, as in this case, to the plastic structures. Then a selection is made, dividing the cocoons by product classes. In nature, at this point, the moth would get out of the cocoon by damaging it, but to avoid this damage, the cocoons are placed in a dryer, where the heat kills the insect. Because of this passage, sericulture was accused of cruelty to animals. Afterwards, they are immersed in hot water to remove the sericin and release the fibers. Then we move on to the brushing, a slight brushing that serves to unravel the threads. The operator then identifies the "capofilo" and inserts it into a machine that carries out the cocoons. Usually, due to the very thin size of the silk produced by the worm, six, eight cocoons are combined to obtain a thread useful for the production of light garments. The output of this process is raw silk ready to be woven. [186] [185] [187]



Schema of silk productive process

ORIGIN OF RAW MATERIALS IN ITALY AND PROCESSING DISTRICTS

As seen in the section on the history of raw materials, once the cultivation of silkworms was a widespread activity in northern Italy but after the 50s, due to the possibility of buying cheap silk from foreign countries, production has gradually decreased to exhaustion. Today, on the initiative of Crea - Agricoltura e Ambiente, were funded three projects related to the rediscovery of this activity in Veneto. Another project led by the fashion house Gucci in collaboration with Nido di Seta to reintroduce sericulture in Calabria. In 2020 they reintroduced the cultivation of mulberry trees and its sericulture and also textile factories in Trentino-Alto Adige. In the same year the Silk District of Basso Trentino was born. Also in 2022 a silk project dedicated to the food industry of silkworms and aimed at relaunching the cultivation of mulberry and silkworm in Friuli-Venezia Giulia started. [166] [169] [170] [167] [172] [168] Despite all these initiatives, the high production costs do not yet make the product competitive on the fashion market; therefore, currently the product is used in other sectors such as cosmetics or pharmacy. The goal is to become a partner of a fashion house in order to enhance the production entirely made in Italy and the full traceability of production.
Below we report the mapping of the places where silkworms are carried out.

Given the intense momentum of will in the reintroduction of silkworm farming we have assessed the effect that it has on the territory. First, in order to be able to carry out silkworm cultivation it is also necessary to cultivate mulberry trees and specifically, white mulberry trees. This type of trees is very resistant even to low temperatures, does not need particular amounts of water and can grow on any type of soil, from clay to sandy. Therefore, this type of plant does not need particular climatic conditions. From an environmental point of view, the cultivation of these trees brings with it the benefits that planting trees brings to the environment and such as air purification by absorbing carbon dioxide and in addition performs an anti-erosive action of the soil, increases soil fertility, acts on weed species and mitigates the action of pests and diseases.
As for the breeding of silkworms, they grow in particular climatic conditions, in particular at a temperature of about 25 °C with a humidity of 80%. To maintain these optimal conditions, the sheds in which they are usually reared need to install a temperature control system and this involves an energy consumption. [188] [189] [190] [191] [192]

In Italy there are two districts that deal entirely with the processing of silk fabrics, the Distretto serico Comasco in Lombardy and the one born in very recent years in Trentino-Alto Adige, the Distretto della seta del Basso Trentino. Below we report the mapping of these districts. [122] [181]

Map of sericulture

Map of silk district

2.4.3 LEATHER

Leather is animal skins and hides that have been treated with chemicals to preserve them and make them suitable for use as clothing, footwear. The term hide is used to call the skin of larger animals such as cowhide or horsehide, whereas skin refers to that of smaller animals such as calfskin or kidskin. Garments made from this material are waterproof, high abrasion resistance and this leads to increased wear resistance. Following the particular processing, the skin assumes a certain flexibility that allows you to have a particular comfort when wearing it, in addition it allows the passage of air reducing sweat and the formation of bacteria. [193]

TYPES

There are different types of skin on the market, depending on the animal from which it was made. The main are the skins of bovine origin, then obtained from cows, bulls and calves, then there are the skins made from sheep including sheep, lambs, goats or crosses. Skins originated from exotic animals including ostriches or reptiles such as crocodiles, snakes, lizards and iguanas. There are also skin types derived from fish such as salmon, wolf fish and eels. Also famous are skins made from fur animals such as foxes, minks and opossums. Finally, skins derived from wild animals such as deer, wolves and gazelles also exist. [194]

Depending on the type of processing that the leather undergoes, there are different types of leather such as properties, finishes and different softness, the origin and creation of which is carried out by Italian brands and districts. The first is the Vacchetta. It is made by means of Tuscan vegetable tanning, and has a characteristic darker color than other skins treated with other vegetable tannins. This particular material has the ability to never age but to transform and darken.

Cowhide, in general, is used for the production of rigid bags. The goatskin, on the other hand, has a compact structure and a flower, that is the upper part of the epidermis of the animal, with a particularly marked grain, all the more precious if closed and fine. Despite the thin thickness it has considerable mechanical strength.

Saffiano is a printed and pigmented calfskin leather created by the fashion house Prada, which is characterized by its particular texture. The term "Saffiano", in fact, indicates the particular processing that the calf leather has undergone during the final finishing that is almost "scratched". Saffiano leather, therefore, is a valuable material used mainly for accessories of great value. The dollar leather is of bovine origin and is characterized by the inhomogeneity of the surface. It is a texture that is applied on the full flower. It is a very characteristic and soft skin.

Chamois leather may be of ovine or bovine origin. This leather has undergone a particular processing, the removal of the most precious and superficial part, that is, of the flower. Thanks to a complex processing, the

suede acquires a visual and tactile appearance reminiscent of velvet. It is mainly used in the field of clothing and footwear and also in the production of bags. The Ruga is a semi-finished calf leather of high quality. It is smooth to the touch and is characterized by brightness and silkiness.
The wrinkled skin, being more rigid, holds the shape well which allows it to be used for the production of bags and rigid backpacks.

Then there are the finest types of leather, which have not only undergone special processing but also come from exotic animals.

Snakeskin is characterized by unrepeatable designs. Despite its softness, snake skin, in particular python leather, is very resistant over time and is mainly used for the production of high fashion items.

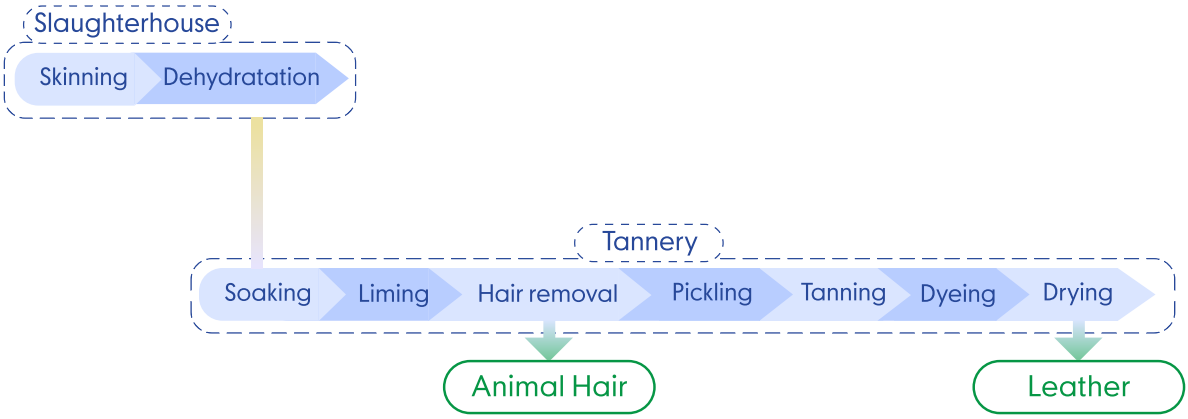
The crocodile skin that is used for Haute Couture products, is usually obtained from the skin corresponding to the belly of the animal or that of the hips since these are the softest parts, which guarantees producers a more refined article in terms of quality.

Finally, there is ostrich leather. This is among the most valuable and expensive types of leather used in the luxury leather goods industry. It is easily recognizable thanks to the follicles distributed evenly over its surface. It is considered one of the most resistant, soft and durable leathers. [195] [196]

PRODUCTIVE PROCESS

The skin, as mentioned, is obtained from animals; therefore, the first step is the removal of the skin from the animal through the skinning and then be prepared for transport to the tannery. Due to the fact that the skin begins to decompose within a few hours after the death of an animal; to prevent this from happening, the skin is cured by a dehydration process that involves air drying, wet or dry salting, or pickling with acids and salts before being shipped to a tannery. These first steps generally take place in slaughterhouses. After the skin has been dried it is shipped to tanneries. Once arrived, as a first step the skin is soaked to remove all water-soluble materials and restore the original shape and softness. Since it is necessary to remove hair from the skin, the skin is subjected to calcination, a process that allows to loosen the hair accomplished by immersing the skins in a mixture of lime and water; hair and foreign flesh and tissue are removed from the machine. The skin is then washed and marinated to provide a final cleaning and softening. Subsequently, the skin undergoes a pickling process, that is, the addition of a chemical that allows the skin to be stored for a long time before tanning. At this point we arrive at the most important process, the one that allows us to obtain the different types of skin that we have listed in the previous section. During the tanning process the skin is treated with tannin (tannic acid), the agent that moves water from the interstices of the protein fibers of the skin and cements these fibers together. There are three types of tanning: vegetable tanning, which is the

oldest among tanning methods, takes g extracts from parts of plants, such as roots, bark, leaves and seed skins, which are rich in tannin. The extracted material is transformed into tanning liqueurs, and the skins are soaked in vats or barrels of liqueur stronger and stronger until they are sufficiently tanned. The end result is water resistant leather.
Mineral tanning, on the other hand, uses mineral salts and produces a soft and flexible skin. Mineral tanning is the preferred method for the production of lighter skins. The use of this method can reduce the tanning period to days or even hours, as opposed to vegetable tanning that also takes months.
Chromium salt is the most widely used mineral agent, but aluminium and zirconium salts are also used. In mineral tanning, the skins are immersed in salt baths of increasing strength or in acid baths in which chemical reactions deposit salts in the fibers of the skin.
Tanning with oil is an old method in which fish oil or other oils and fatty substances are stored, or pounded, in dry skin until they have replaced the natural moisture of the original skin. This type of tanning is mainly used to produce suede, a soft and porous leather that can be repeatedly wet and dried without damage.
At the end of the tanning process, the skins are ready for the final phase of leather production. Tanned skin is first completely dried and then dyed to give it the appropriate color; common methods include drum dyeing, spraying, brush dyeing, and staining. The skin is then dried either in air or in a drying tunnel or first stretching the skin and then air or tunnel drying. The skin is now ready to be shaped. [197] [198]

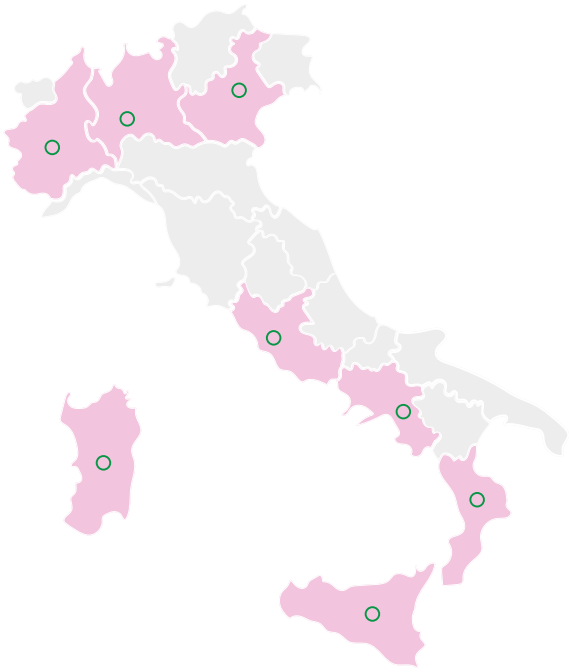


Schema of leather productive process

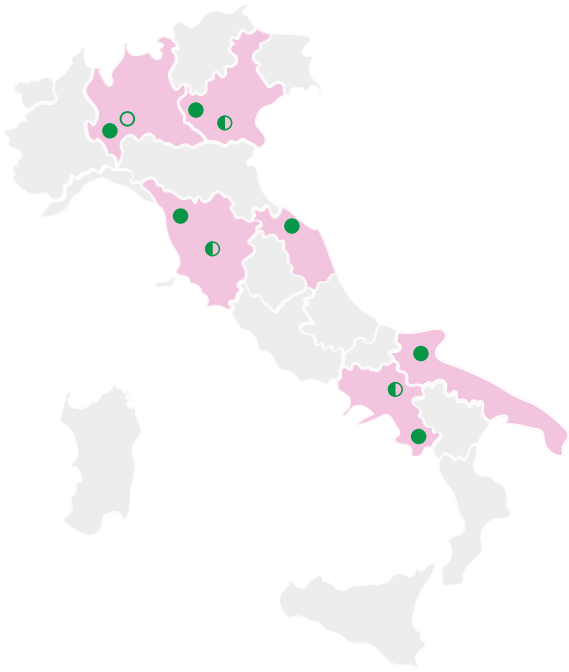
ORIGIN OF RAW MATERIALS IN ITALY AND PROCESSING DISTRICTS

In contrast to wool production, animals whose skin is used to make leather are not bred for the sole purpose of making leather but are a by-product of the slaughter of animals; Thus, their production is an integral part of the slaughter process. [199] [200]
Below is the mapping of the farms of animals whose skin is used for the production of leather.

Italy is famous all over the world for its leather production, in particular Tuscany.
On the Italian territory there are four different districts whose unique occupation is to make leather and leather products. Three of these districts are located in Tuscany and one in Campania. In Tuscany there are the Distretto della pelle, cuoio e calzature of Castelfiorentino, the Distretto conciario e calzaturiero of Santa Croce sull'Arno and the Distretto della pelle, cuoio e calzature of Valdarno superiore. In Campania, however, there is the Distretto conciario of Solofra. [122] [181] Below is the mapping of the districts that deal with the realization of leather and products made with this material.



Map of farms



Map of leather district

LEGISLATION

Given the notoriety and the high skill that Italian tanning masters possess, in order to preserve and give recognition to this craftsmanship, a certification of the origin of leather has been created in defense of Italian production: the EN 16484 certification (ex UNI 11239) "Denominazione di origine della produzione delle pelli", then a certification for the denomination of the production of skins. To define a leather as of Italian origin it is necessary that at least the retanning, dyeing and fattening phases have been carried out in Italy. If all stages of production took place in the same country of origin, a 100% "Made in" can be issued. The peculiarity of this certification is that it certifies, in a specific way, the origin of the leather as raw material, unting it from the subsequent processing that such skin will undergo. The "Made in" of leather production, in fact, does not automatically pass to the "Made in" of the product; therefore, the country of origin of the production of the raw material does not constitute the "Made in" of the finished product.
The body ICEC, accredited body Accredia, issues the license of use of the brand "Leather from Italy" to companies producing leather goods that use Italian leather certified under the standard UNI EN 16484. Upon request and in a controlled manner, a uniquely numbered label bearing the "Leather from Italy" logo with technical explanations related to this marking is provided as certification. These labels are affixed to the products made with a predominantly certified leather, and can thus reach the final consumer by communicating that the article is made with leather produced in Italy and certified. The labels are printed exclusively by ICEC which completely manages the traceability and regulates the relative license of use of the brand. [201] [202]

The focus on animal welfare and cruelty has been increasing for several years now. As a result of a large movement by consumers that slowly were also supported by large fashion houses, with the Legislature 17ª - Bill No. 62 that states "Sono vietati l'allevamento, la cattura e l'uccisione di animali da pelliccia di cui all'articolo 2, o di animali appartenenti a qualsiasi altra specie per la principale finalità di ottenere pelle o pellicce." And "Ai sensi del comma 1 è altresì vietato produrre, esportare, sfruttare economicamente, trasportare, cedere o ricevere, a qualunque titolo, pelli o pellicce ricavate da animali appositamente allevati, catturati o uccisi in Italia."
With this decree, in 2018, the breeding, capture and killing of animals was banned in Italy whose only purpose is to obtain fur. [203] [204] [205]
The union between public opinion and large companies has made possible the formulation of a law that has banned the use of fur. To date there are movements that require the abolition of the use and manufacture of leather clothing to avoid killing animals for their skin. This time, however, despite fashion houses like Giorgio Armani have declared "Enough cruelty against animals", referring to the use of furs, other fashion houses would find this deprivation very difficult because, made it a real trademark such as Prada. Moreover, the abolition of the production of leather products would lead to a loss of historical know-how by

the Tuscan and Campania master tanners, moreover, being a by-product of slaughter, if it were not used for the manufacture of leather, animal skin would become a waste that would have to be disposed of by other means. Despite these aspects that could make the balance needle towards the maintenance of this practice, many start-ups are emerging in Italy that deal with the creation of leatherette garments from vegetable waste such as grapes or orange peel.

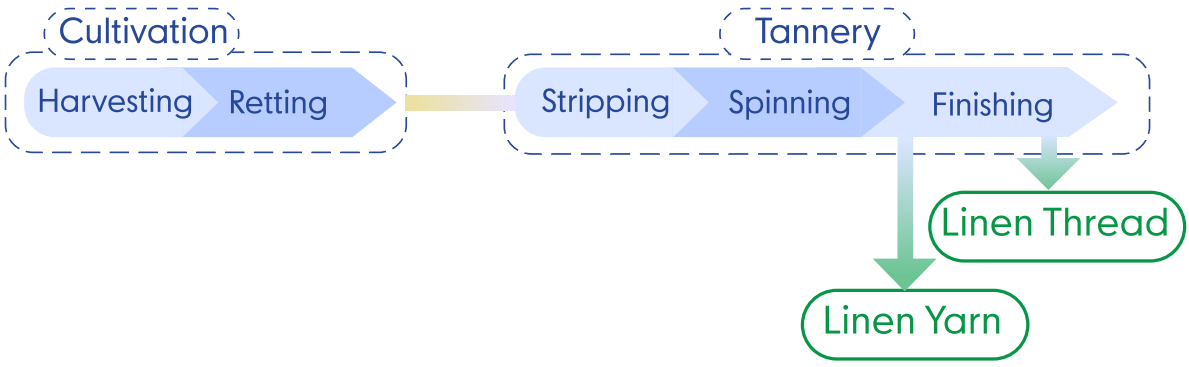
ICEC Certification [202]

2.4.4 LINEN

Linen garments are made from the processing of the flax plant. Its processing begins from very ancient times in warm countries, such as Egypt. It is a fabric that is able to absorb moisture and therefore sweat letting the skin breathe, in addition it also acts as a filter against UVA rays. Linen is able to give freshness, so it is perfect for summer garments but it is also able to keep the temperature constant so more be used even with lower temperatures. It is also hypoallergenic and very suitable for sensitive skin. [206] [207]

PRODUCTIVE PROCESS

Linen is a material of natural origin and specifically is obtained from the flax plant, for this reason the first step of the production process starts with the cultivation of the flax plant in plantations. When the time for harvesting has come, the plant is taken from the soil and macerated. The collection time is not the same but varies depending on the type of fiber you intend to get. After maceration, the plant undergoes a stripping process in which the flax fibers are extracted from the plant and then cleaned and combed. Then the flax fibres are spun with different techniques to obtain the desired product. Finally, there is the finishing phase. In this process linen is worked to brighten the fabric. It is at this step that you give the color to the fabric or make the fibers more rigid. [208]



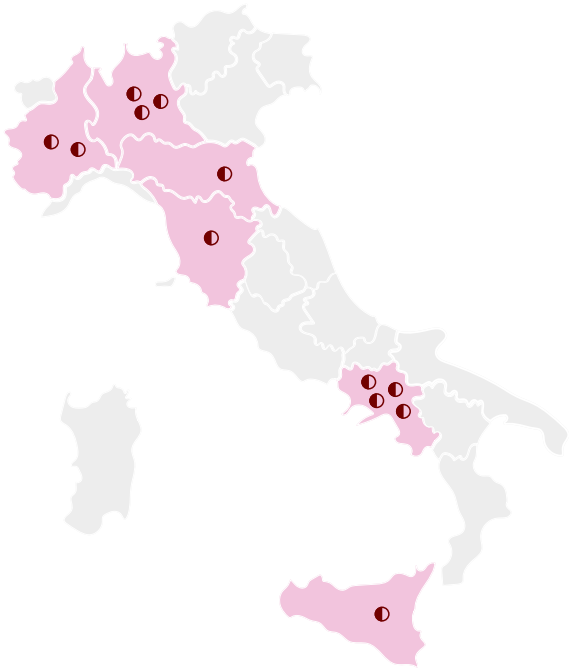
Productive process of the linen

ORIGIN OF RAW MATERIALS IN ITALY AND PROCESSING DISTRICTS

As seen in the section on the history of raw materials, the flax was widely cultivated especially in the Po Valley but then following the introduction in the fashion world of artificial fibers in the 50s and the change of the agricultural organization the cultivation of flax has gradually disappeared from the territory Italian. It is only in recent years that projects have started for the reintegration of these crops in Italy. In 2022 the Linificio e Canapificio Nazionale relaunched the flax industry in Italy. Currently the cultivation of flax is limited to only four regions of the peninsula. Production is limited and for this reason it is used only to make garments of a high level of excellence. [209] [210]
Below is the mapping of the regions where flax is currently grown in Italy.

Given this renewed interest in the reintroduction of flax cultivation in Italy, an assessment has been carried out on the impact that the introduction of the cultivation of these plants leads to the region in which it is cultivated. Flax grows in cold temperate climate and suffers from a lack of water. It prefers a type of medium-structured soil, with medium fertility and acidic soils.
From an environmental point of view, these crops, despite suffering from water shortages, do not have a high water requirement and do not require high quantities of pesticides and fertilizers. The presence of these plants improves the structure and fertility of the soil and in addition "eats" a huge amount of CO2, for example, 1 hectare of flax can eliminate up to 3.7 tons of CO2. [211] [206]

Map of flax coltivation



Map of textile district

This type of vegetation does not grow only in particular climatic and soil conditions; therefore, its spread cannot be spread throughout the Italian territory, but its impact on the environment does not turn out to be too hydrovorous and harmful for use of pesticides and fertilizers.

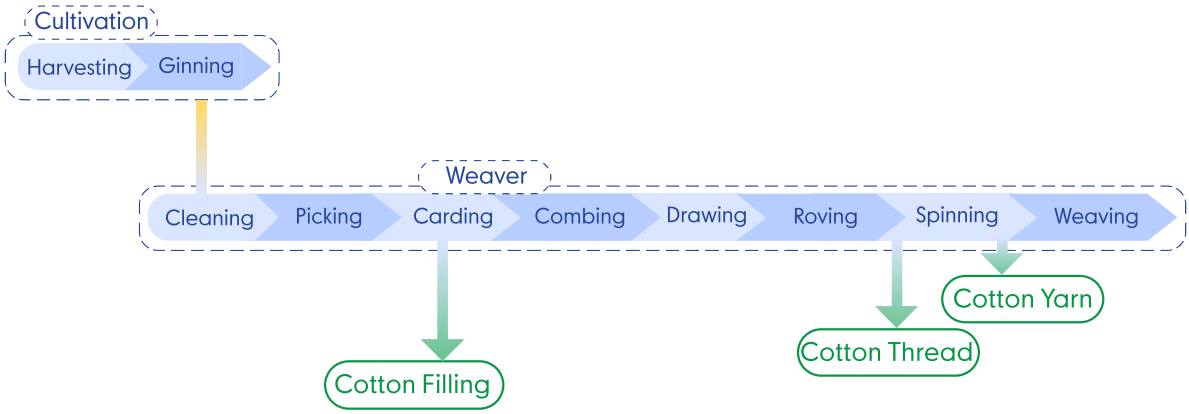
Despite, in the past the production of linen in Italy was substantial, on the Italian territory there is no district that deals exclusively with the processing of linen. In fact, there are many districts that deal with the production of fabrics in Piedmont, Lombardy, Emilia-Romagna, Campania, Sicily and Tuscany but none of them is specialized for this material. [122] [181]

2.4.5 COTTON

Cotton is perhaps the most widely used natural fiber in the fashion world. This fiber is obtained from the cotton wool that wraps the seeds of cotton plants and processed to obtain the garments that we are all used to wearing. These fabrics are characterized by their lightness, softness, is hypoallergenic and possesses the ability to absorb moisture. In addition, this fabric allows the skin to breathe. [212] [213]

PRODUCTIVE PROCESS

Being a fiber of natural origin, and specifically obtained from a plant, in the first place it is necessary to grow cotton plants in plantations. The first step in the production process is therefore that of cotton harvesting. Since the fibers are produced by the plant to protect the seeds, the next step is to separate the cotton fibers from the seeds. This mechanical process is called ginning. Subsequently, the ginned cotton is shipped in bales to a textile factory for yarn production.
The cotton bale is opened and its fibres are mechanically raked to remove foreign elements such as soil and seeds. Then, a picker, ie a collection machine, wraps the fibers in one turn. Next, a machine for carding brush the loose fibers into rows that are then joined into sheets, or web, and form them into a soft rope known as sliver cards. In the drawing phase, a series of variable speed rollers reduces the tape to uniform wires. Next, there is the roving process, in which the tape is converted to roving to be pulled and slightly twisted. Finally, the roving is transferred to a spinning frame, where it is drawn further, twisted on a ring spinner and wrapped on a coil as yarn.
Once the cotton yarn spools are obtained, the yarn is woven with similar procedures to the other yarns. The output of this production process can be yarn rolls or cotton fabrics. [214] [215]



Productive process of cotton

ORIGIN OF RAW MATERIALS IN ITALY AND PROCESSING DISTRICTS

As seen in the previous section dedicated to the history of raw materials, we saw that in Italy there were cotton crops, definitively disappeared in 2000 due to the growth of Asian industry that allowed access to cheap raw cotton. In recent years large fashion brands have sponsored projects for the reintegration of cotton cultivation in Italy. A collaboration between the clothing brand OVS and the farm Santiva have reintroduced the cultivation of cotton in Sicily. In 2023 the Puglia Regenerative Cotton Project by Giorgio Armani and the Fashion Task Force of the Sustainable Markets Initiative founded by King Charles III reintroduced the cultivation of cotton in Puglia. [216] [173]
These initiatives are very recent, therefore, their production is still experimental.
Below we report the mapping of cotton crops in Italy.

Map of flax coltivation

In view of the trend to re-introduce cotton production in the Italian territory, we have carried out an environmental impact assessment that this reintegration brings to the territory. Specifically, we analyzed the organic cultivation of cotton because, this is the type that these two initiatives have applied.
Cotton grows in warm, sunny and humid places. It needs high water levels in deep, well-drained clay and sandy soils, with enough clay and organic matter.
The harvesting practices take place in rainy conditions, so that there is a lower energy consumption, the fertilizers used come from the farms and 95% of the water used to irrigate is green water, therefore rainwater and water already present in the ground.
This type of plantation is certainly the most impactful compared to the other analyzed, especially for the high amount of water required. [217] [218] [219]

Despite, in the past it was produced and processed cotton in Italy, on the Italian territory there is no district that deals exclusively with the processing of cotton, as is also the case for linen. In the territory, in fact, there are many districts that deals with the production of fabrics in Piedmont, Lombardy, Emilia-Romagna, Campania, Sicily and Tuscany but none of them is specialized for this material. [122] [181]

2.4.6 SYNTHETIC FIBERS

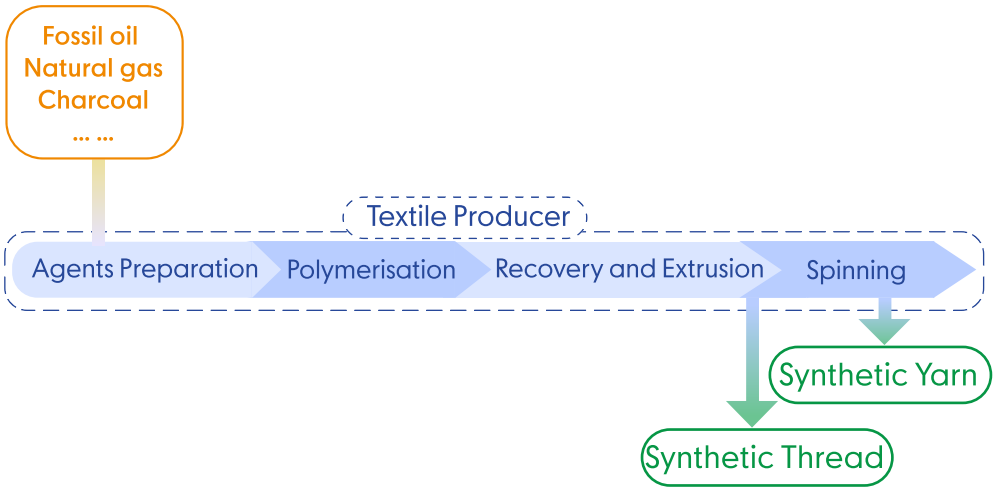
Nowadays, synthetic fibres are widely used in the fashion world. The peculiarity of these fibers, in fact, is that, being created in the laboratory, they can artificially assume any property it is necessary to entrust to a particular garment, such as waterproofing or thermoregulation. They can be used alone to make an entire garment or combined with natural fibers to change its properties by creating a mixed material. [220]

PRODUCTIVE PROCESS

These fibers are generated by a chemical reaction and are made from materials derived from oil, coal or natural gas.
The first step to make a synthetic thread is the preparation of the agents that will react together during polymerization to create a liquid material. Polymerization is a chemical reaction that leads to the formation of a polymer chain, or a molecule consisting of many equal parts that are repeated in sequence, starting from simpler molecules. Subsequently, the liquid created by polymerization is forced through fine nozzle holes in a process called extrusion. Once the liquid has been extruded it is cooled so that it solidifies to form thin wires. Then, these threads can be spun together to create a fully synthetic fiber or yarn with other fibers to create mixed fabrics. [220]

ORIGIN OF RAW MATERIALS IN ITALY AND PROCESSING DISTRICTS

The use of synthetic fibres in Italy began in the 1950s and continues today. In Italy, however, there is no specific district that deals exclusively with the creation and processing of this material. It, since it can be spun with other fibres, including natural ones, is also used in districts that are specialized in other materials. This depends on the type of garment you want to make.



Productive process of synthetic fibers

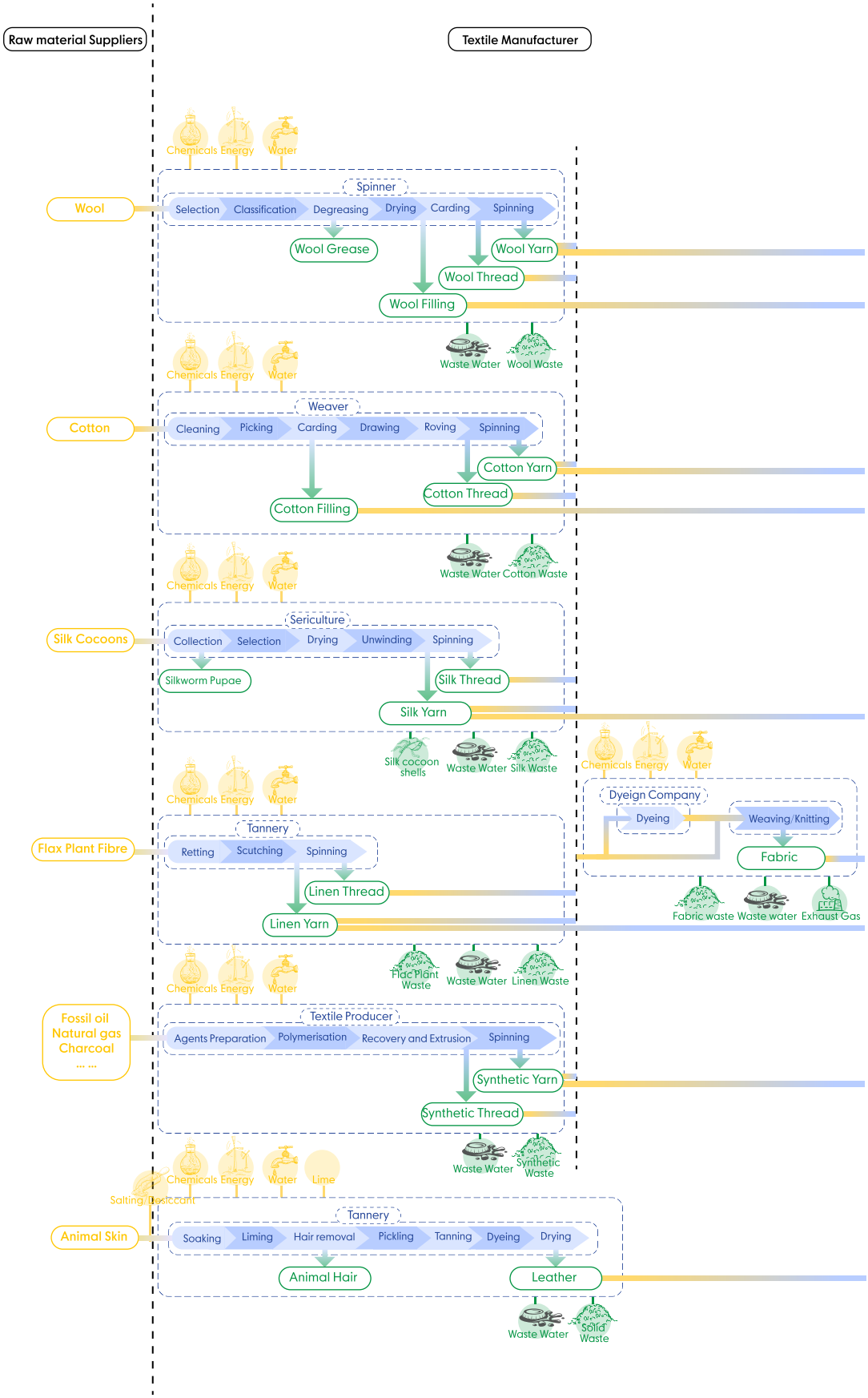
REGULATION AND CERTIFICATIONS

In recent years, there has been increasing attention to respect for the environment and the use of raw materials, for this reason many projects for the realization of "ecological" synthetic fibres have started in Italy. An example is Econyl [221], a regenerated nylon derived from the recycling of fishing nets taken from the oceans made by Aquafil, an Italian company, or NewLife [222] a synthetic textile fiber created with recycled plastic bottles produced by an Italian company that exports all over the world.

In order to be able to declare that the synthetic fibres produced are sustainable, there are several textile certifications. Specifically, since these fibres are of chemical origin, if they were produced in Europe they must comply with the European REACH regulation on the registration, evaluation, authorisation and registration of chemicals, which entered into force in 2007. This Regulation excludes from production the use of chemicals harmful to the environment and human health. [223]
Another certification is the OEKO-TEX, a certification standard whose purpose is to verify and manage the presence of toxic substances in textile products. This certification, however, is independent and voluntary, so companies must make an explicit request to obtain it in contrast to the European regulation that requires it regardless of all products produced in Europe. [224]
A further certification, linked to the recycling of plastic and therefore concerning synthetic fibres, is Plastica Seconda Vita, issued by the IPPR-Institute for the Promotion of Recycled Plastics. This certification is not only linked to the production of synthetic fibers but covers a wide range of products made by recycling plastic. This certification issues a label that is different depending on the origin of the recycled plastic or the use that will be made of the product made. [225]
Finally, there is the Global Recycle Standard GRS, a certification promoted by the Textile Exchange, a global non-profit organization that works to guide the textile industry towards greater sustainability, with the aim of encouraging the use of recycled materials in the textile sector. This certification, unlike for example Plastica Seconda Vita, does not limit its action to recycled plastic only, but evaluates any type of recycled material; therefore, it can also be applied to other recycled fibers such as wool. [226]

Regulation and certifications [223] [224] [225] [226]

2.5 TEXTILE MANUFACTURERS IN ITALY



In Italy, the textile manufacturing industry boasts a long history and rich tradition, having developed a comprehensive and refined production process. The transformation of various raw materials into yarn or thread has been detailed extensively in previous chapters. Once these raw materials are made into yarn or thread, they proceed to the dyeing and fabric-making process.

Dyeing is a crucial step in textile production. Dyeing companies are responsible for treating the undyed yarn or fabric with a series of chemical processes to achieve the desired color and texture. Through rigorous process control and innovative techniques, they ensure that each piece of fabric has a uniform and long-lasting color. In this process, the use of chemicals, energy, and water is a key factor affecting both environmental impact and production costs.

After dyeing, the yarn and fabric are sent to subsequent weaving and knitting stages, eventually forming various fashionable fabrics and products.

2.6 APPAREL MANUFACTURERS IN ITALY

Italy is renowned for its exceptional apparel manufacturing, which is a cornerstone of the country's vibrant fashion industry. The sector is characterized by a commitment to quality, craftsmanship, and innovation. This section provides an overview of the key aspects of apparel production in Italy, focusing on the processes, regions, and significance of this industry.

Craftsmanship and Quality: Italian apparel manufacturing is synonymous with high-quality craftsmanship. Artisanal techniques are passed down through generations, ensuring meticulous attention to detail and superior finishing. This dedication to excellence is evident in both haute couture and ready-to-wear segments.

Regions and Specializations: Different regions in Italy are known for their specialized production techniques and materials. Each region has developed expertise in specific areas, contributing to the overall diversity and strength of the Italian apparel industry.[227]

- Tuscany: Renowned for leather goods, particularly in cities like Florence. Tuscany's artisans are famous for their skill in producing high-quality leather products, including handbags, shoes, and jackets. The region's commitment to craftsmanship ensures that these products are sought after worldwide.
- Lombardy: A major hub for textile production, especially in cities like Milan. Lombardy is home to numerous textile mills that produce a wide range of fabrics, from luxurious silks to durable wools. The region's textile industry supports the fashion houses of Milan, one of the world's fashion capitals.
- Veneto: Known for high-quality wool and fabric production. Veneto's mills produce some of the finest woolen fabrics, which are used by top designers to create elegant and timeless garments.
- Piedmont: Famous for fine textiles and silk production. The region's expertise in silk weaving and textile finishing has made it a leader in producing delicate and high-quality fabrics used in luxury fashion.

Luxury and High FashionItaly is home to numerous luxury brands, such as Gucci, Prada, and Armani. These brands set global standards for fashion and are leaders in innovative manufacturing techniques while maintaining traditional craftsmanship.[228]

Luxury fashion houses in Italy combine traditional artisanal skills with modern design concepts to create exclusive and high-end clothing. These brands often operate their own ateliers, where master craftsmen work closely with designers to produce limited-edition collections. The emphasis on quality, exclusivity, and innovation has cemented Italy's reputation as a leader in luxury fashion.

Furthermore, Italian luxury brands have a significant influence on global fashion trends. Their collections are showcased at major fashion weeks and attract

attention from fashion critics, buyers, and enthusiasts worldwide. This global reach ensures that Italian luxury fashion remains at the forefront of the industry.

The Italian apparel industry includes a significant number of small and medium-sized enterprises (SMEs) and artisan workshops. These entities contribute to the diversity and richness of Italian fashion, producing unique and bespoke items that cater to niche markets.

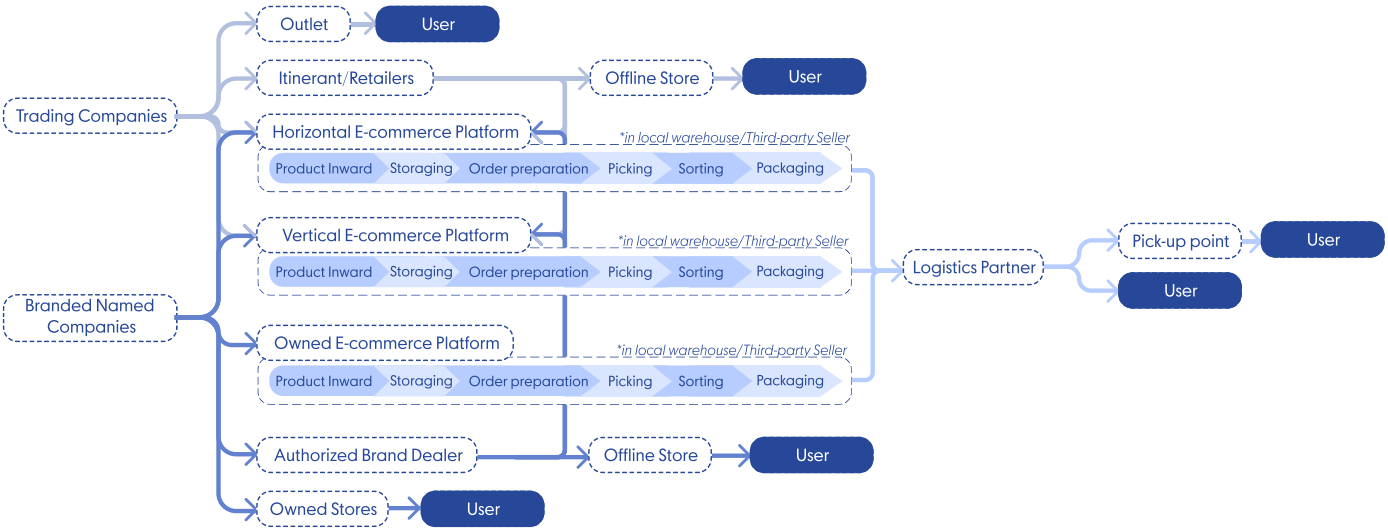
SMEs and artisan workshops often specialize in specific types of apparel or production techniques. For example, a small workshop might focus on handcrafted shoes, while another might specialize in bespoke tailoring. These businesses often operate on a smaller scale but maintain a high level of craftsmanship and attention to detail.

The presence of SMEs and artisan workshops also supports the local economy and preserves traditional skills and techniques. Many of these businesses are family-owned and have been passed down through generations, ensuring that valuable knowledge and expertise are retained within the industry.

Italian apparel production is a blend of tradition and innovation, with a strong emphasis on quality and craftsmanship. The industry's regional specializations, integration of modern technologies, and commitment to sustainability position Italy as a global leader in fashion manufacturing. This deep-rooted heritage and ongoing innovation ensure that Italian apparel continues to set benchmarks in the global fashion industry.

The diverse landscape of Italian apparel manufacturing, from luxury brands to small artisan workshops, exemplifies the country's ability to maintain its cultural heritage while adapting to modern trends and technologies. This unique combination makes Italy's apparel industry not only a pillar of its economy but also a significant player on the world stage.

2.7 FASHION RETAILER IN ITALY



OFFLINE SALES CHANNELS

From the provided flowchart, offline sales channels for apparel in Italy involve traditional brick-and-mortar stores and itinerant/retail outlets. These channels offer customers opportunity to physically interact with products before purchase, which can enhance customer satisfaction and trust.

1. Outlets and Itinerant/Retailers:
   - Outlets: These are large retail spaces where manufacturers sell directly to consumers, often at discounted prices. Outlets typically offer a wide range of products and attract customers looking for bargains on high-quality apparel.
   - Itinerant/Retailers: This category includes mobile vendors and small retailers who sell apparel in various locations, such as street markets and temporary stalls. This method allows for flexibility and direct interaction with customers.
2. Branded Stores and Authorized Dealers:
   - Owned Stores: Many branded companies operate their own exclusive stores, providing a controlled environment to showcase their full product range. These stores are designed to reflect the brand's image and offer a premium shopping experience.
   - Authorized Brand Dealers: These are independent retailers authorized to sell a specific brand's products. They provide an additional sales channel, expanding the brand's reach while maintaining quality control.

In both cases, the products are typically shipped from manufacturers or central warehouses to the stores, where they are displayed for customers to purchase.

OFFLINE SALES CHANNELS

From the provided flowchart, online sales channels have become increasingly significant, offering convenience and a wider reach for apparel manufacturers. These channels include various e-commerce platforms and logistics arrangements to ensure efficient delivery to customers.

1. E-commerce Platforms:[229]
    - Horizontal E-commerce Platforms: These platforms sell a wide variety of products across different categories, including apparel. Examples include Amazon and eBay. They typically handle the entire process from product inward to order preparation, picking, sorting, and packaging. The logistics partner then delivers the products to the user.
    - Vertical E-commerce Platforms: These platforms specialize in a specific category, such as fashion and apparel. Examples include Zalando and ASOS. They provide a focused shopping experience with specialized offerings and similar backend processes as horizontal platforms.
    - Owned E-commerce Platforms: Some brands operate their own online stores, allowing for direct sales to customers. This approach offers greater control over branding, customer experience, and data collection.
2. Logistics and Pick-up Points:
    - Products purchased online are typically stored in local warehouses or handled by third-party sellers who prepare the orders for shipping. Once the products are ready, logistics partners manage the delivery process.
    - Pick-up Points: Customers also have the option to collect their orders from designated pick-up points, which can be more convenient and reduce delivery costs.

Overall, the integration of both online and offline channels allows apparel manufacturers in Italy to reach a broader audience, providing various options to meet diverse customer preferences and needs. The combination of traditional retail presence and modern e-commerce capabilities ensures a comprehensive approach to market penetration and customer satisfaction.

2.8 END-LIFE OF CLOTHES

Art. 183 of Legislative Decree no. 152 of 3 April 2006 defines as waste: "any substance or object that the holder disposes of or has the intention or the obligation to dispose of ", that is, any object that the owner disposes of or has the will to dispose of. [230]
A garment, therefore, is transformed from a good to a refusal following the choice that the user makes. Even what happens in the future to these clothes, become waste, depends on the choice that the user makes. In fact, it can make three possible choices when it wants to throw away clothes: throw them in the bins reserved for clothing, throw them in the bins of the undifferentiated or donate them to charities.
In Italy, the separate collection of used clothing is carried out permanently but not mandatory on the territories of the municipality. There is an agreement that has been signed between ANCI (Associazione Nazionale dei Comuni Italiani, or National Association of Italian Municipalities) and CONAU, Associazione Nazionale Abiti e Accessori Usati, the National Association of Used Clothes and Accessories in which the minimum standards of collection of this type of waste are defined. The collection is carried out with programmed periodicity by means of containers placed on public soil and at ecological areas. The transport of this waste must be carried out by operators authorised and registered in the Albo gestori ambientali (Register of Environmental Managers) in order to ensure full traceability of the waste flow.
The collection of unsorted waste also takes place on municipal soil with scheduled intervals but is carried out by companies that deal with the collection of waste, and that vary depending on the region and/or city in which it is carried out. [231]
Throughout Italy there are several charities and/or religious associations that deal with the collection of clothing in order to use them in humanitarian missions in developing countries. The collection usually takes place in their premises or in special places when events dedicated to charity are organized. It is the user to bring the waste/ donation in these places, there is no periodic collection on the municipal territory as for the other two methods of collection.
Not all types of clothing can be thrown in all bins as the purpose of each waste collection is different. Clothing that can be thrown into clothing bins can be in any type of condition, whether it is still perfectly usable or torn and dirty. In the bin of the undifferentiated, one would generally think of throwing away clothes that are in poor condition but very often are also thrown in good condition, because the user does not know where to throw them or because he does not have a collection bin nearby. If you decide to donate your clothes instead, they must be in good condition and clean.
Therefore, the user, depending on the condition in which the garment is found, chooses the future of the garment based on his choice.

COLLECTING PROCESS

Once the user has thrown the garment it undergoes a different process based on the container in which it was thrown. If the garment has been thrown into the textile waste bin, the waste collection company collects the clothes contained in the collection bins. They are taken to special places of temporary storage before undergoing a selection process. The selection process is aimed at separating garments that will be destined for reuse, if the garments can be used directly in consumption cycles, recycling, to obtain industrial pulp, upholstery or sound-absorbing materials, or intended for disposal if the condition of the garment is irrecoverable.

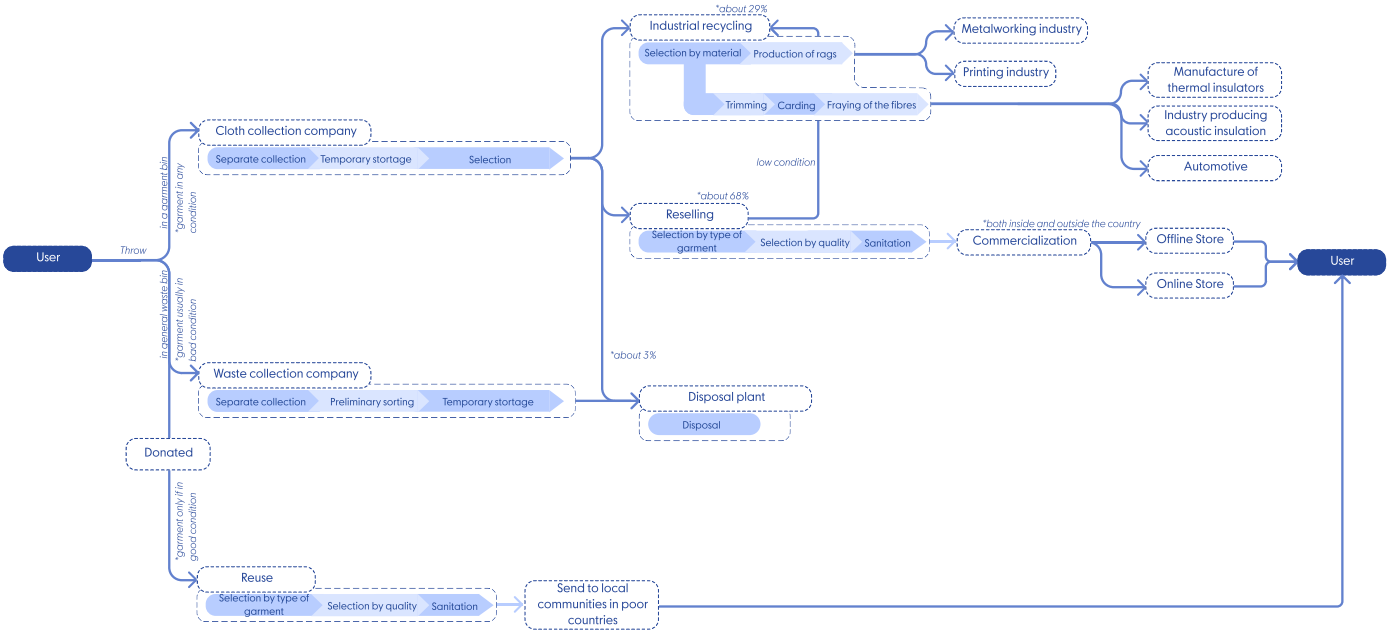
The purpose of reuse is to put on the market clothes that are still wearable. The process that allows the reimmission on the market of these goods foresees a first phase of selection. This phase consists in opening the bags in which the garments are usually wrapped in order to be thrown away and in the first sorting by type of garment, for example, in the case of t-shirts, trousers, etc. At this stage, the garments that are started for reuse are separated from those that are started for recycling to make pieces and/or fraying, in case the garment is not suitable for reuse. The second phase involves a second selection, which this time separates the garments by quality. This phase is usually carried out manually by experienced workers whose aim is to extract the most valuable fraction and create homogeneous batches of reusable products. Finally, as required by law, it is necessary to carry out sanitization of the product started for reuse. It is necessary to ensure the achievement of the microbiological specifications indicated by law. Following sanitization, the products are ready to be put back on the market. Marketing can take place both on the domestic markets of the countries in which the companies operate, and on export.

If the textile waste, after the selection process, has not been selected as suitable for reuse, it will undergo industrial recycling. The purpose of industrial recycling is to produce pieces, such as rags, for industrial use used for cleaning and maintenance in mechanical, typographical and for the protection of floors. Or, as a result of processes such as trimming, carding and fraying of fibers, textile waste is used as fillers and as acoustic and thermal insulators and in the automotive. [231] [232] [233]

If the garment is thrown into the undifferentiated bin, the collection would be carried out by a waste collection company. After the normal stages of collection, separation from other types of waste, such as plastic collection and temporary storage, unsorted waste is disposed of in disposal facilities. Waste can be disposed of in landfills, or used for energy recovery by means of waste-to-energy plants.

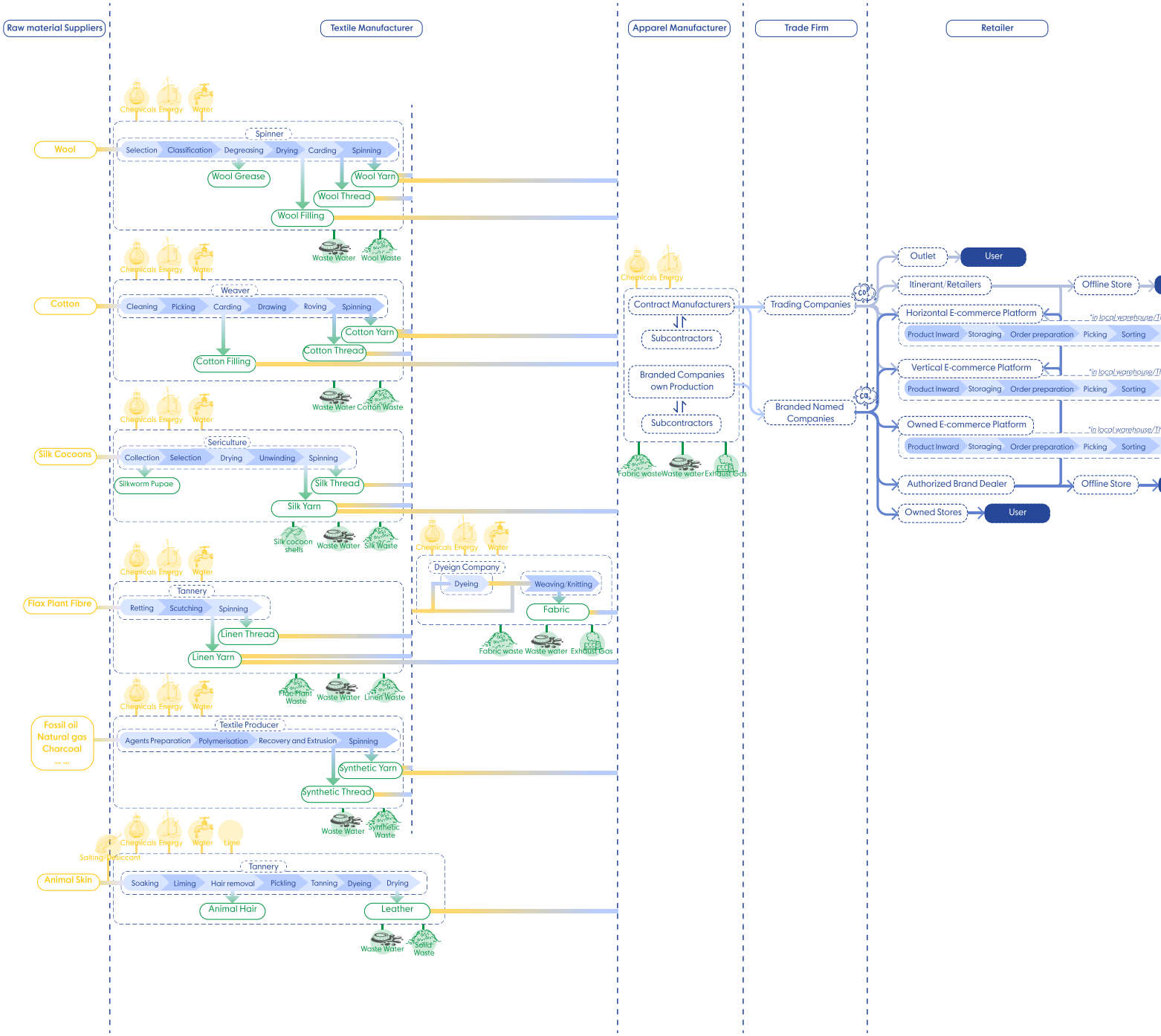
In the event that the user donates their clothing, a mechanism is triggered similar to that employed by the clothing

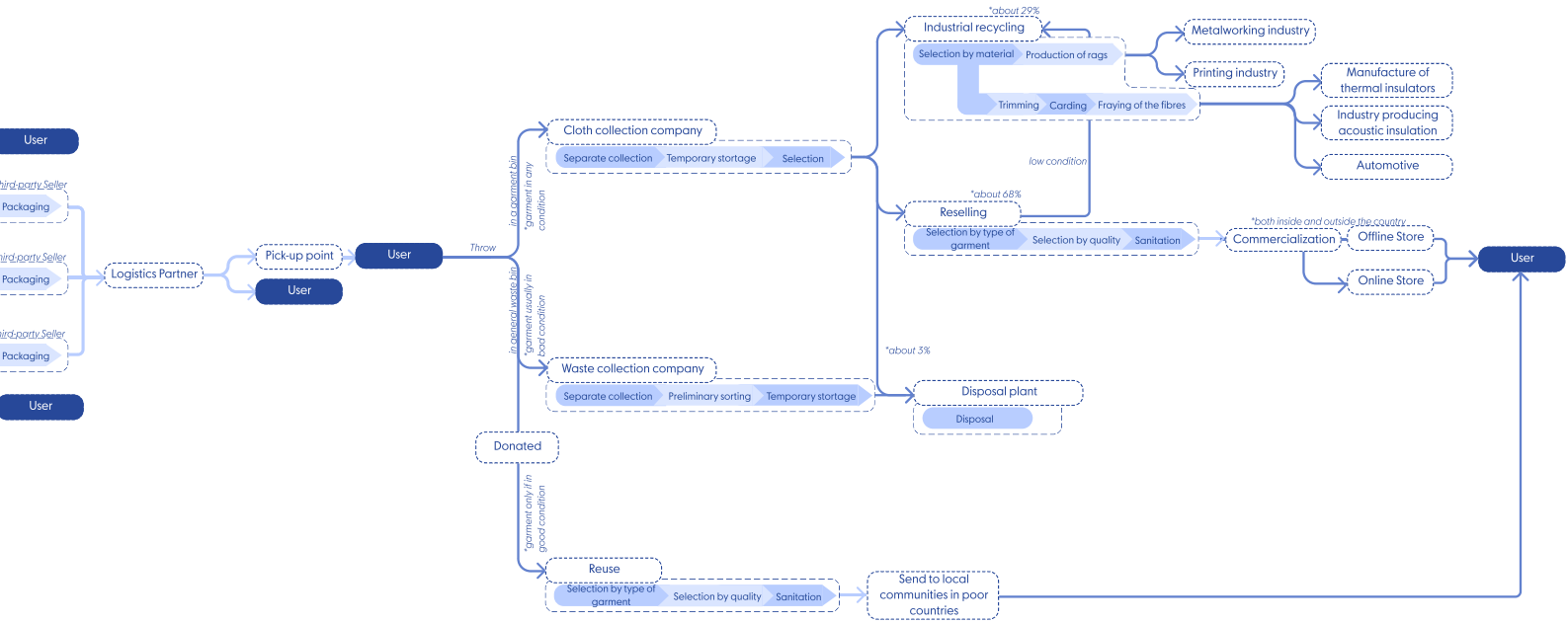
collection companies that deal with the recovery. The clothes are selected on the basis of the type of garment and the quality and then be sanitized. In this case, however, the garment is not on the market but is shipped to needy communities in poor countries to reach its new owner.



End life of the clothes schema

ENTIRE SUPPLY CHAIN

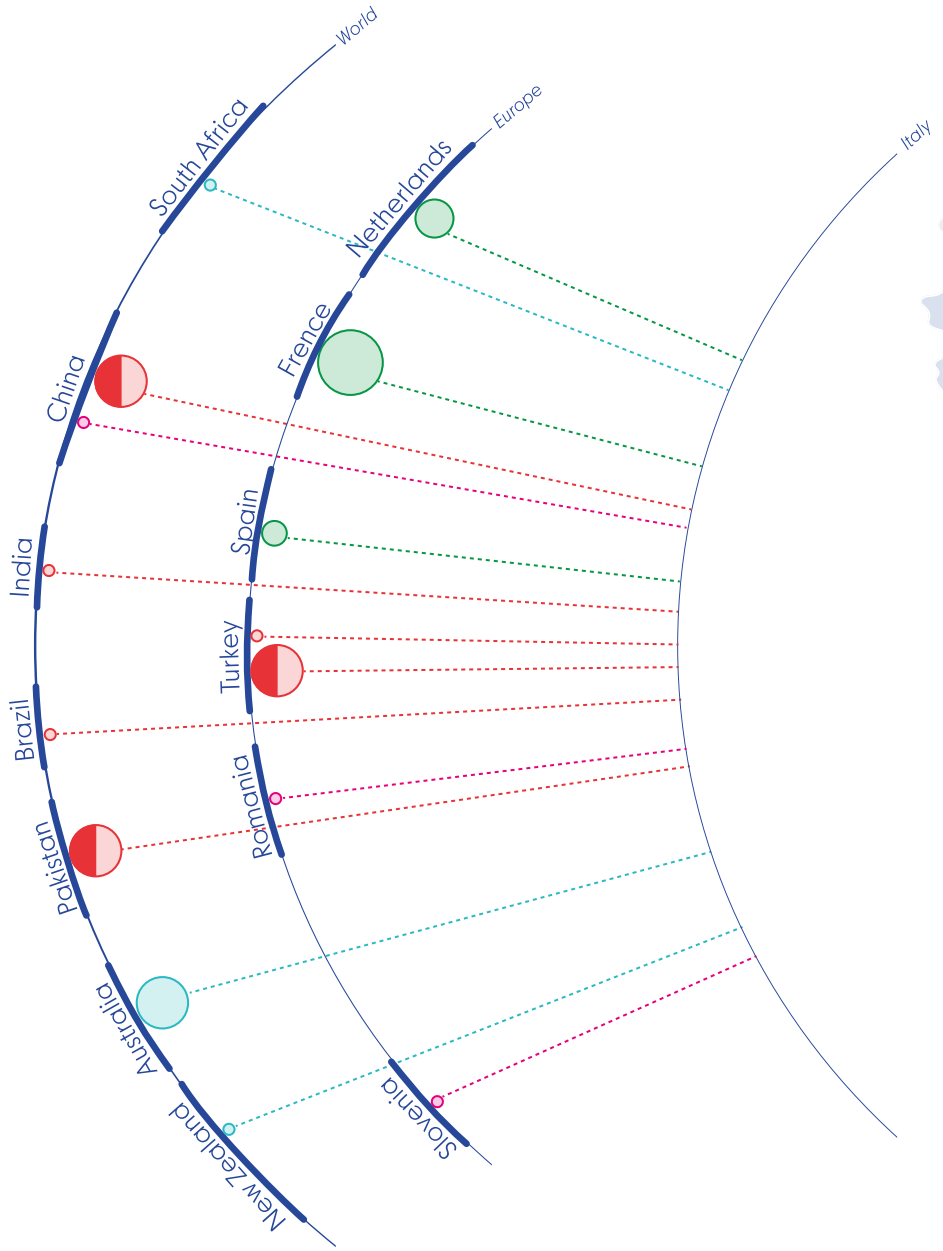


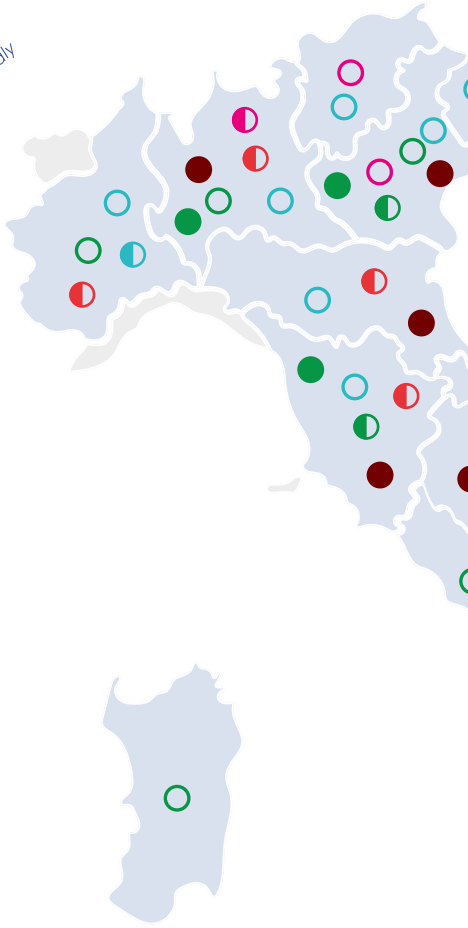


Fashion Supply Chain

2.9 THE EXPORT AND IMPORT OF ITALY

IMPORT(M $)





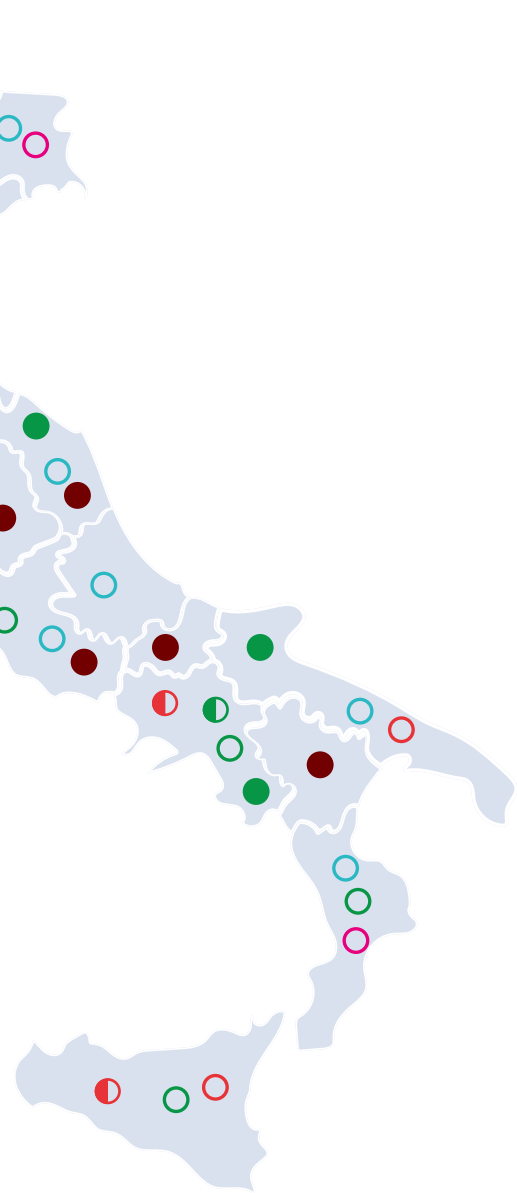
Legend

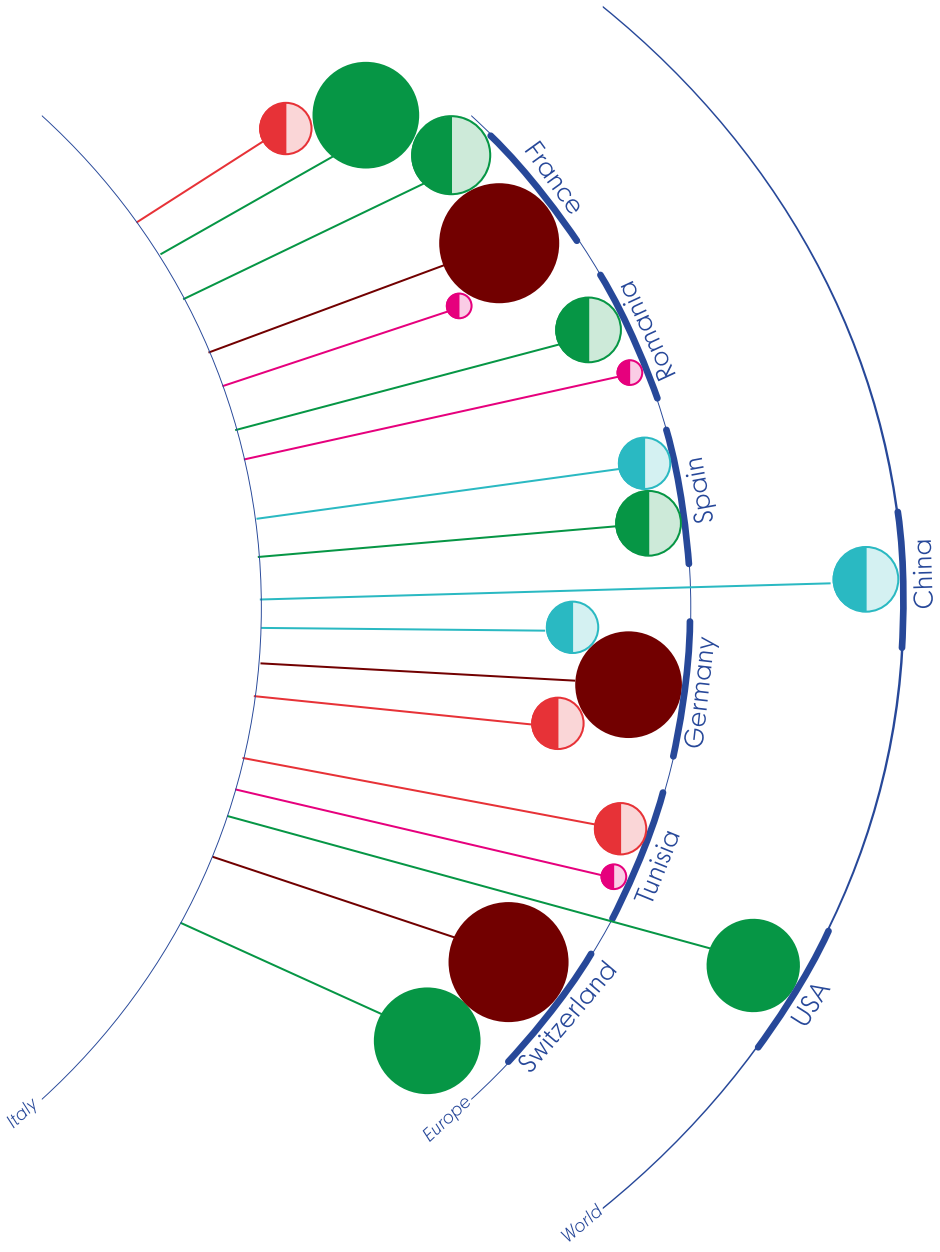
IMPORT ····· EXPORT ——

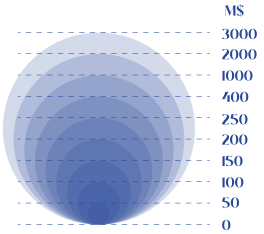
- cotton
- silk
- wool
- flax
- skin(leather)
- synthetic
- raw material production
- textile production
- apparel general
- apparel leather

The Export and Import of

EXPORT(M $)




France
Romania
Spain
China
Germany
Tunisia
Switzerland
USA
Italy
Europe
World


M$
3000
2000
1000
400
250
200
150
100
50
0

The provided chart delineates Italy's import and export activities within the fashion industry, showcasing the intricate web of global trade connections that sustain this vibrant sector. The legend clarifies the meaning behind the various circles, representing different materials and production types. The data is come from *Sistema Moda Italia,Federazione Tessile E Moda*[234] and *Centro Studi Confindustria Moda* [235] .

IMPORT ANALYSIS

Italy's fashion industry heavily relies on the importation of raw materials and textiles from a wide array of countries. These imports are crucial for maintaining the high standards of quality and craftsmanship that Italian fashion is known for globally.

The import section of the chart reveals that Italy sources its cotton (denoted by red circles) predominantly from countries like China, India, and Turkey. These nations are recognized for their robust cotton production, which supplies Italy with the essential raw material needed for textile and apparel manufacturing. Cotton is vital for producing a wide range of garments, from everyday wear to high-end fashion items, ensuring versatility in Italian fashion production.

Wool (represented by blue circles) is primarily imported from Australia and New Zealand, both of which are renowned for their superior wool quality. This wool is integral to Italy's textile industry, providing the foundation for the fine fabrics used in various clothing items. The imported wool is often transformed into luxurious products such as suits, coats, and knitwear, reflecting Italy's commitment to quality and sophistication.

Leather (indicated by green circles) is another significant import, with major suppliers including Brazil and Pakistan. The high-quality leather from these countries supports Italy's extensive leather goods industry, producing items such as shoes, handbags, and jackets that are famed for their durability and elegance. Leather craftsmanship is a hallmark of Italian fashion, with many luxury brands relying on these imports to maintain their premium standards.

Additionally, Italy imports silk (pink circles) from China, which is the largest producer of silk globally. Silk is a critical material for creating high-end fashion items, including elegant dresses, blouses, and accessories. Flax (purple circles) and synthetic materials (orange circles) are also imported from various countries to meet diverse manufacturing needs. Flax is used for producing linen fabrics, which are prized for their breathability and comfort, while synthetic materials offer versatility and durability for a wide range of fashion applications.

IMPORT ANALYSIS

On the export front, Italy stands out as a major exporter of finished fashion goods, encompassing general apparel, leather apparel, and textiles. The export destinations highlighted in the chart emphasize Italy's global influence in fashion.

Italy exports a significant portion of its general apparel (brown circles) to countries like France, Switzerland, and Germany. These nations appreciate the quality and style of Italian clothing, which includes everything from everyday wear to high-end fashion pieces. The strong demand in these countries is driven by Italy's reputation for cutting-edge design, exceptional craftsmanship, and use of premium materials.

Leather apparel (green circles), another key export, finds major markets in the United States and China, where the demand for Italian leather goods is driven by their renowned craftsmanship and design. Italian leather jackets, shoes, handbags, and accessories are considered luxury items in these markets, symbolizing status and quality. The meticulous attention to detail and the use of top-quality leather make these products highly desirable.

Italian textiles (black circles) are exported to numerous countries, including the USA and China, as well as several European nations. These textiles are prized for their quality and are utilized by fashion industries around the world to create garments and accessories. The versatility of Italian textiles, which range from luxurious silks and wools to innovative synthetic fabrics, supports a wide variety of fashion applications.

While Italy is predominantly an importer of raw materials, it also exports some of its raw material production (white circles), catering to countries that require high-quality Italian inputs for their manufacturing processes. These exports include specialized fabrics and unique materials that are valued for their superior quality and innovation.

SUMMARY

The trade flow of fashion goods to and from Italy is characterized by the importation of essential raw materials and textiles, which are then transformed into high-quality finished products for export. This cycle underpins Italy's stature as a global leader in the fashion industry. By importing diverse and high-quality materials and exporting premium finished goods, Italy sustains its reputation for excellence in fashion manufacturing.

The intricate trade relationships depicted in the chart reflect Italy's strategic position in the global fashion market. The country's ability to import raw materials and convert them into world-class fashion products ensures that Italian fashion remains synonymous with quality, innovation, and style. This dynamic exchange underscores the importance of both importing and exporting in maintaining the vitality and global influence of Italy's fashion industry.

PACKAGING IN FASHION

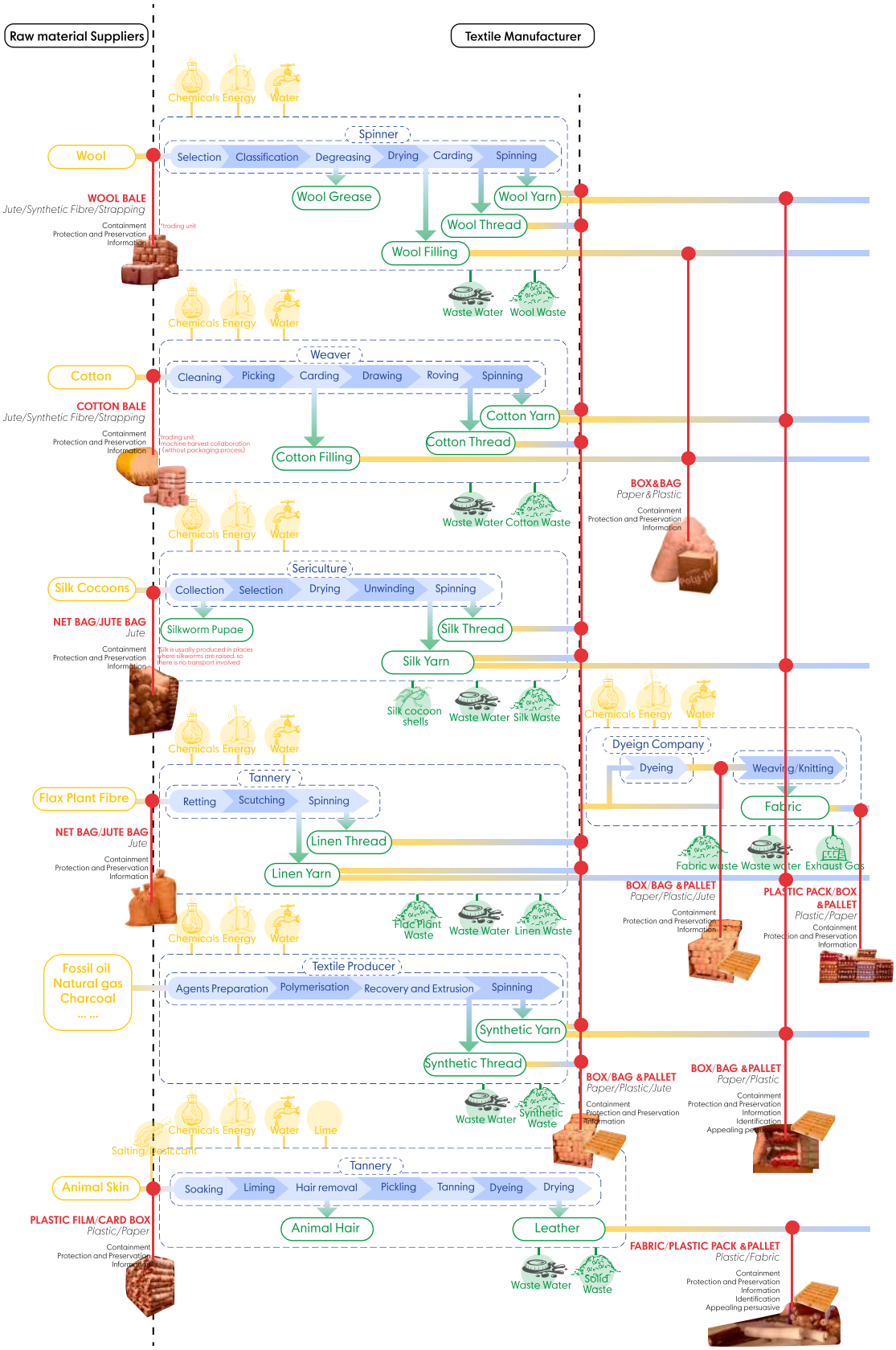
This chapter analyzes the types of packaging that are used throughout the supply chain and the information that is provided. A study was also made of the flow of packaging used in the different sales channels. In addition, the types of information that must be provided by law through the label presented on clothing have been researched, as the label is also considered to belong to the sphere of packaging. Finally, the end-of-life of packaging was analysed, both at the level of material flow and at the legislative level.

3.1 KIND OF PACKAGING USED IN FASHION

In the fashion industry, packaging plays a crucial role in maintaining the integrity and quality of materials and products as they move through various stages of the supply chain. Initially, from raw materials to textile processing, diverse packaging solutions are utilized to protect and preserve the quality of fibers such as wool, cotton, silk, flax, synthetic fibers, and leather. Materials like jute, synthetic fibers, plastic films, and containers are chosen for their ability to safeguard these raw materials against contamination and physical damage during transportation and storage.

As the raw materials are transformed into textiles and subsequently into apparel, the packaging requirements evolve to cater to different stages of the supply chain. Finished textiles are often packaged in protective boxes, bags, and pallets to ensure safe transit and storage. The flow of apparel from manufacturers to end-users involves multiple layers of packaging, including primary packaging for individual items, secondary packaging for bulk transportation, and tertiary packaging for logistical efficiency. These packaging solutions not only provide essential protection but also promote sustainability through reusable and recyclable materials, ensuring the products reach consumers in optimal condition.

3.1.1 PACKAGING FROM RAW MATERIAL TO TEXTILE



Packaging used from raw material to textile

Packaging used in raw material process

The diagram illustrates the various types of packaging used throughout the transportation and handling stages of different raw materials in the textile production process. Each raw material has specific packaging requirements to ensure its protection, containment, and preservation during transit and processing.

A wool bale is a standardized pack of sorted wool, compressed mechanically using a wool press. This method is regulated to ensure the wool remains uncontaminated and easily identifiable. Additionally, a wool bale serves as the standard trading unit for wool in both national and international wholesale markets [236]. Wool is transported in wool bales made from jute or synthetic fibers, which are securely strapped. This packaging serves to contain and protect the wool, maintaining its integrity by preventing contamination and physical damage during handling and transportation.

Similarly, cotton is packaged in cotton bales using jute or synthetic fibers and strapping. A cotton bale is a standardized pack of compressed cotton lint produced after the ginning process. The size and weight of these bales can vary depending on the cotton-producing country. The purpose of this packaging is to keep the cotton clean and intact as it moves from the field through various processing stages, such as cleaning, picking, and spinning, ensuring that the fibers remain uncontaminated.[237]

Bale management involves the systematic processes of categorizing, blending, and evaluating bales based on fiber attributes to achieve the desired quality of yarn production at an optimized cost. Cotton fibers inherently vary in staple length and other physical characteristics. Known also as "bale mixing," this practice entails analyzing, classifying, and then blending fibers from different bales, including those received from other stations, based on their properties to produce yarn of specific quality at the most cost-effective price.[238][239]

Silk cocoons are stored and transported in net bags or jute bags. These materials allow for adequate ventilation while providing protection against physical damage and contamination. The packaging of silk cocoons is crucial for maintaining their delicate structure as they are collected, selected, dried, unwound, and spun into silk threads. Flax plant fibers, similarly, are packaged in net or jute bags. This type of packaging ensures the flax fibers are securely contained during retting, scutching, and spinning processes, preserving their quality and preventing them from being scattered or lost.[240]

Synthetic fibers, derived from fossil oil, natural gas, or charcoal, require different packaging approaches. They are typically packed in plastic bags or containers, which protect them from moisture and contamination during transportation and storage. The plastic packaging is essential for maintaining the purity and usability of these synthetic materials as they go through

the stages of polymerization, recovery, and extrusion before being spun into synthetic yarn and thread.

Animal skins, used for leather production, are packaged in plastic films or card boxes. This packaging type is designed to protect the skins during the various stages of processing, such as soaking, liming, hair removal, pickling, tanning, dyeing, and drying. The plastic films and card boxes ensure that the skins remain intact and free from contaminants, which is critical for producing high-quality leather.

Overall, the packaging materials chosen for these raw materials—ranging from jute and synthetic fibers to plastic films and containers—are selected for their ability to protect, contain, and preserve the materials during transportation and storage. This careful selection ensures that the raw materials arrive at textile manufacturing facilities in optimal condition, ready for further processing into yarns and fabrics.

Packaging used in textile process

Packaging from Raw Material to Textile
The highlighted section of the diagram illustrates the detailed journey of various raw materials through the stages of textile production, focusing on the packaging used after they have been processed into yarn or thread. Wool, cotton, silk, flax, synthetic fibers, and leather all undergo extensive processing before they are packaged for further use or distribution.
Once wool is processed through selection, classification, degreasing, drying, carding, and spinning, it is transformed into wool yarn and wool thread. Cotton follows a similar path, undergoing cleaning, picking, carding, drawing, roving, and spinning to become cotton yarn and thread. Silk, after collection, selection, drying, unwinding, and spinning, turns into silk yarn and thread. Flax fibers go through retting, scutching, and spinning to produce linen yarn and thread, while synthetic fibers derived from fossil oil, natural gas, or charcoal are processed through agents preparation, polymerization, recovery and extrusion, and spinning to become synthetic yarn and thread. Leather, produced from animal skins, goes through soaking, liming, hair removal, pickling, tanning, dyeing, and drying to become finished leather.

At this stage, the packaging used for these materials plays a critical role in ensuring their quality and facilitating their distribution. The yarns and threads are typically packaged in boxes and bags made of paper and plastic. This packaging is designed to contain the yarn and thread securely, protecting them from physical damage, contamination, and environmental factors such as moisture and dust. Additionally, these boxes and bags provide essential information for handling, identification, and further processing instructions, ensuring that the materials are managed efficiently as they move through the supply chain.

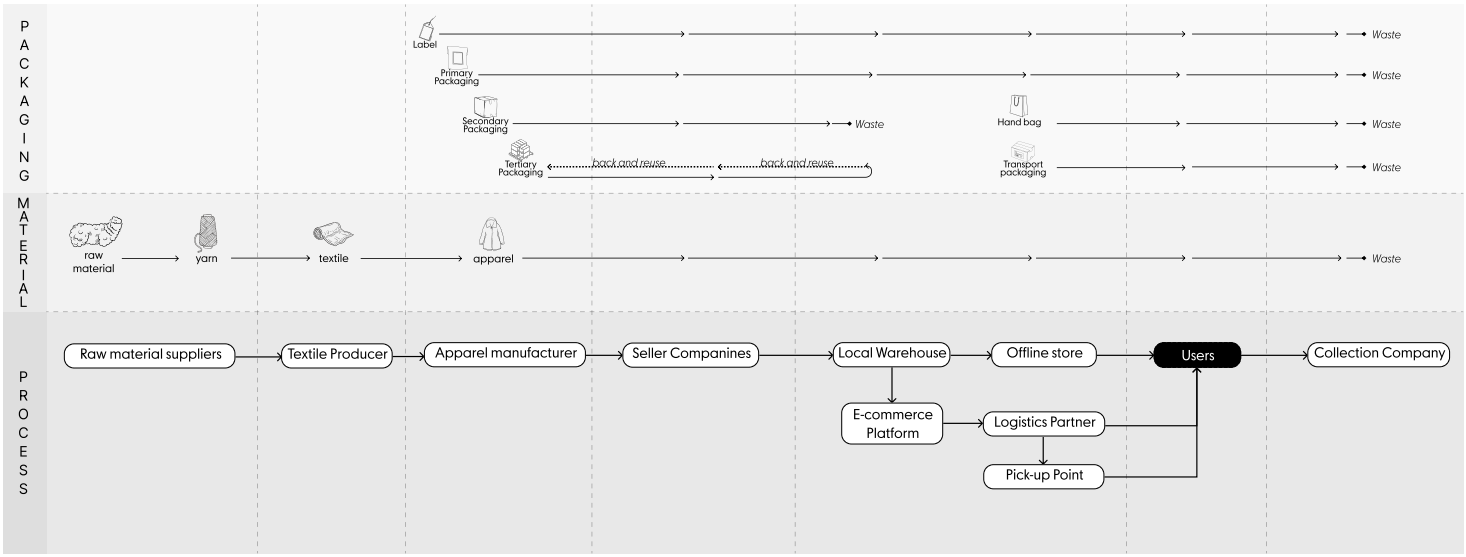
The packaging not only serves to protect and preserve the materials but also facilitates their transportation and storage. For example, boxes and bags made of paper and plastic are used for their durability and protective qualities, ensuring that the yarns and threads

remain intact and uncontaminated. This is particularly important for maintaining the high standards required in the textile industry, where the quality of the raw materials directly impacts the finished products.

Furthermore, the packaging methods are chosen based on their ability to meet the specific needs of the different types of yarn and thread. For instance, wool and cotton, being more susceptible to environmental damage, are often packaged with additional protective layers to ensure their quality is preserved during transit. Silk, being delicate, is packaged in a way that allows for adequate ventilation while preventing physical damage. Synthetic fibers and leather, due to their unique properties, are packaged in materials that prevent contamination and maintain their usability.

In summary, the packaging used after the raw materials are processed into yarn or thread is crucial for maintaining their quality, facilitating efficient handling and transportation, and ensuring they meet the high standards required in the textile industry. This packaging strategy is an integral part of the supply chain, ensuring that the materials are protected, preserved, and properly managed as they move towards further processing or final use. [241]

Packaging used in supply after apparel manufacturer



Sum up system map

The diagram provides a comprehensive overview of the packaging flow and supply chain in the textile industry, highlighting the roles of different packaging types at each stage and how materials move through the process.

In the upper part of the diagram, we can see the flow of labels and various levels of packaging: primary packaging, secondary packaging, and tertiary packaging.

Labels are the initial step, providing essential information about the product, including material type, source, and handling instructions. Labels are crucial for traceability and inventory management throughout the supply chain. We can see that they follow the product all the way to the user, who might either discard or keep them with the clothing. Ultimately, they become waste and are discarded.

Primary Packaging comes next, which is the packaging that directly contacts the product, designed to protect it from damage and contamination. For example, garments are placed in individual plastic bags. Primary packaging ensures the product's integrity until it reaches the next stage. It follows the product from the apparel manufacturing stage through every step of the supply chain until it reaches the user, where it eventually becomes waste.

Secondary Packaging involves grouping primary packaged items into larger containers, such as boxes or crates. This packaging facilitates easier handling and transport, providing additional protection. It often includes further labeling to consolidate information about the batch or shipment. Secondary packaging is typically discarded at local warehouses or offline store warehouses once the products are unpacked.

Tertiary Packaging is used for bulk handling and transportation. This includes pallets and larger shipping containers that hold multiple secondary packages. Tertiary packaging is designed to optimize space and ensure safe long-distance transportation. An important aspect of tertiary packaging is its reusability; pallets and large containers are often returned and reused, promoting sustainability within the supply chain.

In offline channels, we also see the use of handbags for customers. In e-commerce channels, logistics companies often add an additional layer of transport packaging to protect the product during transit. Once the user receives the product and removes it from the transport packaging, this packaging immediately becomes waste.

Regardless of the packaging level or type, most of it ultimately becomes waste. Therefore, waste management becomes a critical issue as products move through various packaging stages. Each stage can generate waste, and effective strategies for reducing, reusing, and recycling packaging materials are essential to minimize environmental impact.

3.2 THE LABEL

3.2.1 TEXTILE LABEL

We are used to seeing a label affixed to a shirt that gives us various information such as composition, how to wash the garment or the origin.
As mentioned in the previous chapters, indicating the place of origin of a product is mandatory, in this section we will see what other information is required to be included in the labels.
In order to sell textile products in the European Union, you must comply with the EU labelling requirements set out in Regulation (EU) no. 1007/2011. All products containing at least 80% by weight of textile fibres and placed on the EU market must be labelled indicating the composition of the fibres used. This label must be firmly affixed to the product.
Therefore, labelling is mandatory in the EU for textile products intended for sale to the final consumer. In the case of inter-company sales, textile labels may be replaced or supplemented by accompanying commercial documents.
This information must always be available during each stage of the business cycle to verify compliance, such as during customs clearance, at the distributor's warehouses and at wholesale or retail outlets.

To go into more detail, the label must specify the composition of the fabric, with the percentages in descending order, present a clear, legible and uniform text, include a clear distinction between the textile composition and other information, such as product maintenance. Furthermore, clothing sold in one or more EU countries must have labels translated into all the official languages of the territories where it will be sold to the consumer.
Only if the product is entirely composed of the same fiber can it be called "100%", "pure" or "all". These terms can also be replaced by the name of the fiber, such as "silk" to indicate a product made of 100% silk. [242]

Textile label [247]

3.2.2 FOOTWAER LABEL

With regard to the labelling of footwear, it is necessary to comply with the directives set out in Directive 94/11/EC. If shoes are to be sold within the EU, the manufacturer must provide the label and ensure that it is correct. If footwear is imported, this is the responsibility of the organisation which places it on the EU market for the first time.
According to European legislation the term "footwear" means all articles with soles designed to protect or cover the foot, if the product falls within this definition then labelling is mandatory in the EU.
When describing the materials and indicating the parts of the footwear, the pictograms in EU legislation or a written indication in the languages of the EU country where the footwear is to be marketed should be used. The label must describe the materials of the three main parts of the footwear: the upper, that is the outer surface of the structural element attached to the outer sole, the lining and the insole, that is the part that constitutes the inside of the footwear and the outer sole, that is the lower surface of the shoe subject to abrasive wear to which it is attached to the upper. The label must indicate the material of which the footwear is made, so whether it is leather, covered leather, fabric or other materials. If no single material constitutes at least 80% of the product, the label must indicate the two main materials used.
The label should be affixed to at least one of the shoes and can be printed, glued, embossed or tied to the shoe. In any case, the label shall be visible, firmly fixed and accessible and the dimensions of the pictograms shall be easily understandable. [243]

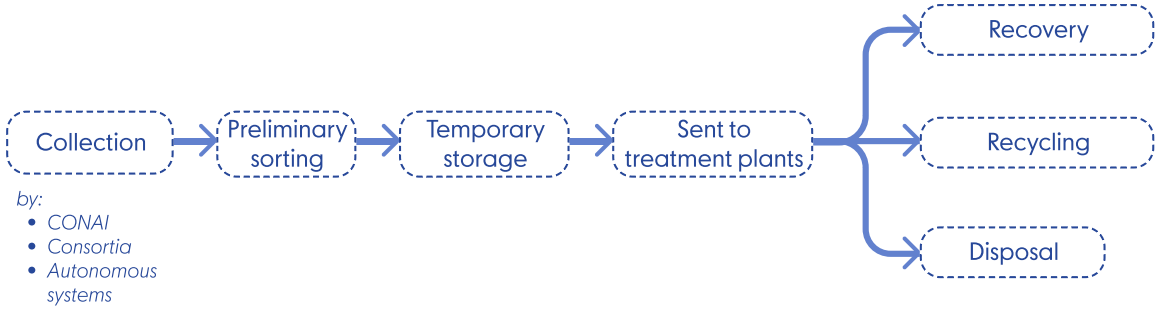
Footware label [248]

3.3 END LIFE OF PACKAGING

As seen in this chapter, all goods are packaged in such a way that they can be transported and presented, and these packages are destined to become waste sooner or later.
The d.lgs. n. 152/2006 defines the refusal of packaging as "qualsiasi sostanza od oggetto di cui il detentore si disfi o abbia l'intenzione o abbai l'obbligo di disfarsi", that is, any object the holder disposes of or has the intention or obligation to dispose of.
Waste can be classified into hazardous and non-hazardous waste according to its hazard characteristics, for example if it is a toxic waste or not. Furthermore, it also differs according to the origin of the waste. They are divided into municipal, special or similar waste.
Municipal waste is that waste deriving from private premises and places and not produced as part of entrepreneurial activities or those having specific characteristics come from or lie on public places or public use. The special waste instead derives from entrepreneurial activities. Similar wastes are like special wastes, as they come from premises and places other than those of civil habitation which, however, are included among the urban ones due to a choice made by the municipalities for practical and economic reasons.
It is also important to understand the people involved in the implementation and management of waste, because depending on the type of legal entity to which you correspond the level of responsibility is different. For this reason, a distinction is made between packaging manufacturers, users, consumers and end users. Packaging manufacturers are suppliers of packaging materials, manufacturers, processors and importers of empty packaging and packaging materials. Packaging users, on the other hand, are traders, distributors, filling agents, users of packaging and importers of full packaging. Consumers are those who, outside the exercise of a professional activity, purchase or import for their own use packagings, articles or packaged goods. Finally, end-users are those who, in the course of a professional activity, purchase, as capital goods, packed items or goods.
Manufacturers and users are responsible for the correct and effective environmental management of packaging and packaging waste generated by the consumption of their products as stated in the European principle of extended producer responsibility (EPR). They must meet the final targets for recycling and recovery of packaging waste. In addition, they are required to pay for the increased charges for the separate collection of packaging waste delivered to the public service and the costs for the collection and re-use of waste from used packaging and collection and, where appropriate, for the collection of disposal of secondary and tertiary packaging waste on private surfaces, and the costs of recycling and recovery of withdrawn or collected packaging waste. It is expressly excluded that the system may entail economic burdens for the consumer. [244] [245] [246]

3.3.1 PROCESS OF WASTE COLLECTION

Once the packaging becomes waste and is thrown into the appropriate bins, the waste management process is triggered. The first step is the collection, then the collection of waste, including the preliminary sorting and storage for the purpose of their transport in a treatment plant. The collection is divided into two types, simple collection and separate collection. In separate collection, the waste stream is kept separate according to the type and nature of the waste in order to facilitate its specific transport. The transport phase is a phase that takes place transversally to all phases as it is the phase that allows the handling of waste between the different sites where they are deposited, stored and/or treated. Next, there is the final phase, waste treatment which includes two different trade, disposal or recovery. Disposal consists of a set of operations aimed at definitively removing packaging or packaging waste from the economic circuit. Recovery concerns a set of operations that use packaging waste to generate secondary raw materials, products or fuels through mechanical, thermal, chemical or biological treatments. Recycling is contained within the recovery operations, that is the process that allows to recover and reuse a material or for their original function or for other purposes. So making that waste usable again. [244] [245] [246]



Waste collection process

3.3.2 WASTE COLLECTION SYSTEMS

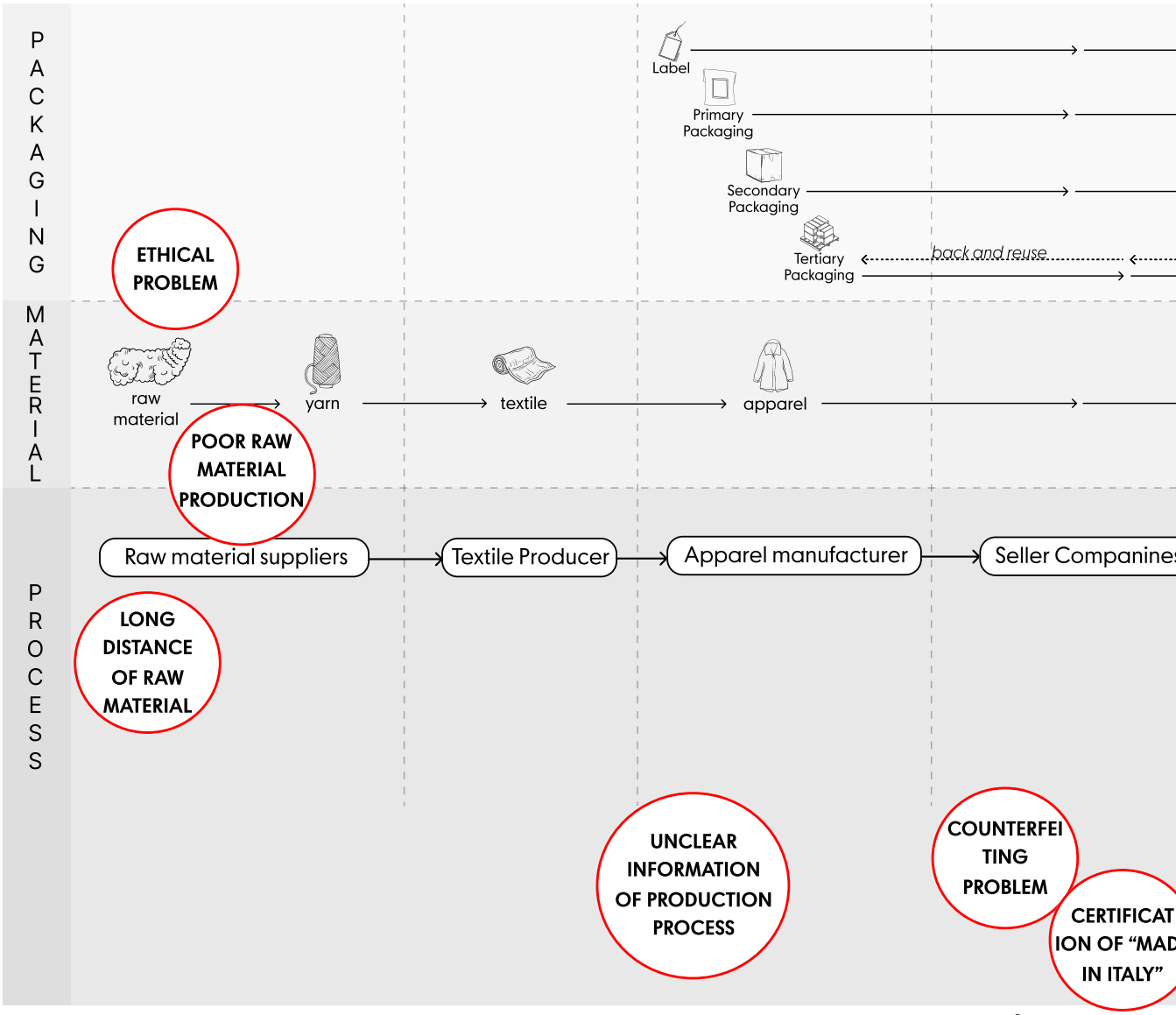
The operation of collection centres, known as ecological islands, that is, special areas manned and set up for the collection activity by separate grouping of municipal waste by homogeneous fractions provided by the holders for transport to recovery and treatment plants. The separate collection of municipal and similar waste is traditionally the subject of municipalities unless this operation is entrusted, following a notice issued by the municipality itself, to externals. However, not every activity of collecting packaging waste must necessarily be carried out by the municipal public administration. In particular, the collection of waste from secondary and tertiary packaging on private land is an activity imposed on packaging producers. Primary packaging waste, which ends up in the hands of consumers, tends to be collected on public land by municipalities, while secondary and tertiary packaging waste, which also derives mainly from industrial and commercial activities, are collected on private surface.

On the Italian territory there are several waste collection systems: the Conai, the industry consortia and autonomous systems. Conai, Consorzio Nazionale Imballaggi, is a consortium with external activities set up not for profit by companies producing packaging other than those that have adopted an autonomous management or refund system. Conai was set up, and the companies participate in it, with the aim of achieving the overall targets for the recovery and recycling of packaging waste, and to ensure the necessary connection with the separate collection of waste on public land carried out by public administrations. The supply chain consortia are consortia are made up of producers of each type of packaging material who have not chosen to operate independently and are the Corepla for plastic, the Cial for aluminum, Recreate for steel, Rilegno for wood, Comieco for paper and cardboard, and Coreve for glass. These consortia operate in the field of recycling and recovery of packaging waste; the recovery of used packaging; the collection of waste from secondary and tertiary packaging on private surfaces; and the collection, on the advice of Conai, packaging waste delivered by the public service. Finally, autonomous systems can operate in two ways, either by managing their packaging waste throughout the country or by setting up a return system for packaging. [244] [245] [246]

DESIGN THE NEW SYSTEM

In this chapter we will discuss the new system. Based on the holystic diagnosis we made in previous chapters to fully understand the current fashion system in Italy and the study of the types of smart packaging, both pillars of our study, In this chapter we will identify the critical points of this system, which are identified as challenges, or aspects that have not been valued that are called possibilities. Then, for each challenge were identified several possible solutions that are called opportunities, by means of case study research to understand what has already been done both at the level of products/ services or what is being studied at the research level to solve these problems. Then, through the selection matrix, a system that allows to estimate the single opportunities in order to understand on which to focus the efforts for the definition of the new system we have selected the opportunities. Once the opportunities were evaluated and skimmed, the new system was defined, which consists of three packages of solutions that concern a system of reuse of clothes, the integration of a QR-Code and the application of blockchain technology to provide information to the user and finally the integration of an RFID Tag in the packaging that allows to reuse the packaging.
Subsequently, the necessary steps for the implementation of these new solutions in the old system were defined, and the positive impacts of these solutions on the new system were evaluated.

4.1 CHALLENGE



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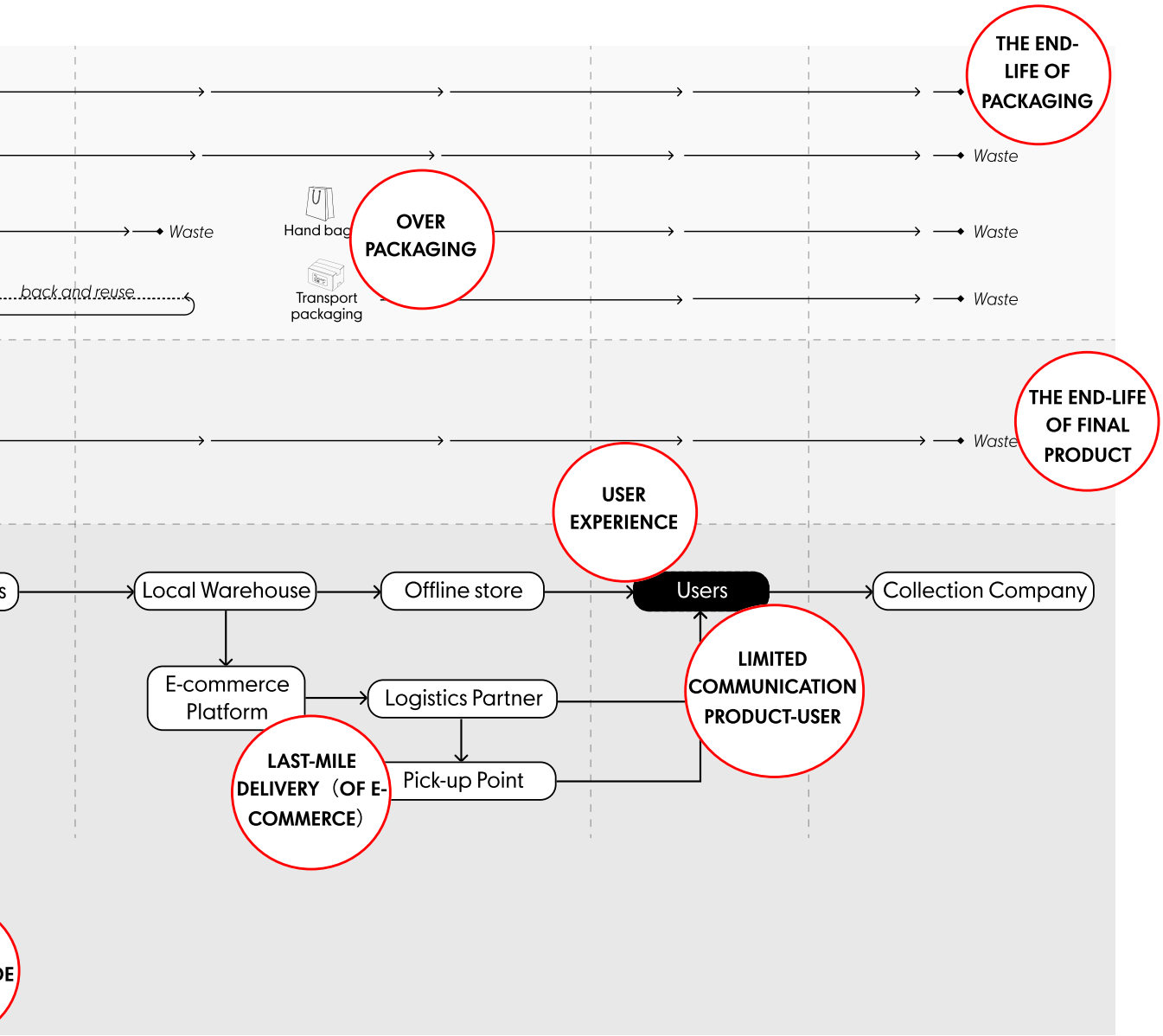


p and challenge

First, this is our summary system, which includes three levels: packaging, materials, and processes. The fashion process starts from raw material suppliers, followed by textile producers, then apparel manufacturers, and seller companies, which can be offline or online. The final step is the collection of the end product by collection companies.

In the subsequent packaging, we can see not only labels/primary packaging but also handbags from offline stores and transport packaging from e-commerce. All these eventually turn into waste.

We have discussed this diagram in detail in the previous third chapter.

4.1.1 THE CHALLENGES

After delving into the supply chain of the fashion industry, we identified several challenges, each marked at the corresponding place in the supply chain. Below is a detailed explanation of each challenge:

Poor Raw Material Production

From the analysis in Chapter 1 on Raw Material Production in Italy and Section 2.9 on the export and import of Italy, it is evident that Italy imports a significant quantity of various raw materials. Research indicates that Italy's local raw material production capacity is limited and insufficient to meet the demands of the textile industry, thereby failing to support Italy's vast fashion manufacturing sector. For instance, the country is heavily dependent on imported cotton. This reliance on imported raw materials adds complexity and uncertainty to the supply chain.

Ethical problem

At the raw material stage, particularly in leather production, ethical issues are especially prominent. Leather production often involves animal welfare concerns, including slaughter conditions and farming environments. Additionally, the leather industry encompasses issues related to workers' conditions and wages, with many workers subjected to poor working environments, long hours, and low pay. These ethical issues need to be addressed through stringent regulations and better enforcement to ensure the ethical and sustainable production process.[249]

Poor Raw Material Production

From Section 2.9 on the export and import of Italy, we can analyze that the majority of manufacturing raw materials for Italy's fashion industry come from outside the country, including some non-EU countries. Since these raw materials need to be transported over long distances to Italy for production, this long-distance transportation results in higher carbon emissions, increased costs, and potential delays. This challenge underscores the importance of local sourcing and production to reduce environmental impact and improve efficiency.

Unclear Information of Production Process

The supply chain is not traceable, particularly concerning the origin of raw materials and the transportation information between different manufacturers. This lack of transparency makes it difficult to monitor each stage of the production process, increasing the challenges in quality control and potentially leading to consumer distrust. Clear and accurate information about how and where products are made is crucial for maintaining brand integrity and consumer confidence.[250]

Counterfeiting Problem

Counterfeiting is a widespread issue in the fashion industry. Fake products not only damage brand reputation but also lead to financial losses and can pose safety risks to consumers.

Certification of "Made in Italy"

The certification of the "Made in Italy" label is crucial for maintaining the prestige of Italian fashion. However, due to a lack of legal provisions and speculative behavior by production companies, many attempt to falsely label their products as "Made in Italy" to enhance their market value. This not only tarnishes the reputation of genuine Italian-made products but also deceives consumers. Ensuring that products genuinely meet the certification standards requires strict supervision and compliance checks. Misuse of this label can undermine its value and mislead consumers.[250]

Limited communication product-user

The information that users receive about the brand and production process of products is limited. Consumers increasingly want to understand the production process and brand background of the products they purchase. Providing clear instructions, product details, and care information can enhance the user experience, ensuring the correct use and longevity of the product.

User experience

User experience includes how consumers interact with and perceive the product and its packaging. Compared to offline purchases, user experience for e-commerce products is even more important, such as the unboxing experience. Poor user experience can lead to dissatisfaction and affect brand loyalty. Ensuring that packaging is user-friendly, informative, and meets consumer expectations is crucial.

Last-mile delivery (of e-commerce)

Dependent on delivery options, it involves transportation costs and environmental issues. Last-mile delivery is one of the most challenging aspects of e-commerce, as it not only relates to cost efficiency but also impacts the environment. Last-mile delivery presents challenges in terms of timely delivery, cost management, and reducing environmental impact. Efficient logistics, optimized routes, and sustainable practices are crucial for overcoming these challenges.

The end-life of final product

Similar to packaging, the disposal of the final product is also a critical issue. Particularly in the fast fashion industry, products that are no longer used by consumers quickly become waste. This rapid turnover not only leads to significant environmental pollution but also represents a loss of valuable

resources. Many of these discarded products still have potential value for other uses.

Over packaging

Over packaging is a common issue that leads to increased waste and environmental impact. Reducing the amount of packaging without compromising product protection is crucial for sustainability. Additionally, the growth of the e-commerce industry has led to a rise in the consumption of packaging materials, as shipping packaging is often used solely to protect products without serving any other function. Over packaging not only wastes resources but also adds to the environmental burden.

The end-life of packaging

We find that regardless of the level of packaging, it ultimately becomes waste. Packaging materials are usually discarded after they have served their protective function, causing environmental pollution. Managing the disposal and recycling of packaging materials is a significant challenge. Implementing sustainable packaging solutions and promoting recycling and reuse are crucial to minimizing the impact.

4.1.2 CRITICALITIES AND POTENTIAL DESCRIPTION

To further analyze each challenge and what actions can be taken, we categorize each challenge into Criticalities and Potentials.

The term "challenge" includes two different categories of instances that can be specifically detected in the system: criticalities, which refer to current model problems and issues, and potentials, which are the assets and features of the system that are either developed or undeveloped.[252]

Poor Raw Material Production

Criticalities (C)

- Italy Produces Insufficient Raw Materials to Meet Domestic Demand: Limited local production capacity is unable to support the industry's needs.

Potentials (P)

- Ancient Know-How of Raw Material Production: Leveraging Italy's traditional expertise in raw material production can improve quality and efficiency.

Ethical problem

Criticalities (C)

- Related to Leather Production: Involves issues of animal exploitation, poor working conditions, and environmental pollution.

Potentials (P)

- Replacing Animal Leather with Alternatives: Using synthetic or plant-based materials can reduce animal leather waste and improve sustainability.

Poor Raw Material Production

Criticalities (C)

- Most of Raw Materials Come from Outside Italy: Reliance on imported raw materials increases transportation costs, carbon emissions, and the complexity of the supply chain.

Unclear Information of Production Process

Criticalities (C)

- Untraceable Supply Chain: Lack of transparency regarding the origin of raw materials and transportation information between different manufacturers increases the difficulty of quality control and leads to a crisis of trust.

Counterfeiting Problem

Criticalities (C)

- Widespread in the Fashion Industry: Counterfeit products not only damage brand reputation but also lead to financial losses and pose safety risks to consumers.

User experience

Potentials (P)

- Enhancing E-commerce Product User Experience: Improving aspects such as the unboxing experience can significantly boost customer satisfaction and loyalty.

Certification of "Made in Italy"

Criticalities (C)

- Lack of Legal Provisions: There are insufficient legal regulations to prevent the misuse of the "Made in Italy" label.
- Speculation by Production Companies: Some companies falsely claim their products are made in Italy to enhance market value, thereby tarnishing the reputation of genuine Italian products.

Potentials (P)

- Increased Recognition of "Made in Italy": Strengthening the "Made in Italy" certification can enhance global recognition and demand for authentic Italian products.

Last-mile delivery (of e-commerce)

Criticalities (C)

- Dependent on Delivery Options, Involving Transportation Costs and Environmental Issues: Last-mile delivery presents challenges in terms of cost efficiency and environmental impact.

The end-life of final product

riticalities (C)

- Products Become Waste When No Longer Used: In the fast fashion industry, discarded products impact the environment, but these items still hold potential value for other uses.

Limited communication product-user

Criticalities (C)

- Limited Information About Brand and Production Process: Consumers increasingly want to understand the production process and brand background of the products they purchase.

Over packaging

Criticalities (C)

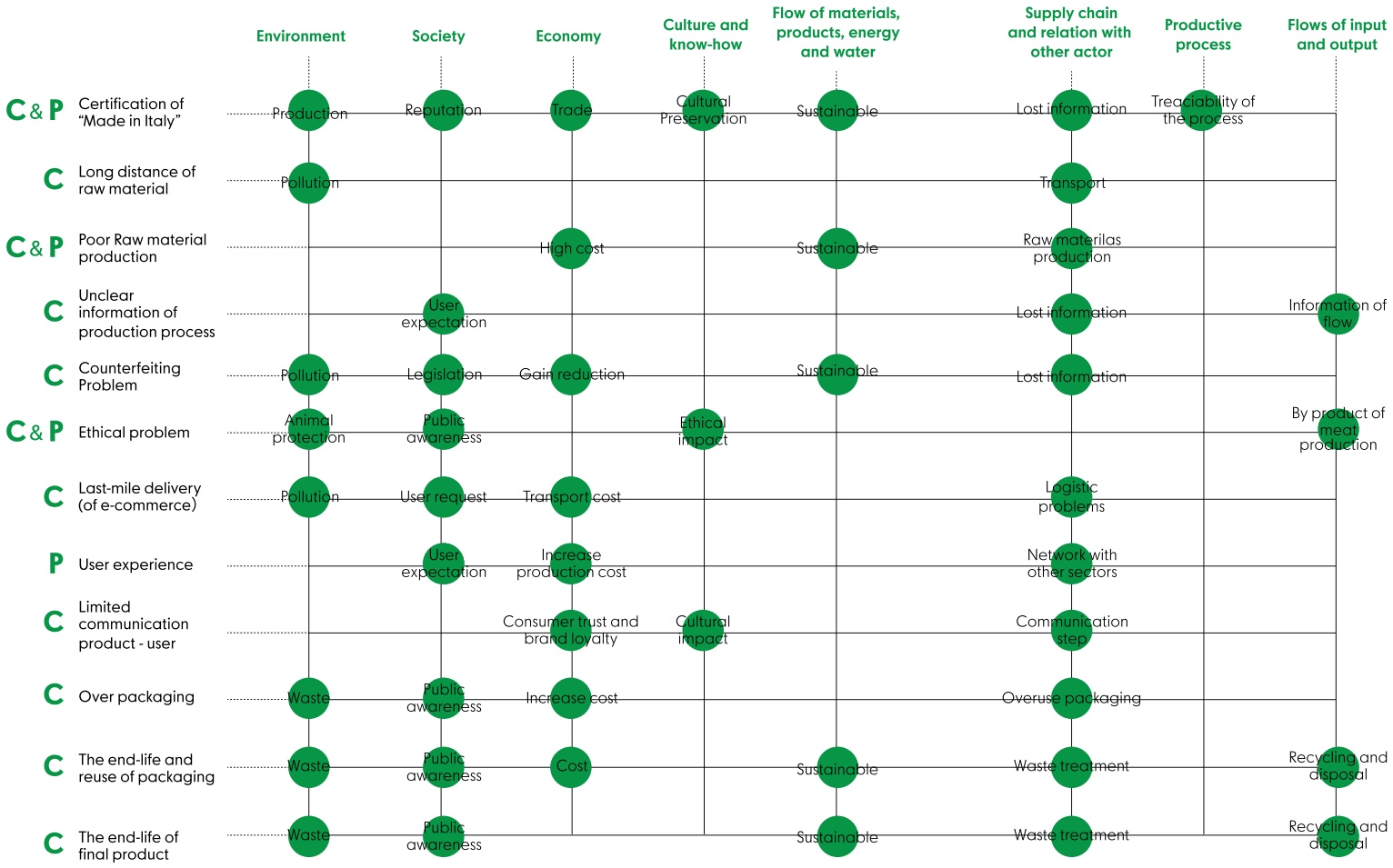
- Growth of the Courier Industry Leading to Increased Consumption of Packaging Materials: Overpackaging is often used solely for product protection, resulting in resource waste and environmental burden.

The end-life of packaging

Criticalities (C)

- Packaging Ultimately Becomes Waste: Regardless of the level of packaging, it eventually turns into waste, necessitating better disposal and recycling solutions.

4.1.3 CHALLENGES IN DIFFERENT ASPECTS



The Influence of Challenge in different Aspects

This chart illustrates the relationship of each challenge (marked as C for Criticalities and P for Potentials) across different aspects in the fashion industry. The main aspects covered in the chart include environment, society, economy, culture and know-how, flow of materials, products, energy and water, supply chain and relations with other actors, productive processes, and flows of input and output.

The first challenge is the certification of "Made in Italy." Criticalities include insufficient legal regulations and speculative behavior by companies, causing environmental pollution and harming brand reputation and trade. Potentials include enhancing global recognition of authentic Italian products and promoting cultural preservation and sustainability.

Long-distance transportation of raw materials results in increased costs, carbon emissions, and supply chain complexity. Environmental pollution from transportation and information loss within the supply chain are significant challenges.

Poor raw material production increases costs and fails to meet domestic demand. However, leveraging Italy's traditional expertise can improve production quality and efficiency, aiding cultural preservation and sustainability.

Unclear information about the production process leads to a lack of transparency, making quality control difficult and causing consumer distrust.

Counterfeiting damages brand reputation, leads to financial losses, and poses safety risks. This also causes environmental pollution and legal challenges, reducing legitimate business profits.

Ethical problems in leather production involve animal exploitation, poor working conditions, and environmental issues. Using synthetic or plant-based materials can reduce waste and improve sustainability.

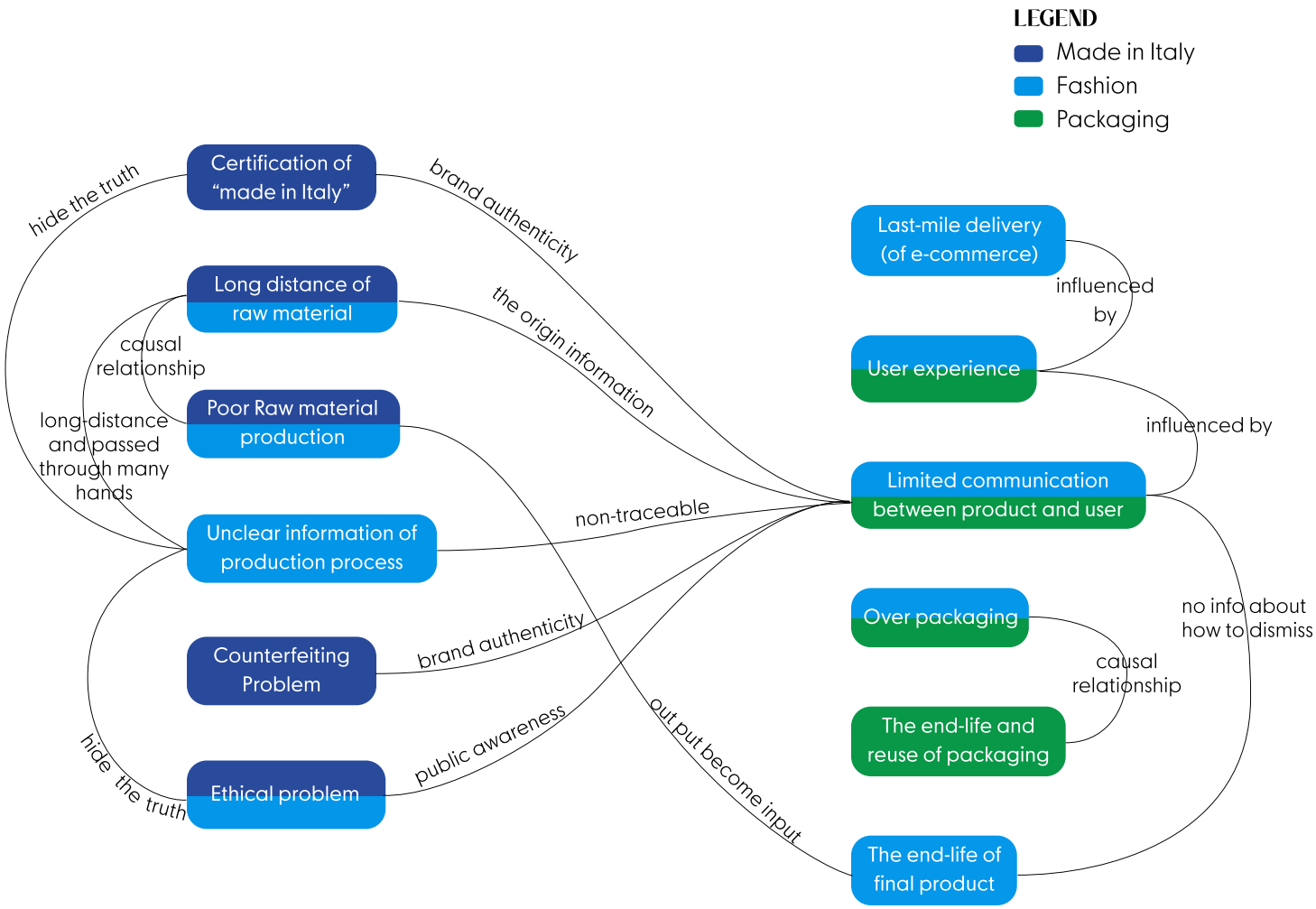
Last-mile delivery in e-commerce is challenging due to its impact on cost efficiency and the environment. Pollution and logistical problems affect the supply chain, but enhancing user experience can improve customer satisfaction and loyalty.

The end-of-life of packaging results in waste, causing environmental pollution. Over packaging wastes resources and increases the environmental burden. Promoting sustainable packaging solutions is crucial.

The end-of-life of final products in fast fashion leads to waste, but these products still hold potential value for other uses. Recycling and reuse can reduce environmental impact and extend product lifecycles.

This chart highlights the complex issues faced by the fashion industry while also showcasing potential solutions and directions for improvement across different aspects.

4.1.4 RELATION BETWEEN CHALLENGES



Relation Between Challenges

To further analyze the challenges, we have categorized them into those related to "Made in Italy," "Fashion," and "Packaging." Then, we examined the relationships between each challenge. As shown in the diagram, each challenge does not exist independently; they are directly or indirectly connected to other challenges.

The certification of "Made in Italy" is closely related to brand authenticity and the information about the origin of raw materials. This means that if the source information of raw materials in the supply chain is unclear, the credibility of the certification will be questioned. This lack of transparency can hide the truth and further weaken consumer trust in the brand.

There is a causal relationship between the long-distance transportation of raw materials and poor raw material production. Since most raw materials need to be transported long distances from outside Italy, this not only increases transportation costs and carbon

emissions but also leads to decreased supply chain complexity and transparency. Long-distance transportation through multiple hands can easily result in loss of information and decline in quality, which is related to the challenge of unclear production process information.

Unclear production process information also directly affects brand authenticity and consumer trust. When the production process is not traceable, consumers find it difficult to obtain reliable information about product manufacturing.

Counterfeiting problems are closely related to brand authenticity and public awareness. Counterfeit products usually do not provide much information about the product content. Limited product information makes it more difficult to expose the truth of counterfeit behavior.

Ethical issues, especially in leather production involving animal exploitation, poor working conditions, and environmental pollution, are closely related to public awareness. Lack of transparency can exacerbate various production problems. Additionally, limited product information makes it difficult for users to judge and make them aware of the ethical issues when purchasing.

Last-mile delivery in e-commerce is mainly related to user experience. Efficient delivery services can significantly improve user satisfaction but also increase transportation costs and environmental burden.

User experience is also related to limited communication between product and user. Consumers want to know more about the brand and product information, not just a simple purchase.

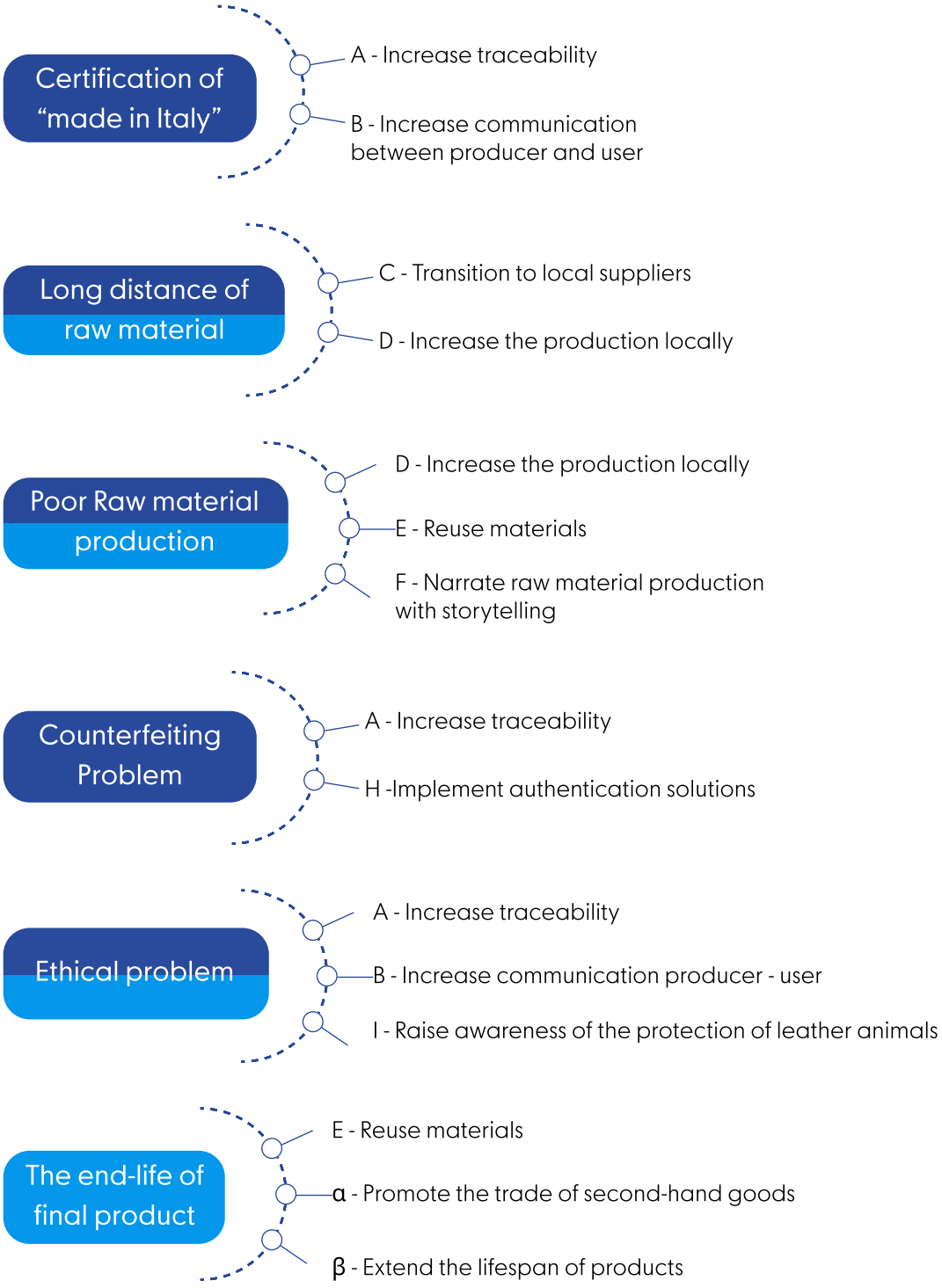
Over packaging is a serious issue in the courier and e-commerce industry. Excessive packaging materials are often used only to protect the product but ultimately become waste, adding to the environmental burden. This is also related to the end-of-life and recycling issues of packaging. Regardless of the level of packaging, it eventually becomes waste and requires better recycling and disposal solutions.

The end-of-life of final products is particularly prominent in the fast fashion industry. Products that consumers no longer use become waste, causing environmental pollution, but these products still have potential for other uses. Limited information can lead to people not knowing how to recycle or dispose of these unused garments properly. On one hand, people discard clothes that still have potential for other uses; on the other hand, raw materials for making clothes face shortages, creating a vicious cycle.

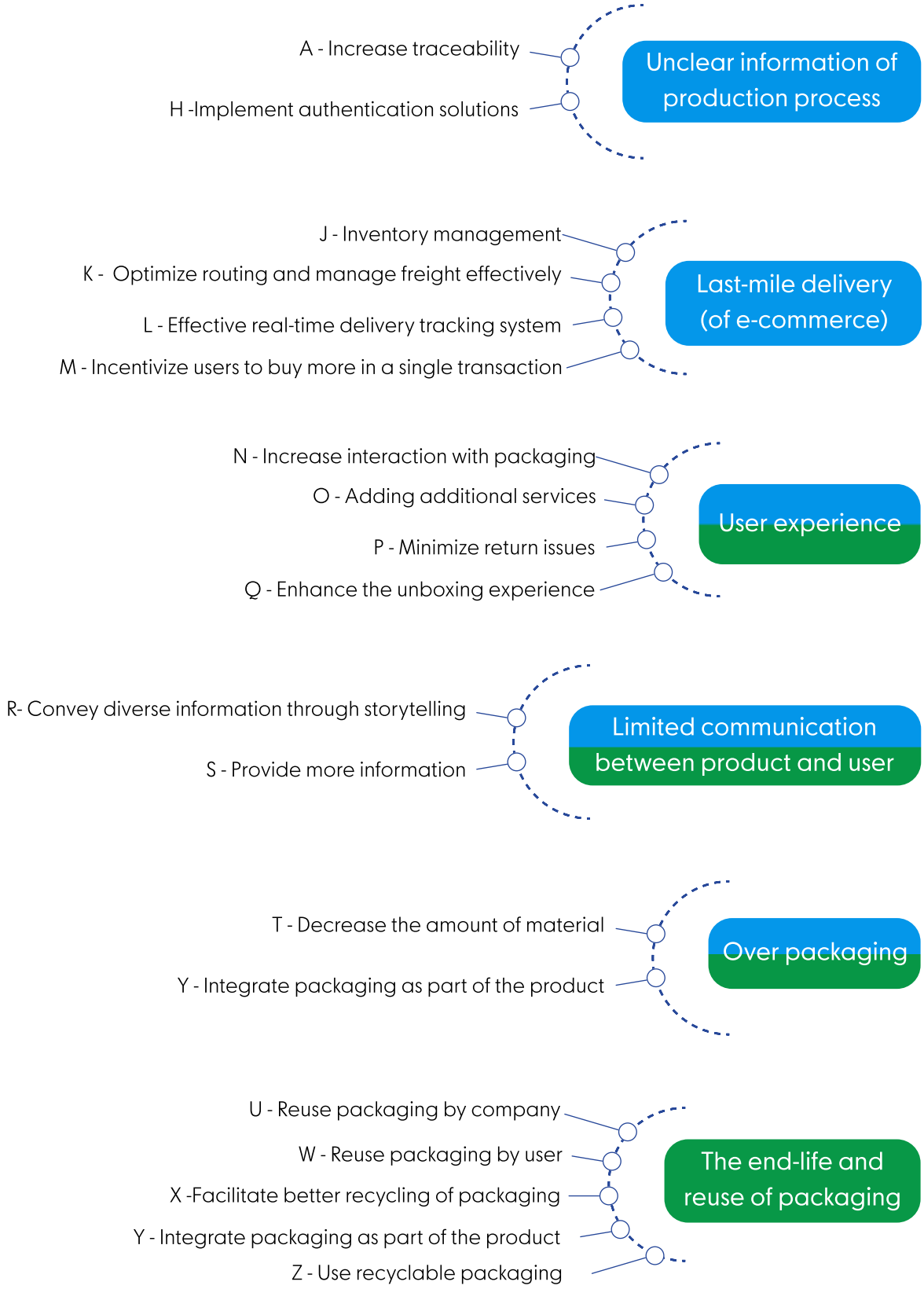
In summary, each challenge illustrated in the chart is interconnected through a complex network, revealing the multi-layered problems and potential solutions in the fashion industry. By systematically analyzing these relationships, we can better understand the root causes and impacts of each challenge, thereby formulating more effective solutions.

4.2 OPPORTUNITIES

4.2.1 OPPORTUNITIES OF EACH CHALLENGES



Opportunities of Each Challenges



Opportunities of Each Challenges

In the following chapters, we will delve into detailed discussions of each challenge along with their corresponding solutions and opportunities. Through these in-depth analyses, we aim to provide practical strategies for the fashion industry, assisting stakeholders both within and outside the industry in addressing these challenges and promoting sustainable development.

A - Increase Traceability

By enhancing traceability in the supply chain, companies can ensure the authenticity of products labeled as "Made in Italy." Implementing technologies such as blockchain can provide transparent and immutable records of each production stage, strengthening consumer confidence in the product's origin and authenticity. This helps to build trust and support brand integrity. For example, using blockchain technology to document each production step, from raw material procurement to final product delivery, ensures that every stage is traceable and verifiable. This transparency not only combats counterfeit products but also improves the efficiency and security of the entire supply chain.

B - Increase communication between producer and user

Between Producer and User
Enhancing communication between producers and consumers bridges the information gap regarding product origins and manufacturing processes. Detailed product descriptions, origin certificates, and storytelling about the craftsmanship involved can facilitate transparent communication. For instance, brands can provide comprehensive production process descriptions and craft videos on product labels or websites, showcasing each step's details and the producers' stories. This approach fosters consumer trust and brand loyalty, giving consumers a deeper understanding and emotional connection to the product.

C - Transition to local suppliers

Transitioning to local suppliers reduces transportation costs and carbon emissions while supporting the local economy. It also simplifies the supply chain, making it more resilient and easier to manage. Local sourcing can lead to faster turnaround times and better quality control. For example, a fashion brand could partner with local cotton farmers, reducing reliance on imported raw materials, thereby cutting transportation distances and associated environmental impacts. Additionally, local supply chains are easier to monitor and manage, enhancing overall production quality and efficiency.

D - Increase the production locally

Boosting local raw material production capabilities meets domestic demand and reduces reliance on imports. Investing in local agriculture and

manufacturing can create jobs and stimulate economic growth. It also ensures a steady supply of raw materials, mitigating risks associated with long-distance transportation. For example, through government and corporate partnerships, establishing local raw material production bases can ensure supply chain stability and sustainability. This reduces dependency on imported raw materials and enhances local economic vitality.

E - Reuse Materials

Reusing materials in the production process reduces waste and the need for new raw materials. This sustainable practice lowers production costs and lessens the environmental impact while addressing ethical concerns about waste and environmental degradation. For instance, fashion brands can adopt recycled fabrics, using fibers from recycled plastic bottles or old garments to create new products. This approach supports sustainable development and responsible consumption by reducing the depletion of natural resources and minimizing production waste.

F - Narrate raw material production with storytelling

By narrating the story of raw material production, companies can increase product value and establish an emotional connection with consumers. Sharing the journey from raw material to finished product, including the craftsmanship and traditions involved, can create a unique selling proposition. For instance, a fashion brand can tell the story of how their cotton is grown, harvested, and spun into fabric by local artisans. This approach not only adds value to the product but also builds a deeper bond with consumers who appreciate the heritage and effort behind the product.

H - Implement authentication solutions

Authentication solutions, such as tamper-evident packaging, holograms, or digital verification methods, can ensure the accuracy and traceability of production information. These measures help verify product authenticity and protect brands and consumers from counterfeit products. For example, using blockchain technology to provide verifiable records of the production process can enhance trust and security. These solutions can be integrated into packaging or provided as part of a digital authentication system, allowing consumers to easily verify the authenticity of their purchases.

I - Raise awareness of the protection of leather animals

Educating consumers about the importance of animal welfare in leather production can drive demand for ethically produced leather. Campaigns and certifications highlighting humane practices can encourage industry-wide changes. For instance, a brand can launch an awareness campaign showcasing their commitment to ethical

leather production, explaining how they ensure the well-being of animals throughout the process. This can involve partnering with animal welfare organizations and obtaining certifications that validate humane practices.

J - Inventory management

Optimizing inventory management can streamline last-mile delivery, ensuring timely product supply and reducing delays. Efficient inventory systems can more accurately match supply with demand, minimizing stockouts and overstock situations. For example, implementing a robust inventory management system can help a company maintain optimal stock levels, reducing the likelihood of delays in fulfilling orders and improving overall customer satisfaction.

K - Optimize routing and manage freight effectively

Optimizing delivery routes and freight management can reduce transportation costs and environmental impact. Advanced logistics can help plan the most efficient routes, minimizing delivery times and fuel consumption. For instance, a company can use route optimization tools to ensure that delivery vehicles take the shortest and fastest paths, reducing travel distance and associated emissions. Effective freight management also involves shipments and using energy-efficient transportation methods.

L - Effective real-time delivery tracking system

Real-time tracking systems provide transparency, allowing consumers to monitor their deliveries. This enhances the delivery experience and reduces anxiety about delivery times. For example, integrating a real-time tracking system into the delivery process enables customers to see the status and location of their orders at any time. This not only improves customer satisfaction but also allows companies to address any issues promptly, ensuring a smoother delivery process.

M - Incentivize users to buy more in a single transaction

Encouraging consumers to consolidate their purchases into fewer transactions can reduce the frequency and cost of deliveries. For example, offering discounts or free shipping for larger orders can motivate customers to buy more at once. This approach not only lowers transportation costs and environmental impact but also enhances the overall efficiency of the supply chain. Additionally, bulk purchasing incentives can lead to increased customer satisfaction by providing more value for their money.

N - Increase interaction with packaging

Enhancing the interaction between users and packaging can improve the unboxing experience. This includes

designing packaging that is easy to open, reusable, or offers additional functionality. For instance, packaging with interactive elements such as QR codes that lead to exclusive content or augmented reality experiences can engage consumers more deeply. Reusable packaging that can be repurposed for other uses adds value and promotes sustainability.

O - Adding additional services

Providing additional services can elevate the overall user experience and product value. For example, offering personalized packaging or gift wrapping can make the purchase more special and memorable. Additionally, providing services like clothing repair or alteration can significantly enhance user satisfaction. For instance, a retailer could include a small sewing kit with clothing purchases or offer free minor repairs and alterations. These services add value to the product, promote its longevity, and encourage sustainable consumption by extending the lifespan of the items.

P - Minimize return issues

Improving product descriptions, size guides, and quality control can reduce return rates. Clear and accurate product information helps consumers make better purchasing decisions, leading to higher satisfaction and fewer returns. Implementing robust quality checks ensures that products meet consumer expectations, which in turn reduces the logistical and environmental costs associated with returns.

Q - Enhance the unboxing experience

A memorable unboxing experience can leave a lasting impression on customers. Thoughtful packaging design and presentation can enhance brand perception and customer loyalty. For instance, using high-quality materials, including personalized thank-you notes, or creating a visually appealing unboxing sequence can significantly improve the customer experience.

R- Convey diverse information through storytelling

Through Storytelling: Using storytelling to convey information about the product and brand can create a deeper connection with consumers. This can include sharing the brand's history, the production process, and the stories of the people behind the product. For example, a brand can use its packaging or website to tell the story of how the product was made, highlighting the craftsmanship and care involved. This approach helps build a narrative that consumers can connect with emotionally.

S - Provide more information

Offering detailed information about the product and brand, including

usage instructions, care tips, and the story behind the product, can help consumers make informed decisions and build trust in the brand. Clear and comprehensive product information can be provided through various channels such as packaging, manuals, and online resources. This transparency enhances the consumer experience by ensuring they have all the information needed to use and maintain the product properly.

T - Decrease the amount of material

Reduce the Amount of Material
Reducing the amount of packaging material used can lower environmental burden and production costs. This can be achieved through smarter design and more efficient packaging solutions. For example, companies can use minimalist designs that require fewer materials or develop innovative packaging that offers protection with less bulk. Implementing lightweight and compact packaging not only conserves resources but also reduces shipping costs and carbon emissions.

U - Reuse packaging by company

Encouraging companies to reuse packaging materials within their operations can reduce waste and resource consumption. This can involve implementing a return program where packaging is collected, cleaned, and reused. Such practices can significantly decrease the need for new packaging materials and lower the overall environmental impact. For instance, a company can collect used boxes and packing materials from customers and reuse them for future shipments.

W - Reuse packaging by user

Promoting the reuse of packaging by consumers can extend the lifecycle of packaging materials and reduce environmental impact. For example, designing sturdy and versatile packaging that can be repurposed by consumers for storage or other uses can encourage them to keep and reuse the packaging. Providing ideas and instructions for reusing packaging can also motivate consumers to incorporate these practices into their daily lives.

X - Facilitate better recycling of packaging

Improving recycling facilities and processes can ensure that packaging materials are effectively recycled, reducing waste and supporting sustainability. Clear recycling instructions on the packaging can help consumers dispose of materials correctly. Additionally, companies can collaborate with recycling programs to enhance the efficiency and effectiveness of recycling efforts. Using recyclable materials and ensuring that packaging is easily separable into recyclable components can further support these initiatives.
The End-Life and Reuse of Packaging

Y - Integrate packaging as part of the product

Designing packaging to be an integral part of the product can eliminate unnecessary materials. For example, creating a packaging box that can transform into a stand for the product during its use serves dual purposes. This approach not only reduces waste but also adds value to the product by providing an additional functional item. Packaging that doubles as a product accessory, such as a stand for a tablet or phone, can enhance the user experience and promote sustainability. By repurposing the packaging, consumers can continue to use it in their daily lives, thereby extending its lifecycle and reducing environmental impact.

Z - Use recyclable packaging

Using materials that are easily recyclable can minimize environmental impact. Providing clear recycling instructions can help ensure that packaging is disposed of correctly. For instance, using biodegradable materials or materials that can be recycled in common recycling facilities makes it easier for consumers to participate in recycling efforts. This not only reduces the environmental footprint of the packaging but also supports broader sustainability goals by promoting responsible consumption and waste management practices.

α - Promote the trade of second-hand goods

Encouraging the resale and reuse of products can extend their lifecycle and reduce waste. Second-hand goods trading platforms can facilitate this process, promoting a circular economy. For example, online marketplaces and apps allow consumers to buy and sell used products easily. This not only keeps products in use longer but also reduces the demand for new goods, thereby conserving resources and minimizing environmental impact.

β - Extend the lifespan of products

Designing durable and easily repairable products can significantly extend their lifespan. Providing maintenance services and encouraging consumers to repair rather than replace items can greatly reduce waste. For instance, companies can offer repair kits, warranty services, and tutorials to help customers fix their products. By focusing on product durability and repairability, brands can foster a culture of sustainability. This approach not only benefits the environment by reducing waste but also builds customer loyalty by providing long-term value.

4.2.2 CASE STUDIES

For each opportunity presented in the previous section, case studies were sought that could satisfy the opportunities. For each of them has been reported an identification code that is based on the reference opportunity, that is for which of them it has been searched. Also, since a case study more be relevant also to other opportunities were reported colored circles containing a letter. The letter refers to opportunities, as indicated in the previous section. The color of the circle, on the other hand, indicates on what, the case study acts, that is if on the packaging (yellow), on the product (orange) or on the system (red). Finally, a brief description of the case study is given.

[A1] Colore Code

A - Increase traceability

Reference opportunities: A H

Keywords: QR code, Packaging

The app allows the user to verify the authenticity of the product they purchase. Through the scanning of the COLOR CODE the end user accesses the information related to the production batch, expiration date, manufacturer date and place of production. [253]

[A2] Tracciabilità, Certificazione ed Anticontraffazione dei prodotti Made in Italy

A - Increase traceability

Reference opportunities: A H

Keywords: Digital ID, NFC Tag, Packaging

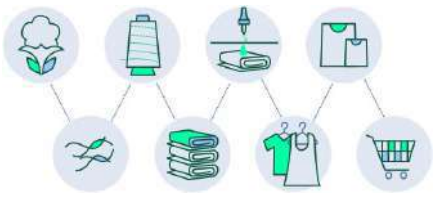
Project carried out by four Venetian universities to create a new tag that allows to track fashion products. [254]

[A3] TextileGenesis™

A - Increase traceability

Reference opportunities: A H

Keywords: Traceability Platform



TextileGenesis™ system creates transparency from fiber-to-retail, and ensures authenticity and provenance of sustainable textiles against generics. [255]

[A4] Furmark®

A - Increase traceability

Reference opportunities: A I H

Keywords: QR code, Label

International traceable, verified and guaranteed labelling system for natural fur. [256]

[A5] Moose Knuckles platform

A - Increase traceability

Reference opportunities: A B R S H

Keywords: Digital ID, NFC and RFID Tag, Digital ID

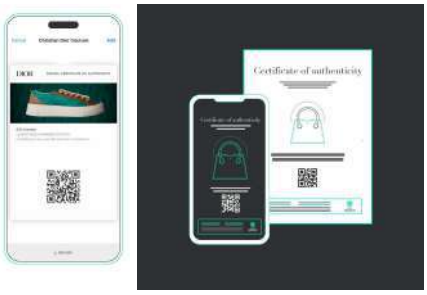
Moose Knuckles embedding r-pac's TWINTAG NFC/RFID tags into garments. The tag provides unique individual component ID's for materials traceability and advanced security and encryption for every individual item, enabling supply chain visibility from farm to manufacture to the consumer. [257]

[A6] Aura Blockchain Consortium

A - Increase traceability

Reference opportunities: A H

Keywords: Blockchain, Digital ID, QR Code



Aura Blockchain Consortium is a non-profit organization offering blockchain agnostic solutions, such as Digital Product Passport and a Digital Collectibles, exclusively to luxury brands. [258]

[A7] TRICK project

A - Increase traceability

Reference opportunities: A

Keywords: Traceability Platform

It is a platform for the traceability of fashion products Made in Italy. The project involves ENEA, 31 companies, associations, non-profit organizations and research centers of 11 countries, funded under the Horizon 2020 framework programme, is coordinated by the Lanificio Fratelli Piacenza Spa. [259]

[A8] Cambio Coffee

A - Increase traceability

Reference opportunities: A

Keywords: QR Code, Packaging, Blockchain

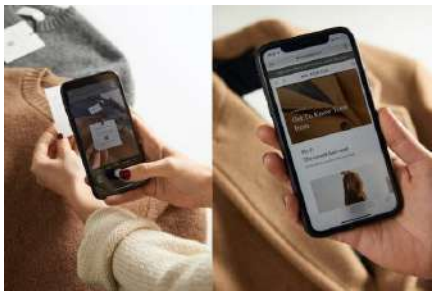
Cambio Coffee implemented ScanTrust's unique QR codes on their packs in May 2018. Currently, the roaster and the delivery company enter data onto the blockchain. The plan is to roll out the feature to the shipping company and eventually the farmers, to cover the whole supply chain. In the future, the two companies want to expand to other blockchain-supported initiatives, like "Tip your farmer". [260]

[B1] Ynap Digital ID for garment

B - Increase communication producer-user

Reference opportunities: B A H

Keywords: Digital ID, QR Code, Label



A digital ID card to trace the history of a garment by scanning the QR code sewn inside the garments. Customers will have access to various information such as the origin and design of the garment, instructions for its maintenance and style tips. [261]

[B2] Tony's Chocolonely

B - Increase communication producer-user

Reference opportunities: B F I

Keywords: Storytelling, Awareness, Packaging

Tony's Chocolonely chocolate uses pachaging and the product itself to communicate their commitment to sustainability and to denounce the exploitation of cocoa bean growers. The aim is to raise consumer awareness of the problems related to the chocolate supply chain. [262]

[B3] Farmison & Co Label

B - Increase communication producer-user

Reference opportunities: B

Keywords: QR Code, Packaging, Advices for consumer

Meat manufacturer Farmison & Co has embedded a QR code on its packaging, which can be scanned with your smartphone. This reveals more information about your product, see the farm through a video, find information about the breed and food miles and download recipes written by Jeff Baker, a famous English chef, specifically for that cut. [263]

[D1] Apulia Regenerative Cotton Project by Giorgio Armani

D - Increase the production locally

Reference opportunities: D

Keywords: Reintroduction of cultivation, Collaboration brannd-producer

Apulia Regenerative Cotton Project by Giorgio Armani and Fashion Task Force of the Sustainable Markets Initiative founded by King Carlo III to introduced cotton conversion in Puglia in 2023. [264]

[D2] San Floro agricultural cooperative - Gucci agreement

D - Increase the production locally

Reference opportunities: D

Keywords: Reintroduction of cultivation, Collaboration brannd-producer

The agricultural cooperative of San Floro in Calabria has signed an agreement with the fashion house Gucci for the production of silk in 2023. [265]

[E1] Recycled wool in Prato

E - Reuse materials

Reference opportunities: E

Keywords: Circular Economy, Waste become Input

Textile District of Prato historically works to give a second life to rags and textile waste by mechanically transforming them into regenerated wool, new recycled yarns and fabrics of the highest quality for haute couture. [266]

[E2] Zara trade-in

E - Reuse materials

Reference opportunities: E β

Keywords: Repair of garments, collection of used also in e-commerce way

Zara provides a garment repair, used clothing collection and resale system. The collection of the garments (of whichbrand) takes place in the store but in Spain this service has been launched also related to e-comerce, on the delivery of a garment it is possible to deliver the used garments to the courier. [267]

[E3] Calzedonia Group trade-in

E - Reuse materials

Reference opportunities: E α β

Keywords: Collection of used, Reward in discounts, Circular Economy

Collection system in store by the Calzedonia Group of any type of clothing and any brand since 2011. The garments in good condition are resold, while those not recoverable are transformed into new yarns to make new garments. [268]

[E4] H&M Garment Collecting Program

E - Reuse materials

Reference opportunities: E α β

Keywords: Collection of used, Reward in discounts, Circular Economy, Clothing rental

H&M store collection system of any type of garment and any brand since 2013. Items in good condition are resold, while non-recoverable items are reused in the Concius collection or recycled. In 2019 they launched a rental service in one of their stores in Stockholm, where you can rent for short periods selected outfits from the collection Conscious Exclusive. [269]

[E5] Patagonia: Worn Wear

E - Reuse materials

Reference opportunities: E β

Keywords: Repair of garments, DIY video tutorial, Sustainability awareness

Patagonia provides a repair service for garments to extend their useful life, as well as providing tutorials on their site to repair their own garments. [270]

[E6] The North Face: Tack back

E - Reuse materials

Reference opportunities: E

Keywords: Collection of used, Reward in discounts, Circular Economy

Collection system in store by North Face of any type of clothing and any brand. Only members can participate in the initiative, receiving in return a voucher. [271]

[E7] Ecovia

E - Reuse materials

Reference opportunities: E

Keywords: Recycling, Clothes become pack

Ecovia, established in 2020, is a clean-tech startup leading the way in compostable packaging, turning clothing waste into compostable bag. [272]

[G1] Sustainability certifications

G - Obtain sustainability certifications

Reference opportunities: G

Keywords: Certification

Set of textile and clothing certifications. [273]

[H1] Watch Certificate

H -Implement authentication solutions

Reference opportunities: H

Keywords: Blockchain, Digital ID

This digital passport authenticates, certifies and insures all watches thanks to the blockchain platform. [274]

[H2] Sneakers authenticity guarantee

H -Implement authentication solutions

Reference opportunities: H

Keywords: NFC Tag, E-commerce

eBay launchs his new Authenticity Guarantee program, guaranteeing a buying and a selling of sneakers safer. eBay offering proof of authentication by using NFC-enabled tag for selected footwear in partnership with Sneaker Con as its third-party authenticator, adding a key level of security to the buying process. [275]

[H3] Delage bag

H -Implement authentication solutions

Reference opportunities: H

Keywords: NFC Tag, Digital ID

Each bag will have a unique chip and a unique digital serial number. Consumers with an NFC smartphone equipped with Selinko's free mobile app will be able to use the tag to access information about their product and confirm its authenticity as well as access marketing offers. [276]

[I1] Reveal Impact

I - Raise awareness of the protection of leather animals

Reference opportunities: I R

Keywords: Storytelling by immage, Thermochromic Inks

Reveal Impact use a thermochromic ink printed on aluminium cans. This solution for aluminium cans uses two different thermochromic inks, which both have the same colour when cooled down. Once the can gets warmer, one colour disappears quicker than the other revealing a hidden message that inform the consumer about the impact on the planet. [277]

[I2] Wineleather

I - Raise awareness of the protection of leather animals

Reference opportunities: I

Keywords: Alternative material, Circular Economy

Natural, sustainable and cruelty-free. Wineleather is an all-Italian vegetable leather made from waste produced during winemaking. [278]

[I3] Ohoskin

I - Raise awareness of the protection of leather animals

Reference opportunities: I

Keywords: Alternative material, Circular Economy

Ohoskin is an organic textile material coated with Sicilian orange and cactus. It has the feeling of high quality animal skin but is vegan and 100% vegetable and not fossil. [279]

[I4] Box Water is Better

I - Raise awareness of the protection of leather animals

Reference opportunities: I

Keywords: Storytelling by text, Packaging as manifesto

Boxed Water is Better uses the surface of its packaging as a poster to sensitize the consumer to a more conscious consumption. Emphasize this message by employing a minimalist style. [280]

[J1] Amazon Robot

J - Inventory management

Reference opportunities: J

Keywords: Automation

Amazon has introduced within its warehouses robots able to manage orders independently so as to improve and speed up the management and organization of orders . [281]

[J2] Tally 3.0

J - Inventory management

Reference opportunities: J

Keywords: Computer vision, RFID

With both computer vision (CV) and RFID/Digimarc capabilities combined, Tally's sensing system is able to seamlessly scan and track products in diverse retail environments. [282]

[J3] ShockWatch 2 Impact Indicators

J - Inventory management

Reference opportunities: J

Keywords: Impact indicator, Unique identifier to traceability

ShockWatch® 2 impact indicators are single-use, go/no-go devices that determine if fragile products have been dropped during transit or in storage. The indicators are field-armable, tamperproof devices that turn bright red when an impact beyond a specific threshold has occurred. Each ShockWatch® 2 has a unique identifier to support traceability. [283]

[J4] Amazon's Just Walk Out system

J - Inventory management

Reference opportunities: J

Keywords: Computer vision

Shop where you take the products from the shelves and do not have to go through the payment point because thanks to the Computer Vision it "reads" the products that were taken from the shelves and automatically the consumer pay what he takes. [284]

[K1] Valerann's Smart Road System

K - Optimize routing and manage freight effectively

Reference opportunities: K

Keywords: Traffic management, Data-driven decision making

Timely delivery of essential information is critical. The ability to make swift, accurate, timely and actionable decisions in modern road traffic management based on data-driven insights is paramount. [285]

[M1] SHEIN

M - Incentivize users to buy more in a single transaction

Reference opportunities: M

Keywords: Buy more in one time, incentives

Shein is an online sales platform that encourages the purchase of multiple items at once, providing the user a discount on shipping to incentivize it. [286]

[N1] Star Wars Coca Cola limited edition

N - Increase interaction with packaging

Reference opportunities: N

Keywords: OLED, light interaction

Thanks to Inuru's OLED (=Organic LED) technology Coca COla create a packaging with the new light up label for the Star Wars Coca Cola limited edition. Coca Cola Singapore and Inuru created a label with glowing lightsabers, that light up when the label is touched.. [287]

[N2] FACT Water

N - Increase interaction with packaging

Reference opportunities: A B N S

Keywords: Blockchain Technology, QR code for user reward System

Crown has produced physical beverage can with blockchain technology for FACT Water. Each can will be marked with a 2D unique scannable code, making FACT beverage cans to have a unique digital identity. Consumers can scan a unique hidden product code and rewards them by unlocking tokens that are redeemable for cash. [288]

[N3] O'airy

N - Increase interaction with packaging

Reference opportunities: N Q R

Keywords: AR tech to see the pack, connect with the product inside

AR technology was added to this project. After scanning the QR code and installing the app, the design on the packaging can be seen in 3D form. Shaking the packaging causes the liquid inside the 3D capsules to move as well. [289]

[N4] Christmas AR Packaging

N - Increase interaction with packaging

Reference opportunities: N R

Keywords: Web AR, play with Santa

The Good Crisp Company, a new and better-for-you take on the classic canister chip, is launching a Web-based Augmented Reality (WebAR) feature on its packaging that will turn The Good Crisp Company canisters into a holiday-inspired winter wonderland, complete with Santa. [290]

[N5] AR Delivery Boxes

N - Increase interaction with packaging

Reference opportunities: N

Keywords: Draw and use AR to interaction

Amazon created AR delivery boxes that allow customers to access AR Halloween content. Customers can scan an AR delivery box using an app, titled Amazon Augmented Reality. The app is available in both the App Store and Google Play. [291]

[O1] Tostitos

O - Adding additional services

Reference opportunities: O

Keywords: A noble effort to prevent drunk driving on Super Bowl Sunday

Created in partnership with creative agency Goodby Silverstein & Partners, the Tostitos Party Bag is outfitted with sensors to detect alcohol on a person's breath. If you're in the clear, the bag turns green and you're free to go about your night. If alcohol is detected, the bag turns red with the message, "Don't drink and drive," and offers a $10 Uber credit for a discounted ride home. [292]

[O2] Medical Prescription

O - Adding additional services

Reference opportunities: N O

Keywords: IoT and with packaging

The Internet of Things (IoT) is increasingly entering the pharmaceutical and healthcare industries. Technological progress offers new opportunities for drug packaging. Together with our partner Avnet Integrated, we have developed three smart packaging solutions. These show examples of how drug packaging will improve patient compliance in the future and facilitate the handling of medications. Folding Carton with digital connection to App via Bluetooth . [293]

[O3] Coca-Cola® Christmas Pack with NaviLens

O - Adding additional services

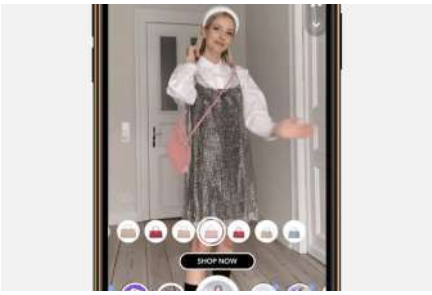
Reference opportunities: N O

Keywords: Beverage brand to pilot Navilens technology for visually impaired

NaviLens technology allows blind or visually impaired people to access the information normally printed on the packaging. By scanning the particular application-specific QR-Code with the NaviLens App, the system will provide information to recognize products, listen to their name, nutritional information and allergens. [294]

[P1] Prada – elevating the try-on experience

P - Minimize return issues



Reference opportunities: O P

Keywords: E-commerce virtual dress fitting

Snapchat users will now be able to try on clothing, glasses, purses and bracelets virtually with upgraded technology that detects and responds to body movements and facial dimensions. Other new tools include voice- and gesture-controlled filters (which Snap calls Lenses), brand shops and product catalogue integrations, virtual stores and the ability for users to search for and shop images or items seen in real life. Farfetch, Prada and Piaget are among early adopters of the new tools. [295]

[P2] Carolina Herrera – accessible AR through the web

P - Minimize return issues

Reference opportunities: O P

Keywords: E-commerce virtual dress fitting

Fashion brand Carolina Herrera has launched a new augmented reality (AR) experience to allow customers to get up close with its latest clothing collection. lets customers place holograms of models wearing select apparel in their homes to enhance their online shopping experience. [296]

[Q1] Adidas: leather-bound box

Q - Enhance the unboxing experience

Reference opportunities: N Q

Keywords: Like a shoe package

All elements anddetails of this leather-bound box were inspired by the relevant tools of arugby game and the key values of this partnership. We created a unique,limited and personalized publication which is very surprising for the recipientand arouses a strong emotional experience. [297]

[R1] Napolina tomatoes can

R- Convey diverse information through storytelling

Reference opportunities: A R

Keywords: Story telling, QR code

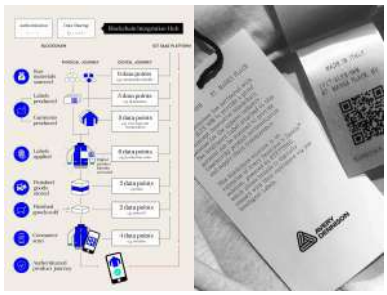
The codes will enable users to access a dedicated webpage walking them through the journey of the product through the supply chain, from farm to supermarket. It will help the company to “clearly and conveniently” tell the sustainability story of the 250 million units of tomato products it manufactures each year. [298]

[S1] Alyx blockchain project

S - Provide more information

Reference opportunities: S B

Keywords: Blockchain, QR Code, Label



Matthew William's Luxury fashion brand Alyx in 2019 implemented a scannable QR code in the garment that showcases it the entire supply chain history. That includes when and where the raw materials were sourced, where the garment was manufactured, and its shipping record. [299]

[S2] Mousline

S - Provide more information

Reference opportunities: A S

Keywords: Blockchain

Nestlé, in collaboration with Carrefour, makes traceability information of its products accessible thanks to users' access to the blockchain. [300]

[T1] Rompiscatole by Biticino

T - Decrease the amount of material

Reference opportunities: T

Keywords: Reduced packaging, eco-design

WrapEasy Universal Packaging is a simple sheet of corrugated cardboard with specially designed pre-cuts and creases. This new type of packaging adapts to the dimensions of the accessories, guaranteeing lower volumes, transport costs and storage of the finished product. It also allows easier disposal on site, without functional gluing, and guarantees packaging with standard operations. [301]

[T2] Nike: One box

T - Decrease the amount of material

Reference opportunities: T

Keywords: In to one box, One Box halves packaging

An innovative solution that allows shoes to be shipped directly in their own box, rather than sending a box containing another box. As a result, for every pair of shoes purchased, there is one less box on the road and in the recycling bin. [302]

[T3] PUMA: Clever Little Bag

T - Decrease the amount of material

Reference opportunities: T W

Keywords: Clever little bag, resuable for consumer

Designed an innovative solution called the clever little bag, which saves 20 million megajoules of electricity, 1 million liters of water, 500,000 liters of diesel fuel (lighter weight), and 8,500 tons of paper per year. At the same time, the solution is reusable for the consumer, and fully recyclable at the end of its life. [303]

[T4] Amazon: Frustration-Free Packaging

T - Decrease the amount of material

Reference opportunities: T

Keywords: Reduce packaging weight, Delight customers

Amazon partners with brands around the world to delight customers and reduce the need for Amazon to add additional protective packaging. Since 2015, this and other efforts have allowed Amazon to reduce packaging weight per shipment on average by over 41% and avoid more than 2 million tons of packaging. [304]

[U1] Sustainable HF RFID Assisted E-fulfilment Package

U - Reuse packaging by company

Reference opportunities: U X

Keywords: Screen printing, Radio frequency identification, Paper substrate

Intelligent packaging is an emerging technology, aiming to improve the standard communication function of packaging. Radio frequency identification (RFID) assisted smart packaging is of high interest, but the uptake is limited as the market needs cost-efficient and sustainable applications. The integration of screen printed antennas and RFID chips as smart labels in reusable cardboard packaging could offer a solution. [305]

[X1] Holy Grail 2.0

X -Facilitate better recycling of packaging

Reference opportunities: X

Keywords: Imperceptible codes, Accurate sorting streams

Digital watermarks are imperceptible codes, the size of a postage stamp, covering the surface of a consumer goods packaging and carrying a wide range of attributes. The aim is that once the packaging has entered into a waste sorting facility, the digital watermark can be detected and decoded by a high resolution camera on the sorting line, which then – based on the transferred attributes (e.g. food vs. non-food) – is able to sort the packaging in corresponding streams. [306]

[Y1] P&G's Liquid Tide Eco-Box

Y - Integrate packaging as part of the product

Reference opportunities: W Y

Keywords: Sealed package, Get rid of secondary re-boxing

The Tide Eco-Box arrives on a shopper's doorstep in a sealed, shipping-safe cardboard box. Inside the box is a sealed bag of ultra-compacted Tide liquid laundry detergent. To use, a perforated cardboard flap is peeled off to reveal a dosing cup and a new "no-drip" twist tap. To make dosing simpler on flat surfaces, the box includes a pull-out stand to raise the height of the box so the cup fits easily beneath the tap. [307]

[Z1] Lush Cosmetics:Eco-Friendly Packing Peanuts

T - Decrease the amount of material

Reference opportunities: N Q Z

Keywords: Collection of natural product, full of natural ingredients, support environmental causes

Nature is inspirational. Lush make the most of it in our glorious products, like our fresh face masks, packed full of natural ingredients. We also protect it by supporting fantastic environmental causes through initiatives such as Charity Pot. When we combine these aims together, sustainable packaging is the result. [308]

[α1] Nona Source

α - Promote the trade of second-hand goods

Reference opportunities: α

Keywords: Circular platform, Approach waste issue

Nona Source is a groundbreaking, circular platform that will revolutionise the fashion industry . It's no secret that the fashion industry has a huge waste issue. This is where Nona Source come in, taking these incredible deadstock fabrics from the world's leading fashion maisons under the LVMH umbrella and offering them at competitive prices – meaning they are accessible for all brands, new and old. [309]

[α2] Chloé Vertical

α - Promote the trade of second-hand goods

Reference opportunities: A B α

Keywords: Traceable vertical collection, Entire supply chain track

The initial launch includes bags, footwear and ready-to-wear, with Chloé suppliers and manufacturers involved in every stage of the project. The partnership enables the brand to track the entire supply chain and production process of all pieces in the Chloé Vertical capsule collection. The materials used in the Chloé Vertical collection are 100% traceable linen, silk, wool and leather. [310]

[α3] Levis: second hand

α - Promote the trade of second-hand goods

Reference opportunities: α

Keywords: Vintage Levi's sales, sustainable fashion, timeless style, environmental impact reduction

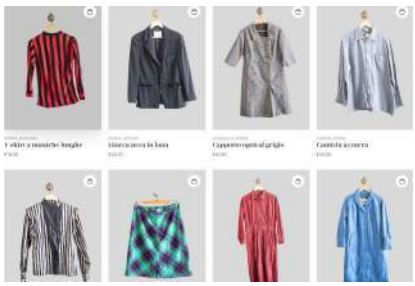
Levi's SecondHand, by Levi Strauss & Co., sells second-hand and vintage jeans and jackets, fostering sustainable fashion by encouraging recycling and reuse to cut waste. It highlights the brand's durable, classic style, supporting environmental consciousness and the circular economy, appealing to those seeking authentic vintage Levi's with less environmental impact. [311]

[α4] Humana

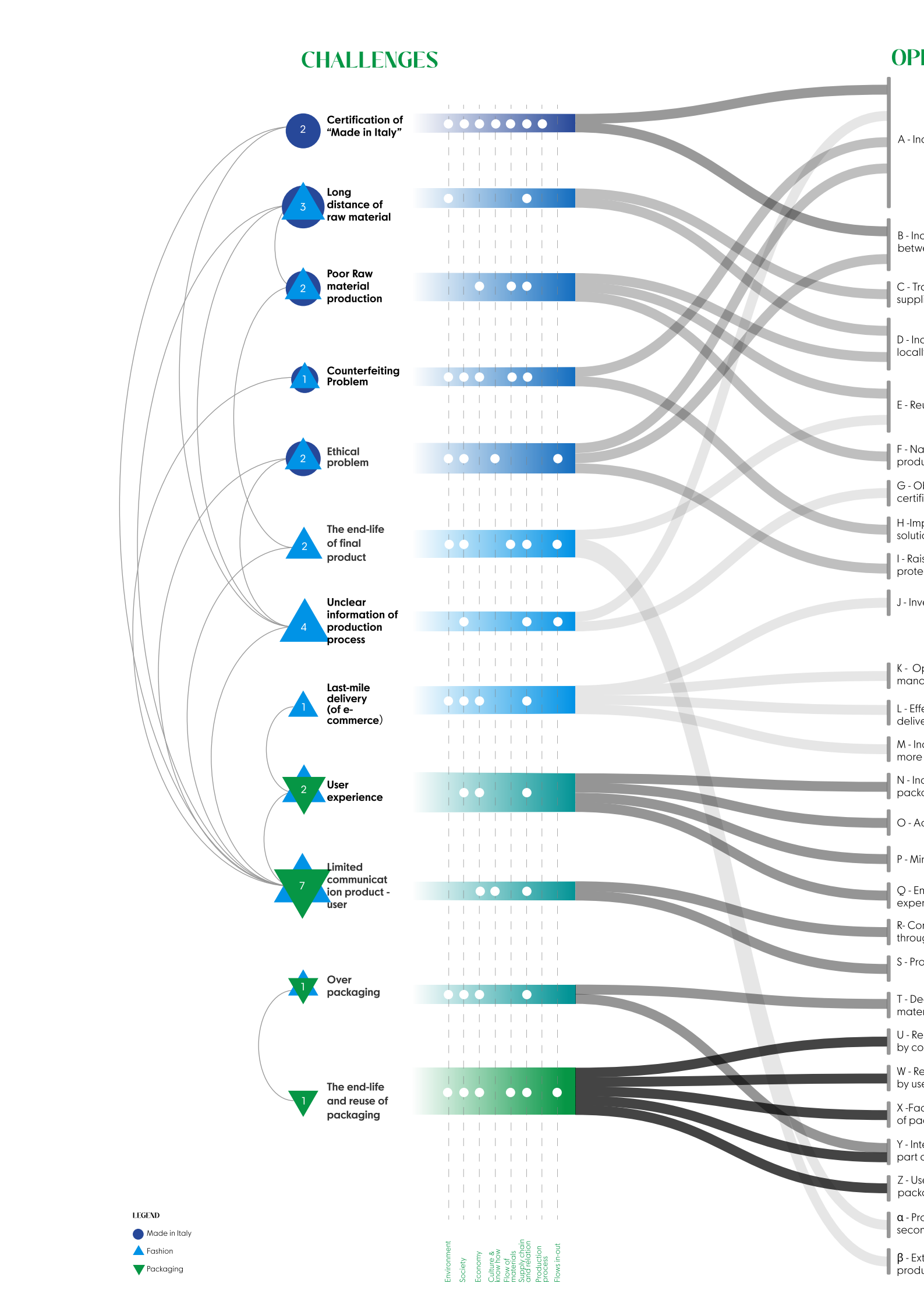
α - Promote the trade of second-hand goods

Reference opportunities: α

Keywords: Curated vintage clothing, Physical store experiences



Humana Vintage is an Italian online store offering a curated selection of vintage clothing, promoting sustainable fashion with items for men, women, and genderless options. Each piece is chosen with care, emphasizing the unique story and continued journey of every garment. Additionally, the site highlights its physical stores where customers can experience their quality firsthand, supported by a team of stylists and vintage enthusiasts. [312] [313]


CHALLENGES
OPI
2
Certification of "Made in Italy"
3
Long distance of raw material
2
Poor Raw material production
1
Counterfeiting Problem
2
Ethical problem
2
The end-life of final product
4
Unclear information of production process
1
Last-mile delivery (of e-commerce)
2
User experience
7
Limited communicat ion product - user
1
Over packaging
1
The end-life and reuse of packaging
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B - Inc betwe
C - Tra suppl
D - Inc locall
E - Reu
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G - Ob certifi
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I - Rais prote
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α - Pro secon
β - Ext produ
Environment
Society
Economy
Culture & know how
Flow of materials
Supply chain and relation
Production process
Flows in-out
LEGEND
Made in Italy
Fashion
Packaging

PORTUNITIES

Analysis of the relation between CHALLENGES AND OPPORTUNITIES of Fashion Sector in Italy

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CASE STUDIES

A1 Color code	A H
A2 Tracciabilità, Certificazione ed Anticontraffazione dei prodotti Moda Made in Italy	A H
A3 TextileGenesis	A H
A4 Furmark®	A I H
A5 Moose Knuckles platform	A B R S H
A6 Aura Blockchain Consortium	A H
A7 TRICK project	A
A8 Cambio Coffee	A
B1 Ynap Digital ID for garment	B A H
B2 Tony's Chocolonely	B F I
B3 Farmison & Co Label	B
D1 Apulia Regenerative Cotton Project by Giorgio Armani	D
D2 The agricultural cooperative of San Floro agreement with the fashion house Gucci	D
E1 Recycled wool in Prato	E
E2 Zara trade-in	E β
E3 Calzedonia Group trade-in	E α β
E4 H&M Garment Collecting Program	E α β
E5 Patagonia: Worn Wear	E β
E6 The North Face: Tack back	E
E7 Ecovia	E
G1 Sustainability certifications	G
H1 Watch Certificate	H
H2 Sneakers authenticity guarantee	H
H3 Delage bag	H
I1 Reveal Impact	I R
I2 Wineleather	I
I3 Ohoskin	I
I4 Box Water is Better	I
J1 Amazon Robot	J
J2 Tally 3.0	J
J3 ShockWatch 2 Impact Indicators	J
J4 Amazon's Just Walk Out system	J
K1 Valerann's Smart Road System	K
M1 Shein	M
N1 Star Wars Coca Cola limited edition	N
N2 FACT Water	A B N S
N3 Q'airy	N Q R
N4 Christmas AR Packaging	N R
N5 AR Delivery Boxes	N
O1 Tostitos	O
O2 Medical Prescription	N O
O3 Coca-Cola® Christmas Pack with NaviLens	N O
P1 Prada – elevating the try-on experience	O P
P2 Carolina Herrera – accessible AR through the web	O P
Q1 Adidas: leather-bound box	N Q
R1 Napolina tomatoes can	A R
S1 Alyx blockchain project	S B
S2 Mousline	A S
T1 Rompiscatole by Biticino	T
T2 Nike: One box	T
T3 PUMA: Clever Little Bag	T W
T4 Amazon: Frustration-Free Packaging	T
U1 Sustainable HF RFID Assisted E-fulfilment Package	W X
X1 Holy Grail 2.0	X
Y1 P&G's Liquid Tide Eco-Box	W Y
Z1 Lush Cosmetics:Eco-Friendly Packing Peanuts	N Q Z
α1 Nona Source	α
α2 Chloé Vertical	A B α
α3 Levis: second hand	α
α4 Humana	α

LEGEND

- Packaging
- Product
- System

4.3 OPPORTUNITIES EVALUATION

4.3.1 CRITERIA OF EVALUATION

After identifying the challenges and the respective opportunities, the latter were evaluated so as to focus the scope of the design and design the new system. The different opportunities identified have been skimmed through the selection matrix, in order to identify the best opportunities for a fashion company in Italy.

The criteria by which the different opportunities were evaluated were chosen among the criteria belonging to the Systemic Design Pillars (Relations, Output > Input, Autopoiesis, Act local and Humanity-Centerd Design), the four spheres of sustainability (Cultural sustinability, Social sustainability, Economic sustainability and Environmental sustainability). Moreover, given the central theme of this thesis is to promote Made in Italy, this has been a further evaluation criterion and finally scalability and transferability. Finally, we also evaluated the opportunities based on the number of challenges they meet. By fulfilling the Systemic Design Pillars, a company can develop a sustainable, global strategy that takes into account strong relationships, circularity and sustainability.
Due to the fact that, in this thesis, we have not focused on a specific company and that the boundaries of the territory of investigation are extended to the whole of Italy, the evaluation of the Systemic Design pillars has been carried out in a qualitative way. If an opportunitie satisfies less than two pillars no evaluation is assigned, if it satisfies two or more of two pillars then it is evaluated with +, if it satisfies four or more of four pillars then it is evaluated with ++.
On the other hand, the other criteria, with the exception of challeng satisfied, have been evaluated on a scale from 0 to 3, 0 corresponds to the lack of the criterion, while 3 corresponds to the complete and concrete application of the criterion. For the Challenge satisfied criterion, instead, the number of challenges that are satisfied by that specific opportunities has been reported.

Below are the definitions of the different criteria applied.

RELATIONS

The possibility of creating or reinforce new relations

The potential for establishing or fostering new relationships is crucial since it enables the company to forge cooperative relationships with other industry stakeholders. Strong connections with vendors, clients, and other businesses can promote information exchange, resource optimization, and group development. It fosters a sense of belonging and teamwork with more effective systemic design strategy.

OUTPUT>INPUT

Output of the supply chain become input for other companies

For a system to be sustainable and circular, the idea that the output of one company's supply chain can be used as an input by another is essential. It eliminates waste, maximizes resource efficiency, and promotes the concepts of a circular economy by guaranteeing that the outputs produced by a company's activities are beneficial inputs for other businesses or industries. It supports the long-term viability of the entire supply chain and helps to lessen its negative effects on the environment.

AUTOPOIESIS

Company ecosystem

To maintaining a long-lasting and mutually beneficial business environment, it is crucial to concentrate on building a company ecosystem built on collaboration rather than competition. The industry benefits from symbiotic ties when autopoiesis, which stands for self-organization and self-sustainability, is emphasized. It encourages cooperation, problem-solving as a group, and the creation of a flexible ecosystem that can adapt and coexist.

ACT LOCALLY

Act on social, cultural and material resources

For company's systemic design project, it is crucial to utilize local social, cultural, and material resources. The business can support the socioeconomic growth of the area by interacting with the local people, honouring cultural norms, and utilizing local resources. By reducing transportation and carbon impact, it encourages sustainable practices, boosts the local economy, protects cultural assets, and improves local communities.

HUMANITY-CENTERED DESIGN

The company's systemic design initiative is dependent upon taking human needs, values, and wellbeing into account when designing. The corporation can develop goods that appeal to their target market by giving priority to the satisfaction consumers requirement, such as high quality of the product and sustainability concerns. Designing with humanity in mind promotes consumer pleasure, brand loyalty, and good effects on people's wellbeing while supporting the company's beliefs and sustainability goals.

CULTURAL SUSTAINABILITY

The success of the system design project depends on the enhancement of the cultures of Made in Italy, business and Italy. The company can foster a greater understanding of the art and history of the textile and leather by promoting the cultural heritage of textile and leather production. This not only increases the value of their assets, but also helps to protect and promote the diverse cultural heritage of Italy. Tourists are attracted, local pride is promoted, and the ties of society to its roots are strengthened.

SOCIAL SUSTAINABILITY

The systemic project acts on the collective consciousness to change its behavior and increase individual responsibility, actively involving people in activities related to sustainability, territory and culture.

PROMOTE MADE IN ITALY

The systemic design project requires the network of territorial enterprises to be strengthened. It promotes shared resources and expertise, strengthens supply chain resilience, helps the local economy, and cultivates a sense of community. Regional growth and development might result from bolstering the network of territorial businesses.

ECONOMIC SUSTAINABILITY

The Systemic Design Project must also take into account the economic aspect and therefore the economic feasibility for its realization trying to contain the company's costs.

ENVIRONMENTAL SUSTAINABILITY

The Systemic Design Project must be based on respect for the environment, trying to reduce the environmental impact.

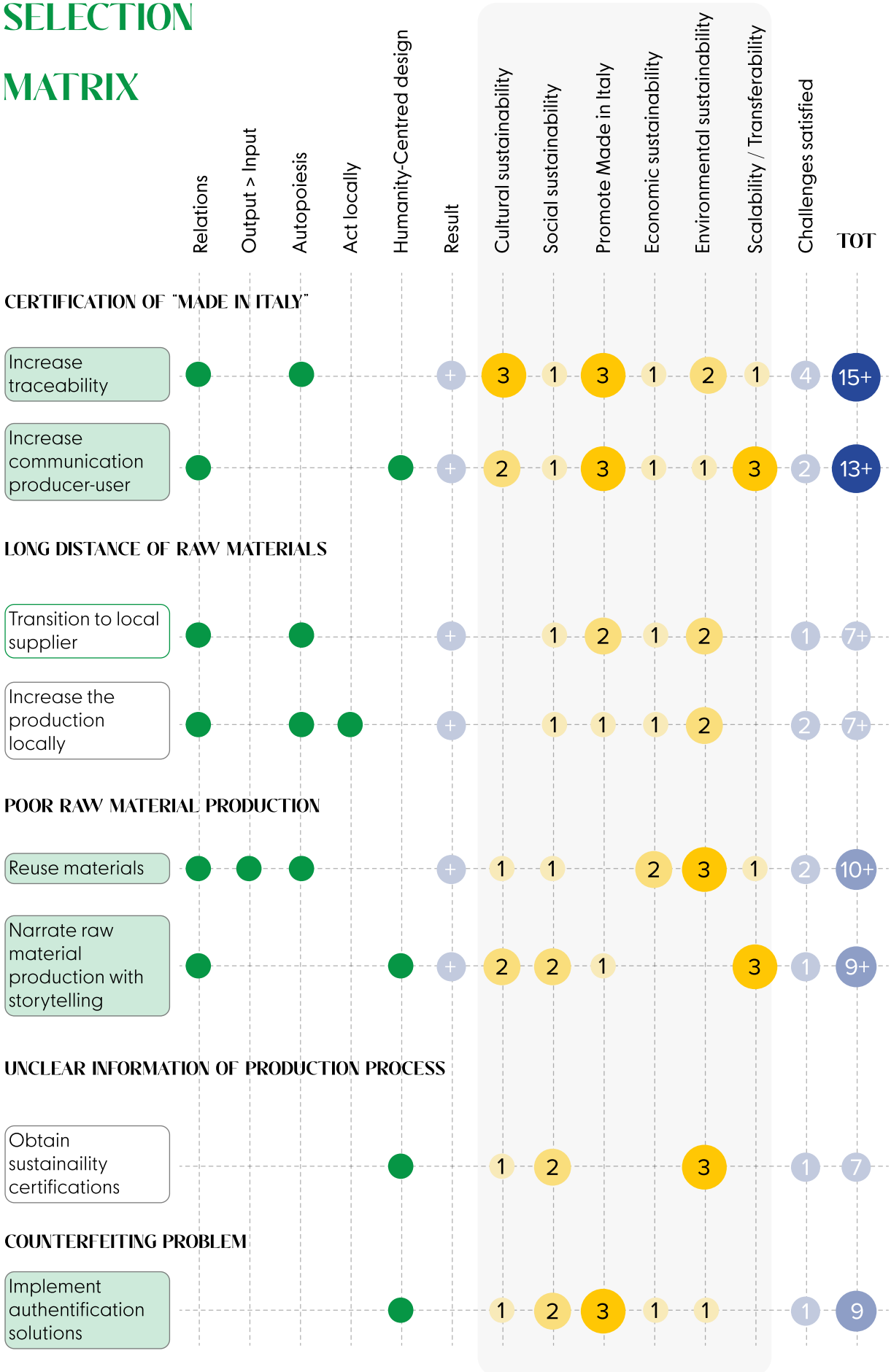
SCALABILITY/ TRANSFERABILITY

The possibility of extending the application of this solution also to a wider territory or to realities that belong either to the same sector or to different sectors.

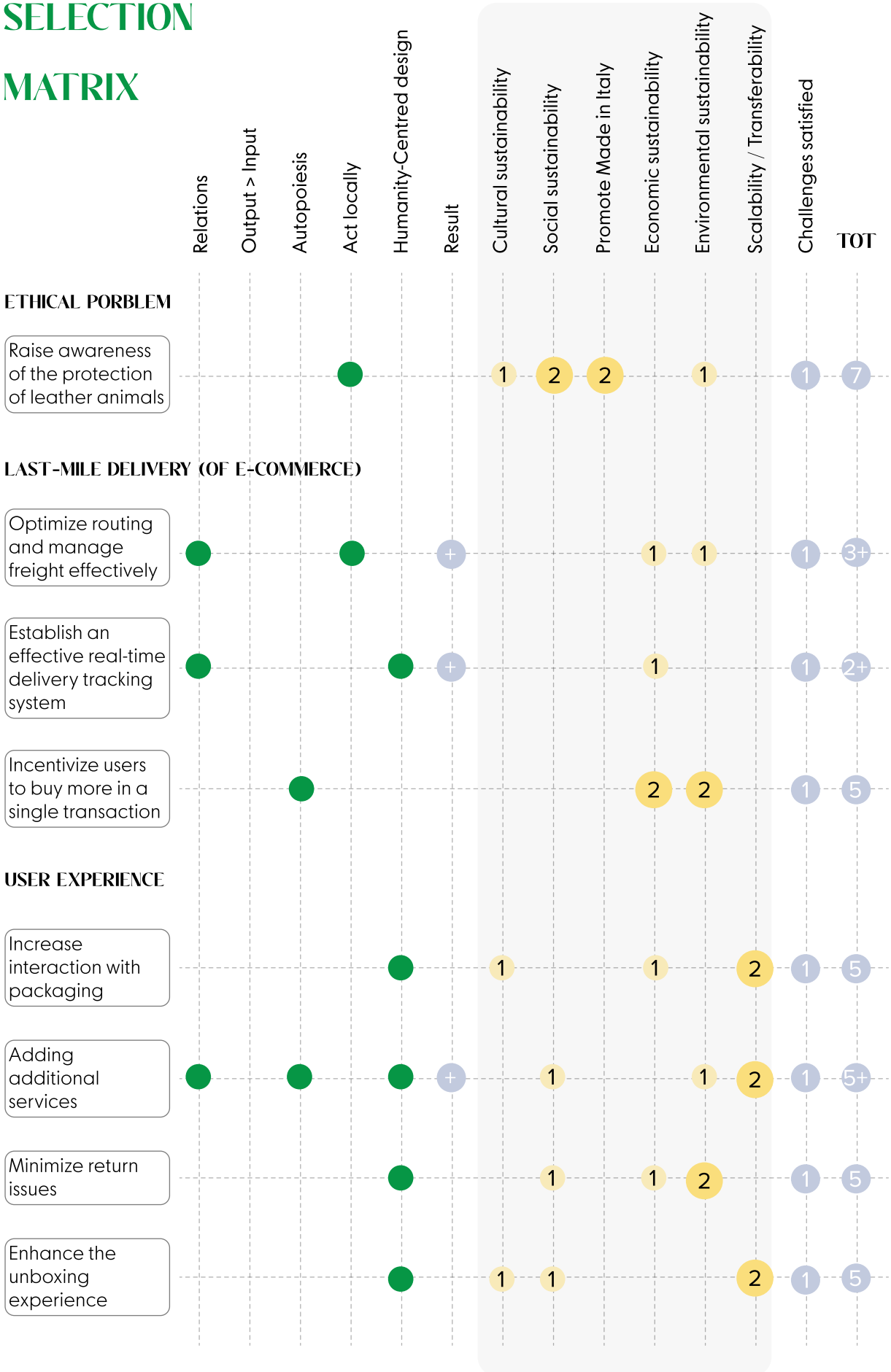
CHALLENGES SATISFIED

The last criterion corresponds to the number of challenges that a single opportunity can satisfy.

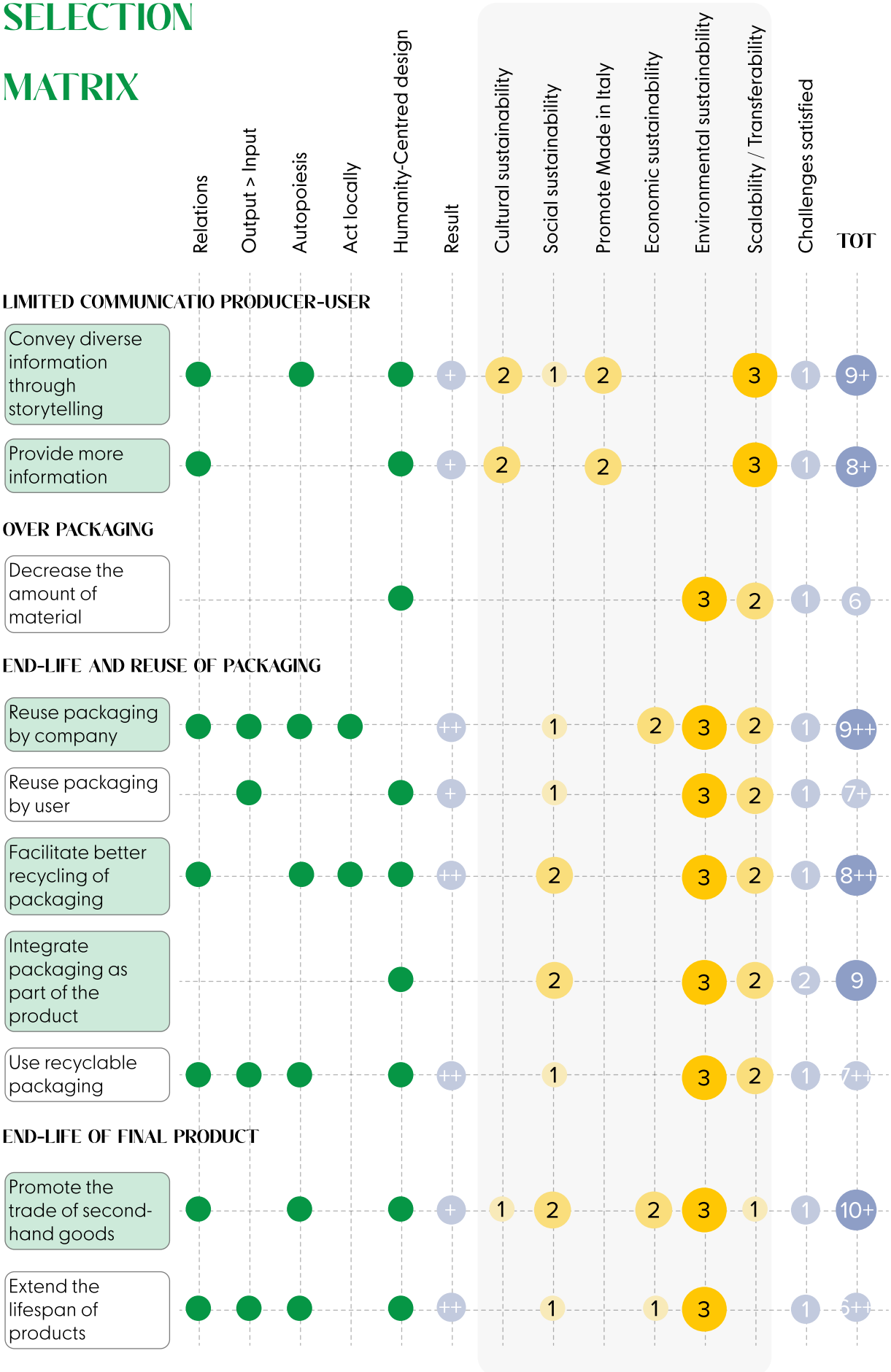
SELECTION MATRIX



SELECTION MATRIX



SELECTION MATRIX



4.3.2 OPPORTUNITIES SELECTION

From the selection matrix emerged opportunities with a higher total score than the others. This has allowed us to identify the best fields to dwell on. The opportunities that have come out belong to the following challenges.

CERTIFICATION OF MADE IN ITALY

- Increase traceability
- Increase communication

By increasing the traceability of a product it is possible to highlight the production of Made in Italy products so as to differentiate more from those companies that can boast of this "brand", but whose production has not entirely taken place in Italy. This is a quality assurance mark and ensures that the products have been manufactured according to European and national regulations on respect for the environment and people, preventing the exploitation of workers and the illegal use of harmful substances and their dispersal into the environment. In addition, making production traceable increases consumer confidence in a particular brand, as there is concrete evidence that the words of sustainability that are used to advertise the brand are expressed based on actions that have actually been taken, regaining the confidence of the consumer that, in recent years, has increasingly been deceived by greenwashing. Therefore, communicating these best practices to users is also crucial, to increase trust and loyalty in the company.

POOR RAW MATERIAL PRODUCTION

- Reuse materials
- Narrate raw material production with storytelling

On the Italian territory there is a shortage of production of raw materials of natural origin, and this leads to the need to import these raw materials from abroad. Although foreign production can be sustainable, even if there are different regulations when leaving the EU, the transport of these raw materials has a high environmental impact. In addition, there is also the problem of the disposal of clothing that has been thrown away. The use of such clothing as secondary raw materials, thus putting it back into production, reduces the costs of raw material supplies, waste disposal taxes and, in addition, reduces the environmental impact, reducing transport distances and the use of areas linked to cultivation, reducing the use of natural resources. This look at sustainability, the use of secondary raw materials, could become another distinctive aspect of the attention and quality that Italian brands and Made in Italy possess. Therefore, making the end user participate in the way the raw materials have been obtained allows him to recognize the attention that the company employs in the realization of its garments, the responsibility that it assumes in reducing its environmental impact not only for its own economic gain but also to improve people's lives.

COUNTERFETING PROBLEMS

- Implement authentication solutions

There are more and more frequent, especially for luxury brands of which Italy can boast, acts of counterfeiting that make people reluctant to buy products of large brands from retailers because of the fear of counterfeiting. Implementing solutions to authenticate a product allows you to reassure the user, to make him feel protected by the company that has his trust at heart. This also makes it possible to increase the loyalty that the user has towards the company because he knows that, having a warranty certificate, it is not linked only to the place where the product was purchased, but that it is intrinsic to the product itself, What he bought is authentic and that was therefore made following the quality standards of which the brand is the bearer.

LIMITED COMMUNCIATION PRODUCER-USER

- Convey diverse information through storytelling
- Provide more information

Communication is the basis of any good relationship and this also applies between company and user. The greater the exchange of information that the company provides, the more the user will feel involved in the process, will be more happy with the choice of purchase made, because it will have greater confidence in the company and the product. In addition to the information that must be provided by law, giving, on its own initiative, further information involves an opening to dialogue, a greater attention to user requests, and transparency, and sincerity of the company's actions. Providing more information, effectively allows the user to know more "intimately" the company, feeling almost part of the family.

END-LIFE AND REUSE OF PACKAGING

- Reuse packaging by company
- Facilitate better recycling of packaging
- Integrate packaging as part of the product

The use of online sales platforms is increasingly widespread and this involves the use of packaging that are intended to protect the product during the delivery phases. This packaging is often thrown away by the user when its function ends but the product is still in excellent condition and can be reused. The reuse of these packaging by the company reduces the disposal costs that the company is forced to bear and also reduces the costs associated with the purchase of new packaging.

Reusing packaging would also reduce waste generation and extend the useful life of packaging. Another important aspect is to make packaging recyclability as easy as possible so that you can fully exploit every resource without losing it because it is difficult to recycle. A further way to reduce packaging waste production is to integrate packaging into the product so that it can extend its useful life.

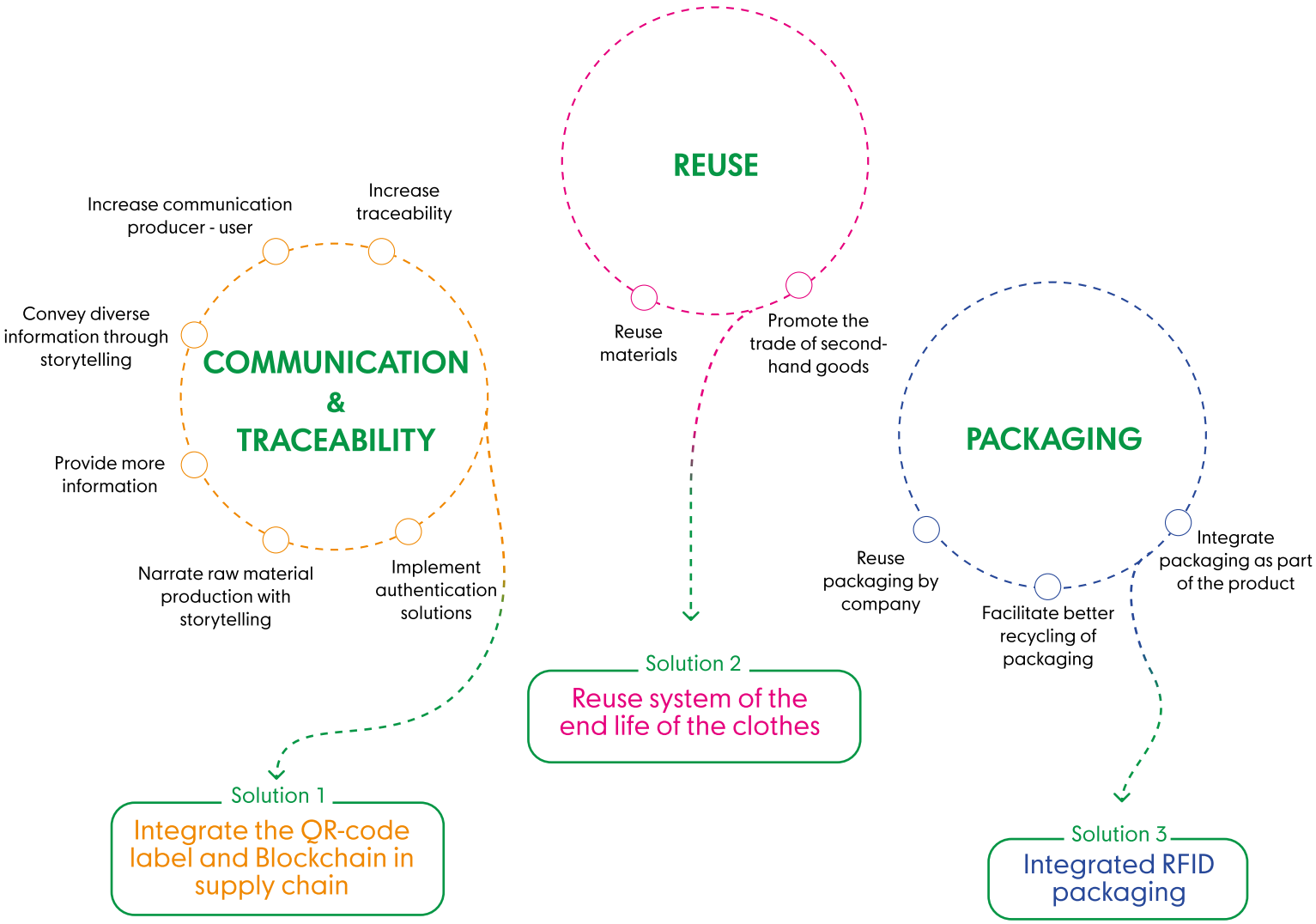
END-LIFE OF FINAL PRODUCT

- Promote the trade of second-hand goods

Very often the clothes that are thrown away are still in good condition and this makes a rejection something that is actually still fully usable. The promotion of the sale of second-hand goods makes it possible to reduce the amount of waste generated, reduce production costs, as they would resell clothes that were not made from scratch and reduce taxes related to waste disposal.

In addition, promoting the sale of second-hand clothes would raise the status of the clothes and the people who buy them, changing their perception by the user, as they would no longer be associated with poverty but would look at a more sustainable aspect, how to reduce environmental impact.

4.4 DESIGN THE SYSTEM

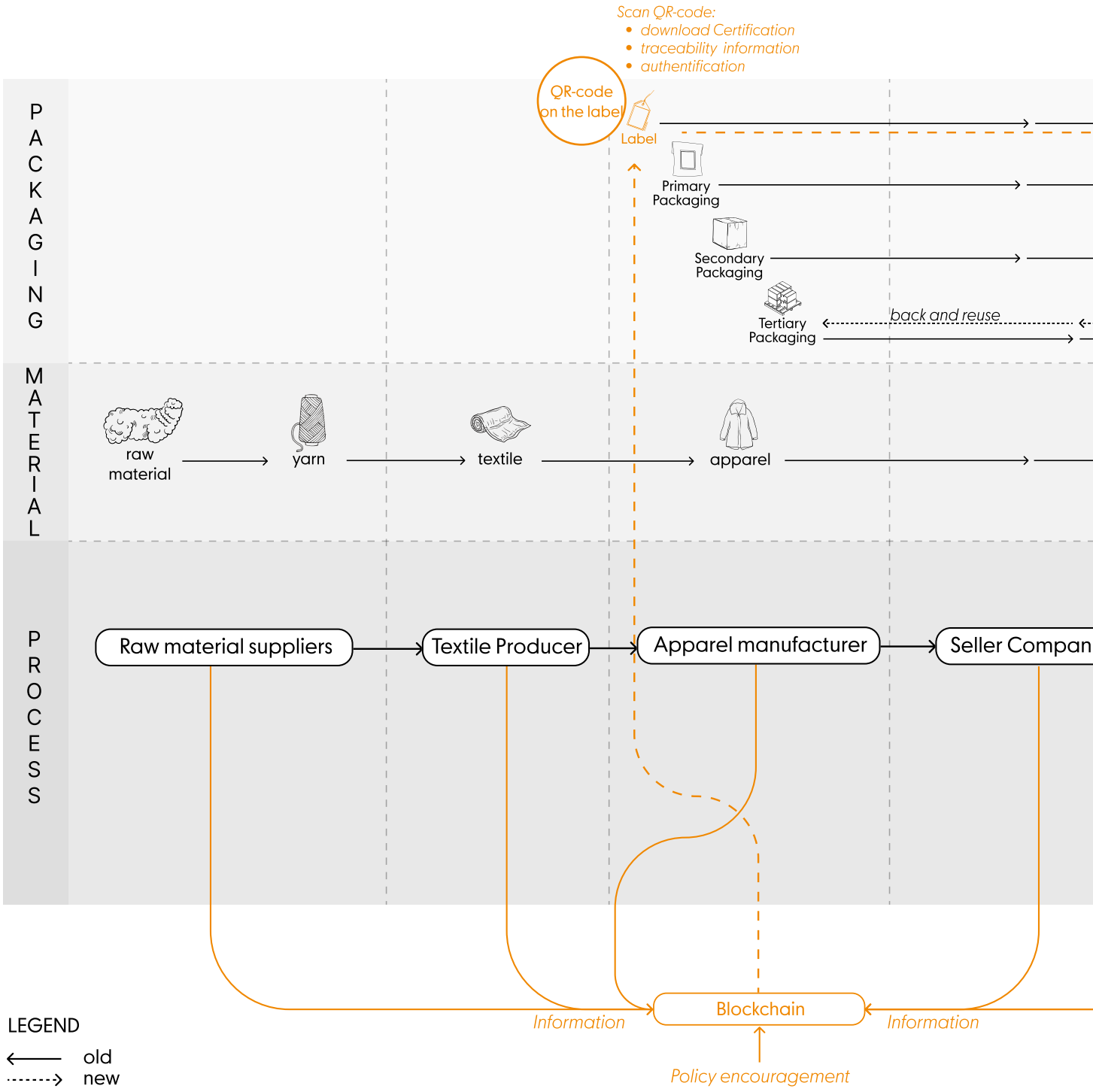


Opportunities and design solution

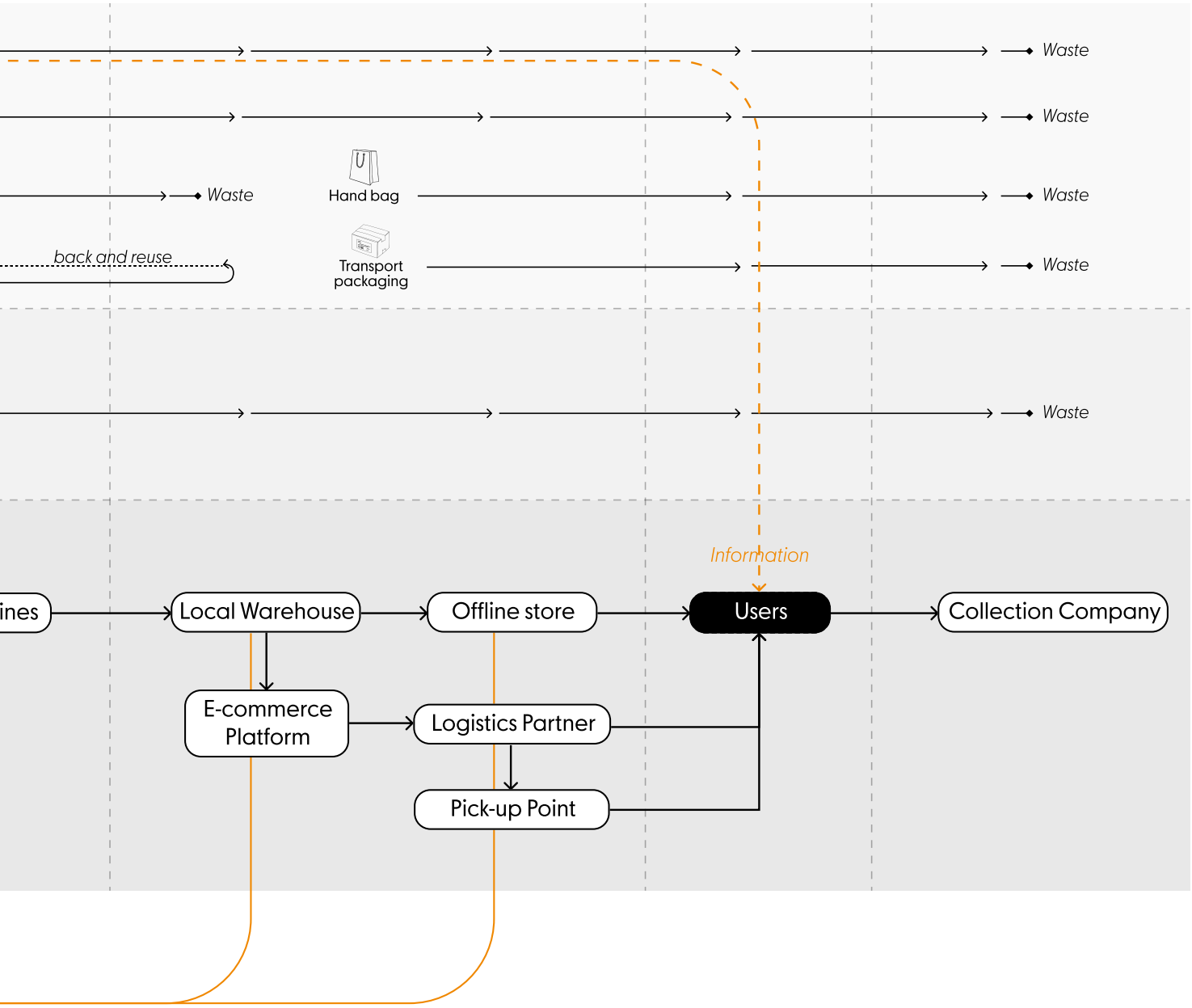
Having now all the necessary elements to be able to design a new system, that is a thorough knowledge of the current system, the identification of the problems (challenge) and possible solutions (opportunities) we are preparing to design the new system.
On the basis of the opportunities that have been selected by means of the selection matrix, and on the case studies that have been researched for each opportunity, a package of solutions has been outlined that have been grouped in three macro-solutions.

The first concerns the increase of information provided by the company, in order to increase traceability, authentication solutions and the flow of information. The second, concerns a system of reuse of clothes to extend the useful life of clothes. Finally, the third concerns the use of a system that allows to reuse the packaging used for e-commerce, thanks to the application of technological solutions.
In the following sections, these three solutions will be explained in detail.
Each of these solutions can be implemented individually or all together, we, continued our assessment as if each of them were applied by a company.

4.4.1 SOLUTION 1: INTEGRATE THE QR-CODE LABEL AND BLOCK CHAIN IN SUPPLY CHAIN



Solution 1: Integrate the QR-co



ode label and Block chain in supply chain

Integrating blockchain and QR code technology in the supply chain can significantly enhance the transparency and traceability of product information. The primary idea is for each supplier to record their relevant information on the blockchain, leveraging its decentralized and immutable characteristics to ensure the authenticity and reliability of the information. Then, by printing QR codes on product labels, consumers can scan these codes to access all the supply chain information recorded on the blockchain[314].[315]

Blockchain technology can significantly improve the traceability of the supply chain, ensuring that every step from raw materials to the final product is accurately recorded and tracked. The decentralized structure of blockchain allows multiple participants to record and verify data without central control. This means that each link in the supply chain can independently add information without relying on a single central database.

Once information is recorded on the blockchain, it cannot be altered or deleted. This immutability provides high security and trust, ensuring that each event in the supply chain is accurate and genuine. Blockchain technology also enables real-time updates of information at each stage of the supply chain. This means that all relevant parties can view the latest product status and location at any time, enhancing the transparency and responsiveness of the supply chain.

Blockchain records all information from raw material procurement, production, and transportation to final sales, forming a complete and immutable traceability chain. Consumers can see the entire lifecycle of the product by scanning the QR code, increasing their trust in the product. Blockchain can integrate information from different sources, including suppliers, manufacturers, logistics companies, and more, forming a unified, comprehensive information platform. Consumers can access all relevant information through a single QR code without needing to obtain information from multiple sources.[316]

Through blockchain and QR code technology, consumers only need to scan the QR code on the product label to easily access all the information recorded on the blockchain. This convenient access improves the availability and transparency of information.

By implementing an integrated solution of blockchain and QR code technology, multiple significant objectives can be achieved, substantially enhancing the transparency and traceability of the supply chain. Blockchain recording and QR code technology enable producers to transparently convey the production process and raw material sources of products. Consumers can scan the QR codes on products to access detailed production information and brand stories, thereby strengthening their trust and loyalty towards the brand. Due to the immutable nature of blockchain, every step in the supply chain can be accurately recorded and tracked. Whether it's the source of raw materials, the production process, or logistics transportation, all information can be recorded on the blockchain, allowing consumers to understand the

entire lifecycle of the product by scanning a QR code.

Moreover, using blockchain to record the production process and brand stories allows rich information to be conveyed to consumers through QR codes. This not only enhances the product's added value but also improves the consumer purchasing experience. Blockchain technology can integrate information from various sources, including suppliers, manufacturers, and logistics companies, forming a unified information platform. Consumers only need to scan a QR code to easily access all recorded information, obtaining comprehensive product background details. Through blockchain and QR code technology, the production and processing of raw materials can be detailedly documented, creating vivid brand stories that enhance the product's value and market competitiveness.

Blockchain technology also provides secure and tamper-proof certification information, such as certificates of origin and quality inspection reports. Consumers can verify the authenticity of products by scanning QR codes, preventing counterfeit products. This integrated technology solution not only ensures the authenticity and reliability of information but also increases consumer trust, promotes brand integrity and reputation, and provides robust support for sustainable development and responsible consumption in the fashion industry.

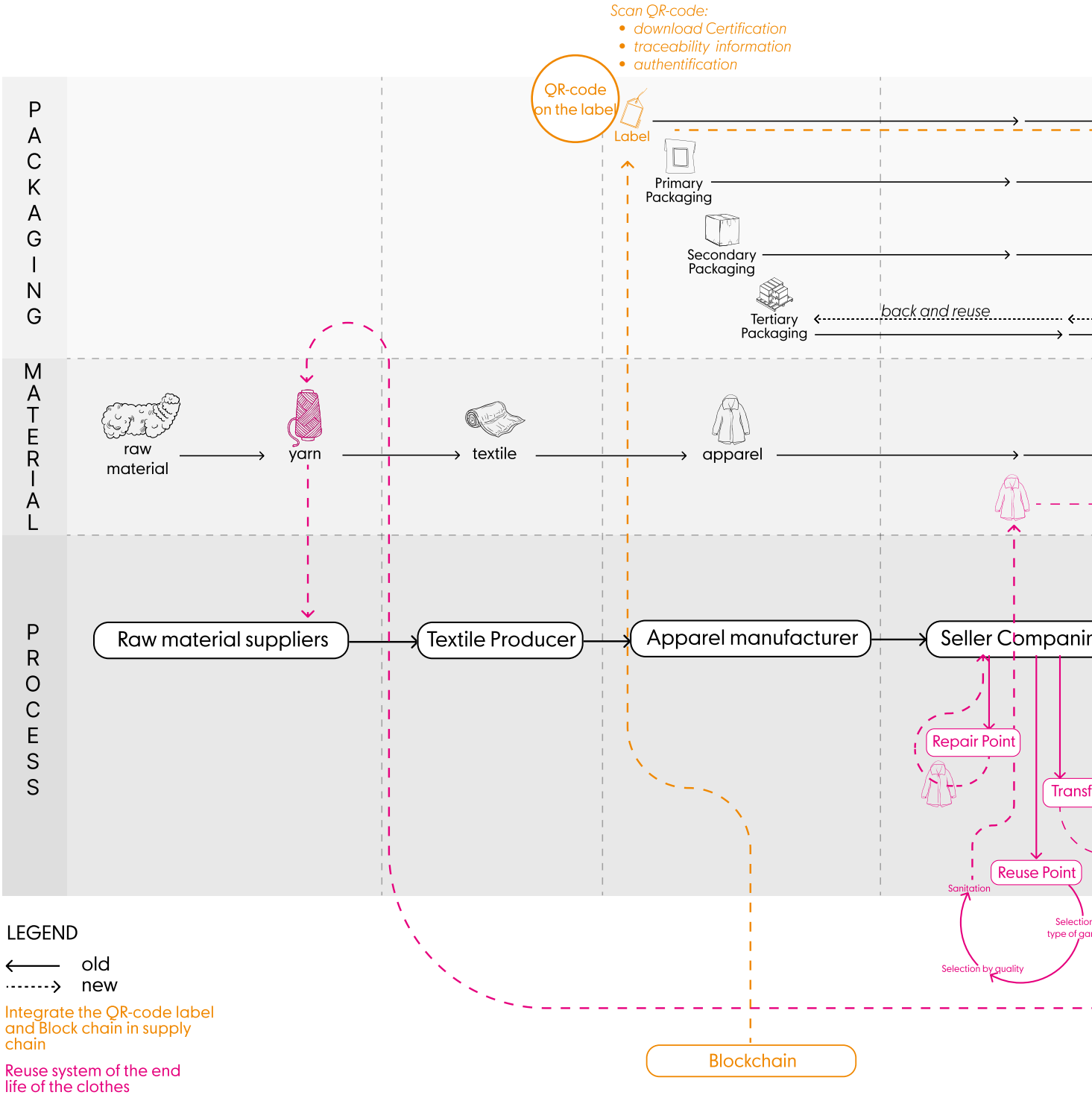
Implementation Steps

Each raw material supplier records the source, initial processing, and transportation information of their products on the blockchain, including the type of raw material, place of origin, and date of collection. During textile production, information such as spinning and weaving steps, process details, equipment usage, and quality inspection results is continuously updated on the blockchain.

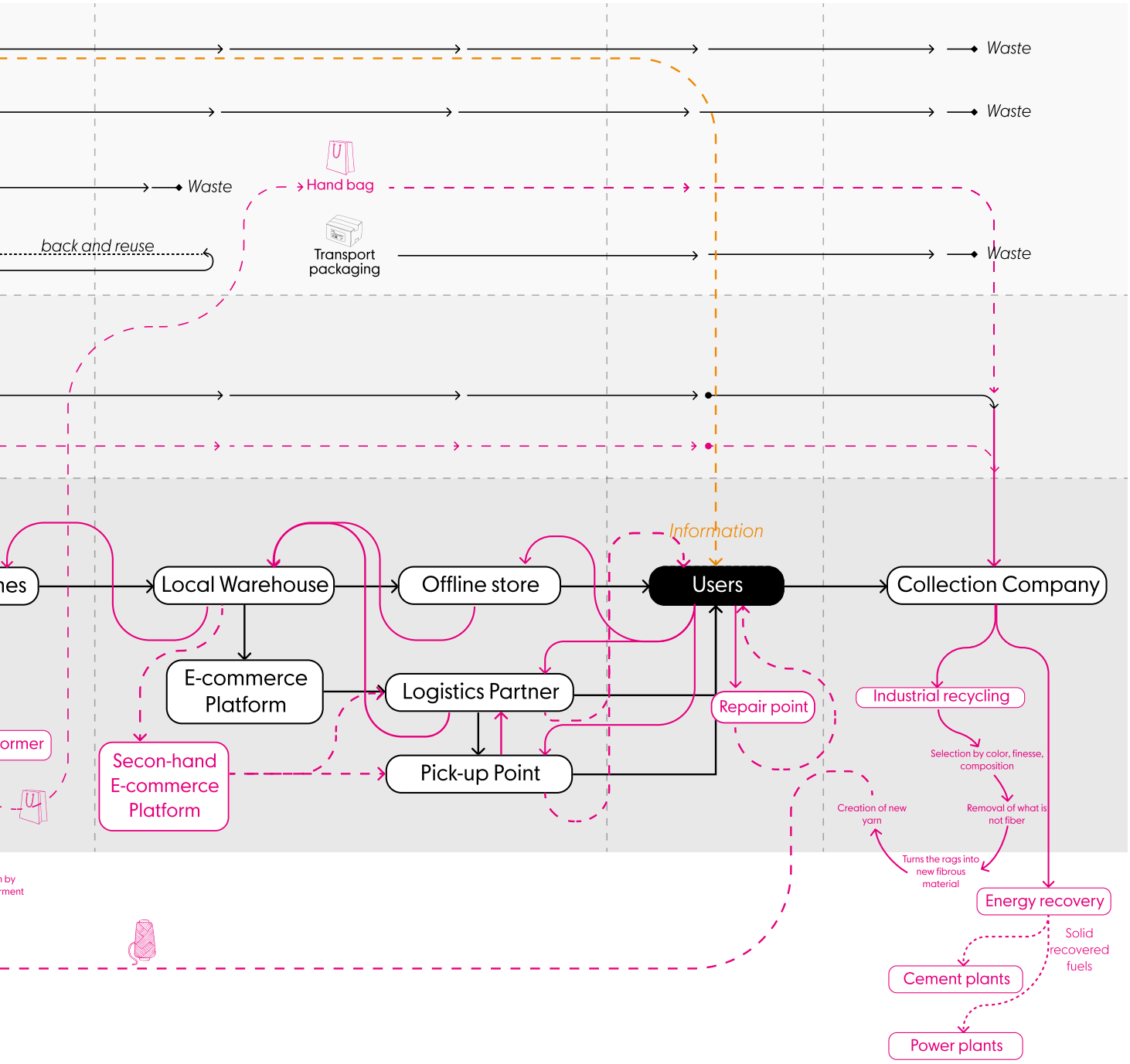
In the finished product stage, apparel manufacturers record all production and processing information, including cutting, sewing, and dyeing, ensuring the process is transparent and traceable. Seller companies then ensure that all production and logistics information, such as batch numbers, shipping times, and transportation status, is recorded and verified on the blockchain before products enter the market.

QR codes are used to track the real-time position and status of products, ensuring transparency in logistics. Information at each transportation node, such as arrival times, storage conditions, and transportation methods, is updated in real-time on the blockchain. Consumers can access all supply chain information, including production history, raw material sources, quality inspection results, and logistics information, by scanning the QR code on the product label. This ensures that users have comprehensive knowledge of the product's background.

4.4.2 SOLUTION 2: REUSE SYSTEM OF THE END LIFE OF THE CLOTHES



Solution 2: Reuse system of the en



d life of the clothes

One of the problems related to the generation of waste related to the fashion world is related to the incorrect disposal of waste. Often people do not know where to throw away clothing, as no clear indications are given on the label, as is the case with other products. On the Italian territory there is no unique system of collection of textile waste and often what is thrown is still in good condition but is thrown into the bin of the undifferentiated because you do not know where to throw it. There are, of course, systems of clothing collection but often are not present in a uniform manner throughout the regional and national territory and therefore, some bins that are present in large cities maybe are not present in smaller ones. In addition, the type of clothing that can be thrown away often must be in good condition because they are donated to charities and therefore dirty or torn clothing can not be thrown in bins dedicated to donations and are often thrown in the bin of the undifferentiated. This obviously turns out to be a great waste of resources, one because garments still perfectly wearable are disposed of to the exhaustion of irrecoverable waste while they can still be worn and moreover, any type of textile waste, even in very bad condition can be reused to create new clothes.

So, based on this problem related to the devaluation of resources that still have a great value, and the scarcity of raw materials that can be found on Italian territory, we designed a system of reuse of clothes.

Connecting to the solution presented in the previous section, then to the use of a QR-Code applied on the garment label that provides information about the traceability and authentication of the garment, it can also provide information regarding the end of life of the garment that you went to buy. The goal is to extend the useful life of the garment as much as possible so as not to turn it into waste but to re-enter it within the supply chain.

When the user frames the QR-Code, they are given information on what to do if they no longer want to keep the garment. The company provides a garment collection service that has been produced by the company itself. The user can use this service by putting the clothing in the appropriate collection bins placed inside the physical stores, or, in the case of online purchases to deliver the clothes you want to return to the men of deliveries or use the collection points. The service would be similar to that of returns, the garment is returned to the manufacturer and the user has a discount on the next purchase. Using a system of "reward" allows to entice the user to apply this new behavior as it can make tangible use of the results of his commitment. Once the garment has returned to the store or in the warehouses of the delivery company, following the same path that the company leads to these places, the opposite path is made so as to bring back to the company the clothing used. At this point the company evaluates the state in which the clothes are, as the

user can return garments in any state, provided they have been produced by the company itself, and can directly put them back on the market if they are in good condition, repair them and put them back on the market if they need repairs or modifications. In the event that the condition of the garment is so low that it cannot be repaired, the fabric is used to make fabric bags that will then be used in physical stores instead of paper bags normally used. In this way, the company would reduce the cost of buying new packaging for physical stores, it would not become waste after its use, and fabric bags have a longer useful life than paper bags generally used in clothing stores. Moreover, being more resistant than paper or plastic bags, they can also be used by the user for different purposes, such as during shopping, to go to the beach, or as full-fledged bags. This increased use of a fabric bag, which bears the name of the brand, and which is also used in contexts other than shopping, can become a free advertising for the company because, simply using them, the user carries around the message of sustainability and innovation that the company is undertaking, making an indirect advertising.

Once the clothes have been repaired or simply rearranged for resale, they are sold following normal sales channels, both in physical stores and virtual platforms. In stores there will be a section dedicated to second-hand clothing, and so on the online sales site. The fact that it is the company itself that sells second-hand clothes, becomes, both guarantee of authenticity, as they sell them on a par with the new one; therefore, the company itself acts as guarantor of authenticity. In addition, promote the purchase of second-hand clothing, in addition to reducing the environmental impact and prolonging the life of the garment, it also reduces production costs by selling a product that has not undergone the same level of processing as a new one and therefore has lower production costs, that are related only to repairs and sanitization. In addition, this elevates people's perception of second-hand clothing. Usually, in fact, buy second-hand clothing, is associated with poverty, usually due to the fact that they are sold at lower prices than new ones, or the great work done by charities that bring clothes to those who can not afford them. To promote this style of purchase, the company aims at the uniqueness of the repaired product. Any kind of tear, stain or loss, is unique in itself, it is difficult for two shirts to tear or machine in the same way and in the same point; Thus, already the repair of imperfections will be unique but also the repair will add that something extra that will make the product even more unique. A same tear, for example, can be repaired using a thread, and already the use of different colors makes it unique, or use a piece, and there are many different types. Therefore, the enhancement of the repaired part, transforms a defect into a unique feature. Therefore, repairs will not take place in the least invasive way possible, so without changing the original appearance of the garment, instead they will be almost extreme, always respecting the style of the company. In addition, this greatly enhances the work of the company, the craftsmanship that Italian tailors and Made in Italy represent, thus giving the opportunity to vent the imagination

again, always maintaining a high quality.

Based on the garment repair concept, the company also provides a repair service, not related to the return of clothes for the purpose of the sale but to increase the use of a garment by the original owner. In fact, a second reason why people throw away clothes is because they are torn or no longer the right size, so they need a "fix". Very often we dispose of clothes that we care about because we are unable to repair them. For this reason, by scanning the QR-Code you can also access the repair service provided by the company that has made agreements with tailors present on the territory, so that the user can locate the tailor closest to him and thus recover his favorite garment. In this way, thanks to the collaboration, the work of the tailoring industry increases, which today is increasingly declining, due to the presence of cheap clothing for which the cost of repair is equal to or higher than the cost of the garment itself, and also helps haberdasheries that provide the necessary materials to carry out repairs. The company guarantees the professionalism of the tailoring shops it relies on, as it is in its interest to maintain high standards of excellence, and this is a guarantee for the user who needs and wants to use this service, and the fact that they rely on local tailors, in addition to keeping the industry alive, as mentioned before, also allows to reduce transport costs. If this service were served in shops, the garments would have to be shipped to processing factories, which are often not located in the same city and sometimes even in the same region. In doing so, however, using local tailors, the repair would remain local and would also reduce service times. In addition, thanks to the presence of the QR-Code, which being placed on the label always remains together with the garment, the tailor who made the repair or modification, can add information on the material used for the repair so that, during disposal, know exactly the final composition of the garment, so that it can be recycled to the fullest.
By scanning the QR-Code, you will also have access to additional information regarding garment disposal. In fact, among the information provided there will also be links to information related to further ways to dispose of waste, such as, for example, a reference to the site of Humana, or information related to the presence of bins for clothing provided by the municipality. Although it is preferable for the company to return the garments directly to it via the channels previously explained, it will still be able to recover its garments thanks to an agreement with the waste collection companies which, in the event that, during the sorting and selection phase, they collect the garments of that company, they return them to the manufacturing company so that they can be resold or processed as explained above. In this way the company would have full control over the end of life of its products.

As for what happens once the garments are collected by the waste collection company, they, as seen in the old supply chain, are recycled industrially to be transformed into rags. Our idea, instead, is to carry out a different industrial recycling system, which transforms clothing no longer recoverable as such into yarns that will

then be purchased by the company to produce new clothes. In this way, the supply of raw materials would no longer come from overseas but would remain on Italian territory and this is also obvious to the scarcity of production of raw materials that Italy can provide. In this way the production is entirely Made in Italy, as every type of processing took place on the Italian territory, also enhancing a technique of garment recycling that has a centuries-old history and that distinguishes Italy.
If the garment is irretrievably recoverable, also for industrial recycling, it is transformed into secondary solid fuels that are used to produce thermal energy in cement plants and electricity in power plants that potentially provide energy to the company.
Thanks to the application of this solution, the company is against compliance with the 2023 decree on extended producer liability. Under the extended liability scheme, the producer is responsible for financing and organising the collection, preparing for re-use, recycling and recovery of textile waste. Among the main objectives of the decree is the sustainability of the product, that is, to design clothing and its components in such a way as to reduce environmental impacts and waste generation. For this reason, the manufacturer is required to develop, produce, market products that can be reused and repaired, that contain recycled, technically durable and easily repairable materials, using the principles and economic models based on circularity. [317]

Thanks to the company's internal management of waste management, it does not have to bear the costs it would have to bear in order to rely on a consortium for the collection of textile fabrics; on the contrary, it allows it to put these garments back on the market, bringing profit. Moreover, this is also part of the objectives set out in the 2030 Agenda, in particular linked to Objective 12 - Ensuring sustainable consumption and production patterns, specifically in point 12.5 and 12.6, which state:

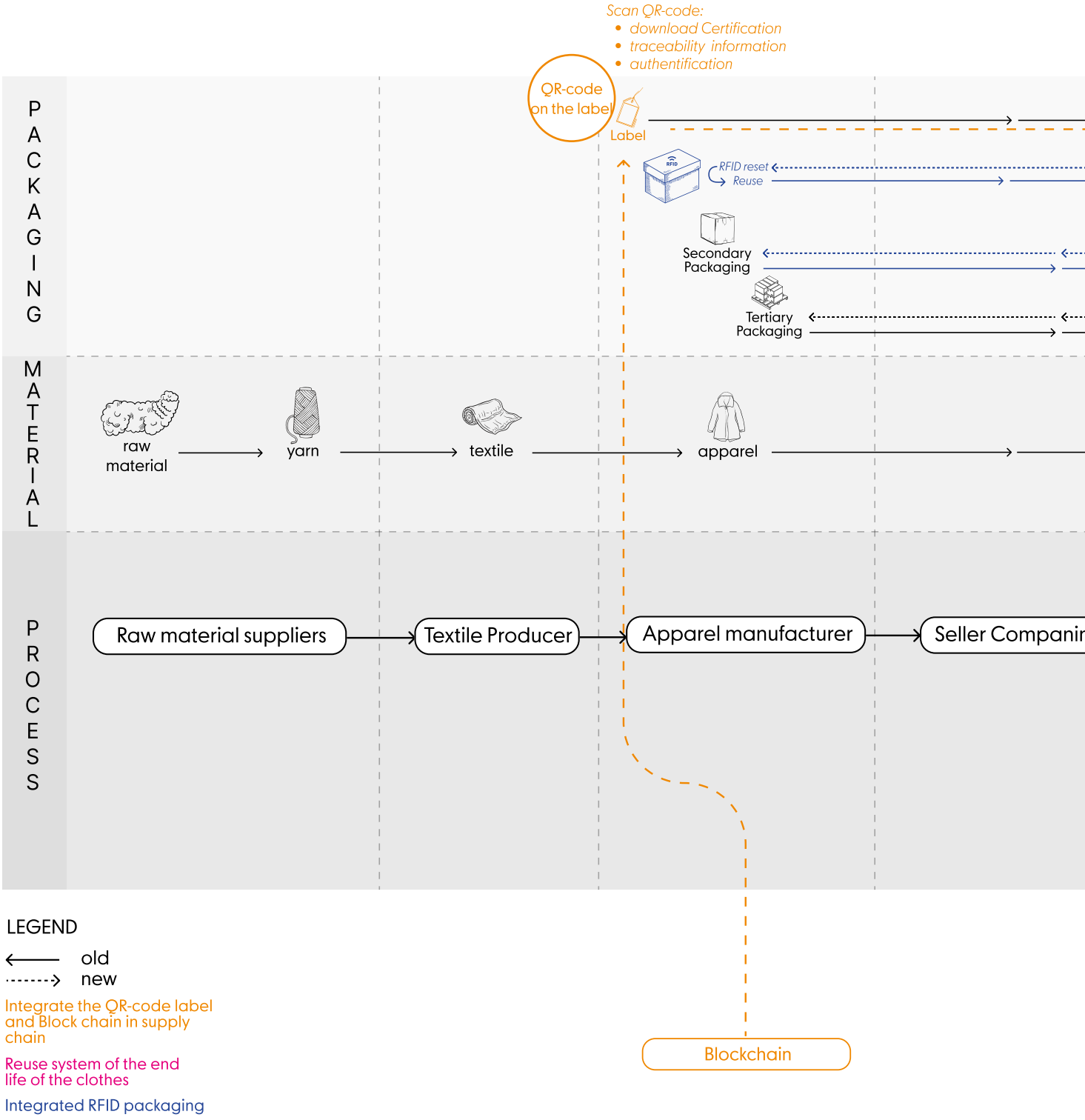
12.5: By 2030, substantially reduce waste production through prevention, reduction, recycling and reuse

12.6: Encouraging enterprises, in particular large multinational companies, to adopt sustainable practices and to incorporate sustainability information in their annual reports [318]

Below is the diagram of the new system applying this solution (pink), compared to the old system (black).

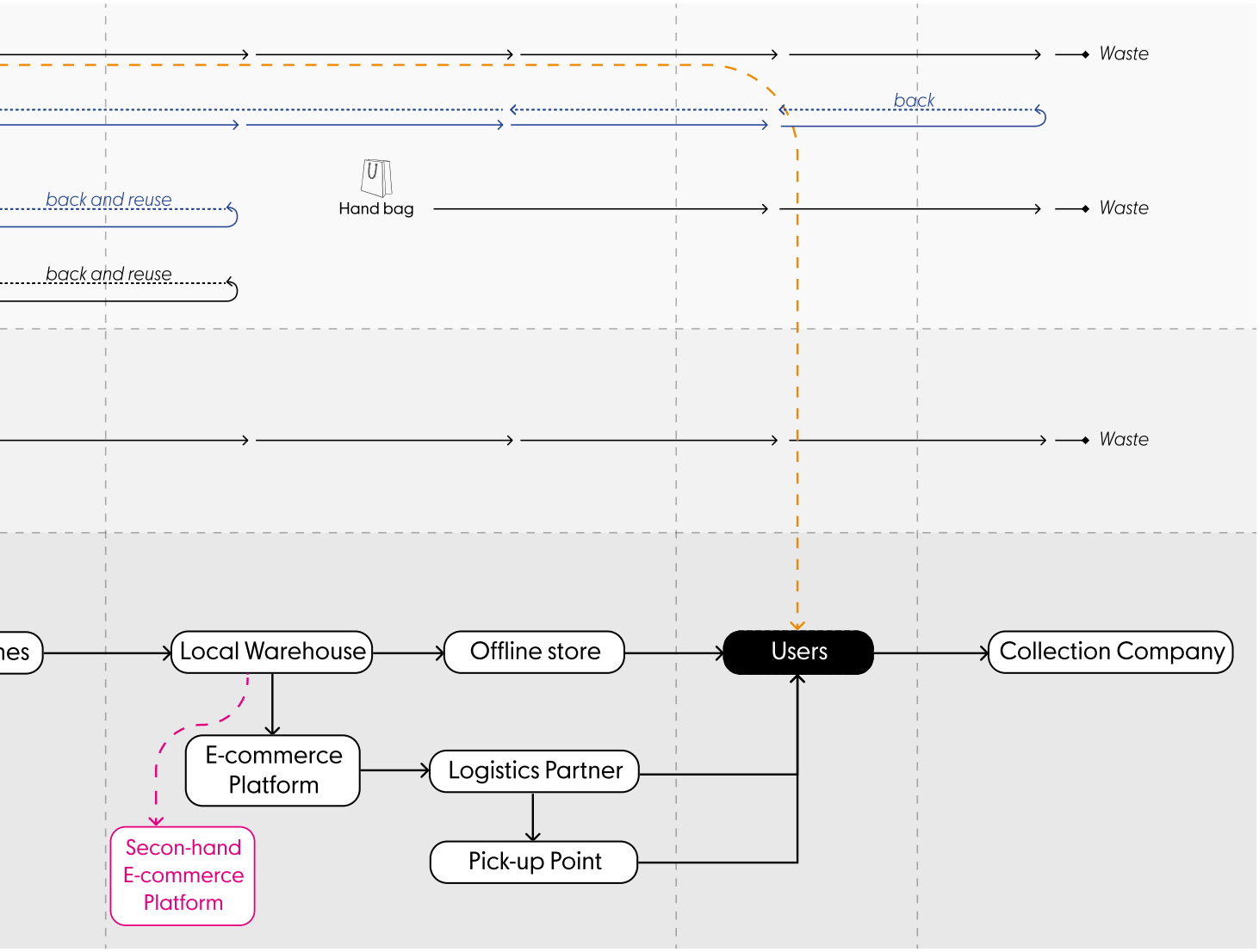
16 sustainable development goals [238]

4.4.3 SOLUTION 3: INTEGRATED RFID PACKAGING



Solution 3: Integrated RFID


Primary Packaging
Transport packaging
RFID
RFID


Waste
back
Hand bag
Waste
back and reuse
back and reuse
Waste
Local Warehouse
Offline store
Users
Collection Company
E-commerce Platform
Logistics Partner
Secon-hand E-commerce Platform
Pick-up Point

packaging

In the third solution, our idea is to integrate primary packaging and transport packaging with RFID technology. This approach aims to reduce the variety of packaging types and enable the packaging to be reused throughout the supply chain. By combining primary and transport packaging with RFID (Radio Frequency Identification) technology, each package can be tracked and managed more efficiently. The RFID tags embedded in the packaging will store unique identification information, which can be read by RFID scanners throughout the supply chain. This integration helps monitor the location and status of products in real time.

Firstly, integrated RFID packaging can make it easier for companies to recycle and reuse packaging. This is because RFID technology can be easily identified during the recycling process, ensuring that packaging materials can be used multiple times, thus reducing waste and resource consumption.

Secondly, integrated RFID packaging can facilitate better recycling of packaging materials. RFID tags provide detailed information about the packaging materials, including their composition and processing methods. This helps recycling facilities to more efficiently sort and process different types of packaging materials, improving recycling rates and quality.

Additionally, integrated RFID packaging can integrate the packaging as part of the product. This means that the packaging is not just a one-time-use container, but can interact with the product itself through RFID technology, providing additional functions and value, such as inventory management, anti-counterfeiting, and customer interaction.

Overall, integrated RFID packaging achieves the goals of environmental protection and smart management by optimizing packaging recycling and reuse, enhancing recycling efficiency, and integrating packaging with the product.

We chose RFID because it offers a unique identifier (UID) without the need for human intervention, providing significant advantages in supply chain management. RFID systems use electromagnetic waves to transmit data wirelessly, particularly for automatic identification, data capture, and tracking purposes. The bidirectional data transmission method includes transponders or tags (located on the object to be identified) and interrogators or readers, which communicate between the tags and the supply chain.[319]

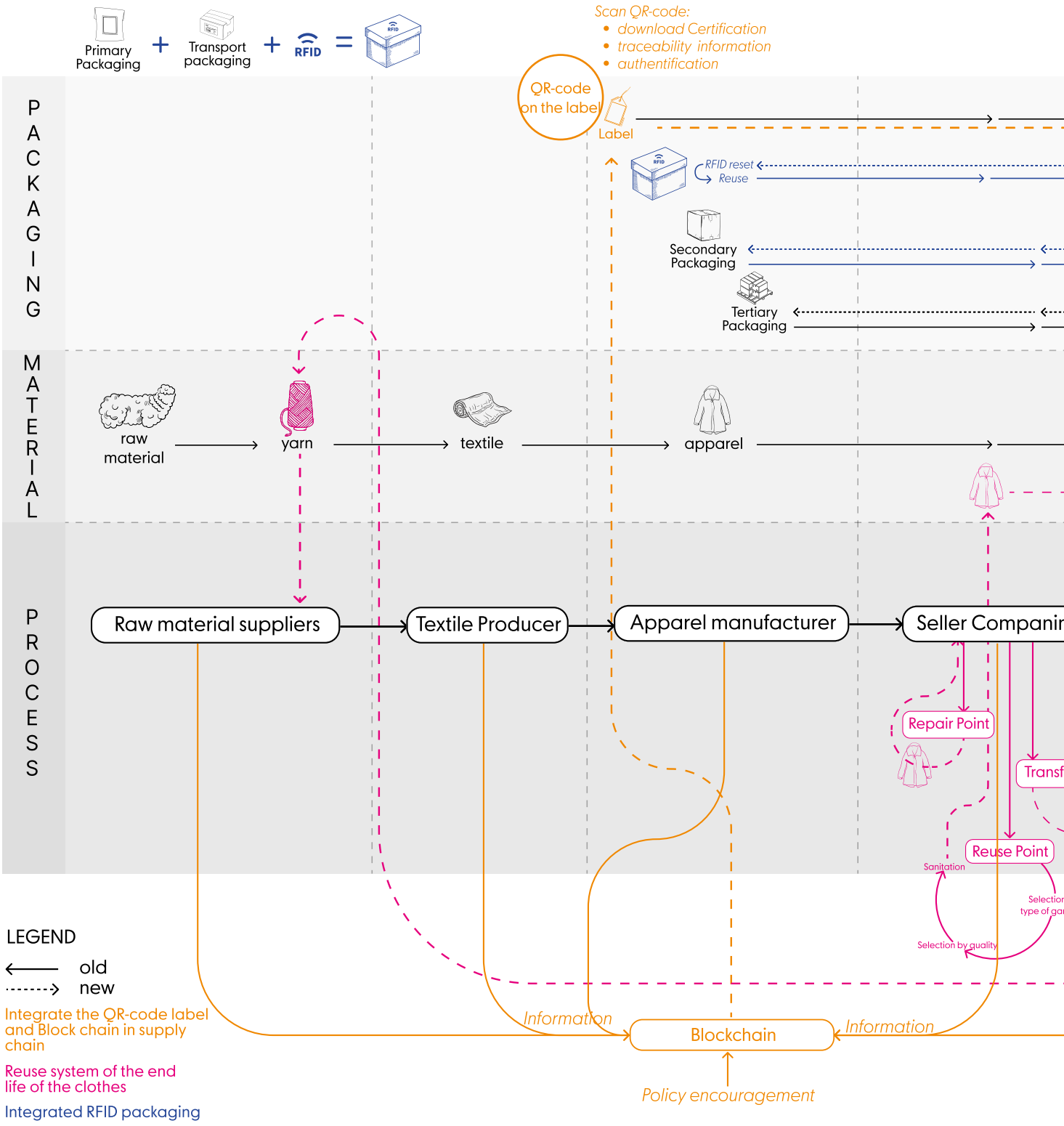
When users receive the product, they can choose to return the packaging to designated locations such as offline stores, logistic pickup points, or logistics partners. These points are responsible for collecting used packaging and sending it back to the manufacturer. Upon return, the RFID tags in the packaging are reset, and the packaging is refurbished if necessary, allowing it to be reused for new products. This process significantly reduces waste and promotes a circular economy in the fashion industry.

Users receive the product and can scan the QR code on the label to access product information. After using the

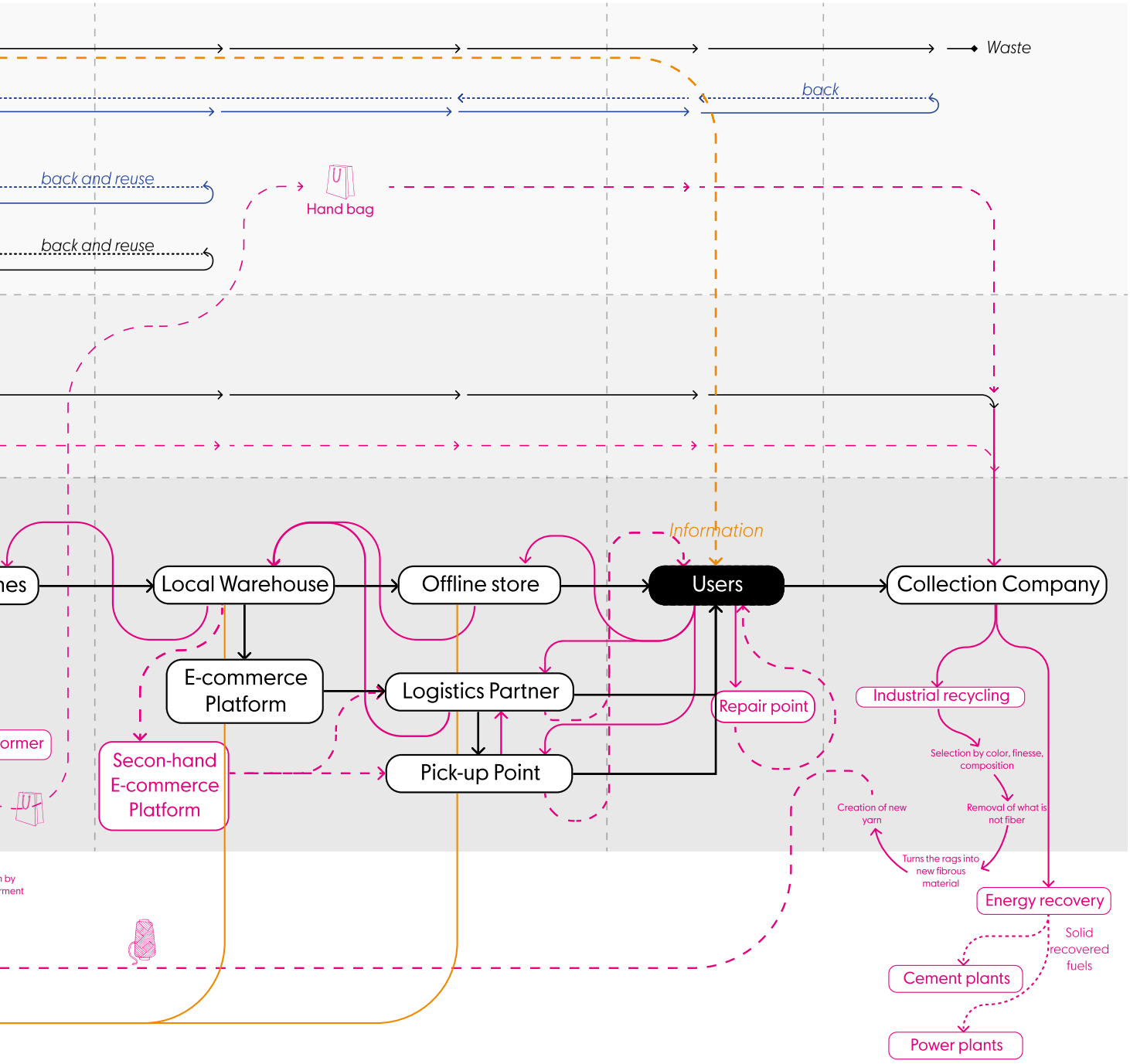
product, they can follow the recycling information provided on the label to return the packaging to designated points, participating in the recycling and reuse process. The recycled packaging is collected by logistics partners and sent back to the manufacturer, where the RFID tags are reset, and the packaging is checked for refurbishment. The packaging can then be reused for new products.

This solution not only addresses the issue of packaging waste but also enhances the overall efficiency and sustainability of the supply chain. By utilizing RFID technology, it ensures effective tracking, reuse, and recycling of packaging materials, promoting a more sustainable fashion industry.

4.4.4 WHOLE NEW SYSTEM DIAGRAM



Whole New



System Diagram

4.4.5 ROADMAP

After presenting the different solutions, implementing the selected opportunities within the new system, showing the new connections, Material and intangible flows and the new actors involved need to develop a roadmap to properly manage the transition from the old system to the new one. The roadmap is based on the definition of a logical and functional step sequence that allows a progressive integration of the new solutions by distributing the implementation steps over a period of time. In our drafting of the roadmap, we have considered three different time frames, short term, medium term and long term, that go to represent a frame of time indicatively of two years for the short term, five years for the medium term and ten years for the long term.
As mentioned above, we outlined the roadmap as if the company decided to implement all three solution packages. Below we will analyze specifically the implementation of each of the solutions.

REUSE SYSTEM OF THE END LIFE OF THE CLOTHES

Bearing in mind the desire to implement all three solutions by the same company, The first solution that will be implemented is that concerning the system of reuse of the end of life of the clothes as it takes more time to be implemented than the other solutions.
In order to apply this solution, the company must make new collaboration agreements and carry out internal reorganizations. For this reason, in a first period it is necessary to carry out a part of research and planning in order to design the reorganization and optimize the physical time that will require the actual reorganization. In particular, the reorganization involves spaces, warehouses and personnel as, this solution provides for the return to the company of a large amount of clothes that the company must store, organize, work and re-enter the market. For this reason, given the vast number of clothes that the company has to manage, first it is necessary to carry out a reorganization of spaces, warehouses and staff. Staff will have to be assigned to new jobs, or they will have to be introduced to a new way of handling clothing.
The agreements that must be concluded concern the company and the waste collection company that will take care of the selection and division of clothes also according to the brand and then will have to provide the company. An ulterior agreement will have to be reformulato with the logistic partner as it will have to manage, not only the part of delivery from the

company to the user but also from the user to the company, involving an internal reorganization of the warehouses in order to manage to the best the spaces.

As for the collection of clothes that takes place in the store, in addition to the reorganization within the company of the spaces, the reassignment of the works so that you can carry out repairs and put the clothes back on the market, it is necessary to train and inform the staff present in the stores, as it will not only have to deal with the management of the arrivals of new clothes that are to be displayed in the store but also the collection, management and return of clothing that has been returned by the user, following specific procedures that will have been defined during the planning and research phase, previously carried out. Next, you need to design and prototype the bin that will act as a collector, produce the bins and finally place them in different stores.

All these three activities require different timing, but it is assumed that these three strands can start in the short term, managing to get an agreement before two years, while the development phase is part of the medium term.

The additional service that the company provides is to repair clothes. Since this service is not internal to the company but is carried out on the basis of the collaboration between the company and the tailors present on the territory, first the company will have to carry out a selection process, starting from the publication of the competition notice in order to participate in this collaboration. During the selection period, as the company finds tailors with whom it wants to collaborate it will conclude collaboration agreements. This phase can have a limited time, be open from the launch of the competition until date to be defined or open at regular intervals so as to leave open the channel of collaborations, so as to increase the service offered to its customers and branch out the collaboration in order to make the network of contacts and collaborations wider.

As for the organization of the online platform for selling second-hand clothes, this service will be added as an additional section to the site, if present, or it will have to be created from scratch, if the company is out of it. Since the development of an additional section of the website does not take much time, on a practical level, to be implemented, as opposed to the technical time required for the organisational work behind what is shown on the screen, the planning of the Second-hand platform will leave once the agreements with the logistic partner are taken and that the internal organization of the company in order to receive the dresses that are withdrawn is already almost completed. The creation of the new online section is consequential to the will and to the realization of the system of collection of clothes, therefore, its development will start when the agreements made are sure and will start the implementation for this solution.

The same applies to the transformation of clothes into packaging. Obviously, for it to be feasible it is necessary a phase

of analysis and research to understand how the fabrics obtained from the garments can be processed to make this new packaging, followed by a design and prototyping phase. Being garments that the company knows very well, as they were produced by itself, the search can start even before you actually have the clothes that were returned by the user, allowing you to go ahead with the search, organizing a set of combinations that can be made on the basis of the type of clothing that will be returned, creating a packaging almost standardized but that will have unique combinations of colors and types of fabrics.

Once each of these aspects has been completed, information related to the location of the collection bins must be organized and entered QR-Code, as well as the location of the tailors performing the repair service, the presence of the Second-hand platform and how the fabric packaging was made. All this information, therefore, will be organized, designed and inserted within the QR-Code, so as to be shown when scanned.

One of the fundamental aspects for this solution to work, in addition to the logistic-organizational part is also the active role of the user. In fact, a fundamental aspect is the part of communication to the user. This phase must start several times before, even before all the other phases are completed, so as to prepare the user for this new service, arousing curiosity, so as to stimulate participation. The communication will not be exclusively by the QR-Code present on clothing, which will still have a very important role, but it will be necessary to carry out an advertising campaign so as to get as many people as possible, and not only after they have already made the purchase.

To implement this solution, it was decided to start from a single Italian region and then extend this service throughout Italy. This is due to the fact that the waste collection companies are not the same in all regions, the number of stores placed on the territory where to add the collection bins and tailors who will carry out repairs also. Therefore, it is assumed that in the medium term all these solutions can be implemented and that in the long term the network of action will be implemented until it reaches the entire national territory. Moreover, in the long term, the company, applying this package of solutions will be able to achieve and meet one of the 2030 objectives of the sustainable development agenda, as already mentioned in the section concerning this solution.

INTEGRATE THE QR-CODE LABEL AND BLOCK CHAIN IN SUPPLY CHAIN

The implementation of the QR-Code in the production of clothes is the greatest vehicle of information and communication between the company and the user. The QR-Code will turn out to be the "frontman" of the company towards the user, and will collect all the information that comes also from the other solutions. For this reason, we will start to design and insert the QR-Code in the production, once the implementation of the other two solutions will be started. The presence of the QR-Code in clothing can also be introduced before the other solutions and information are completed, as it can already provide more basic information, such as advice on washing clothes, or on the materials used, also be able to provide information related to the authenticity and sustainable mode of production, as, at the same time, the company will begin to set and send information to the blockchain, entering into agreements with new or existing suppliers, so as to make production 100% traceable, making the production and supply chain transparent. Being both tied to the communication, these two aspects are not fixed but in continuous reworking, as they will be added information related to the new services offered, through a continuous update of the QR-Code and this also applies to the blockchain as each new collaboration involves new data inserts in the blockchain. In the long term, therefore, an increment of the traceability of the supply chain will be had.

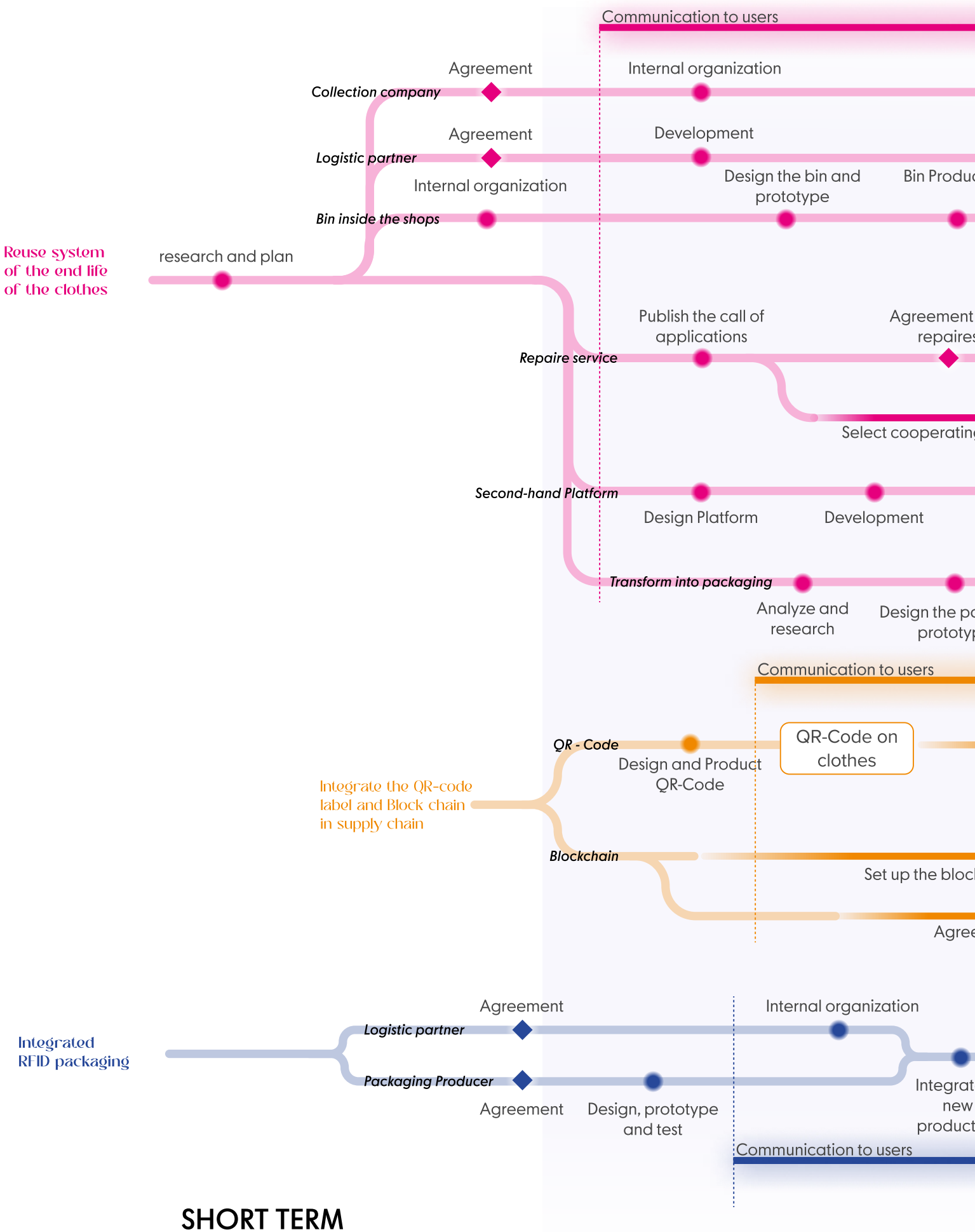
Before the new garments are placed on the market with the QR-Code, it is necessary to inform people of the presence of this new element in the garment label. Usually, when this kind of trick is used to provide more information, the packaging surface is used to use phrases such as "do you want to know more? Scan me!" but one problem with the label on the clothes is that it must be as unobtrusive as possible but at the same time provide as much information. Therefore, we must optimize the best communication by moving this kind of message, from the label to advertising so as to be effective in communicating the same without affecting the comfort of the garment that, having a long label could annoy the user especially if it is in direct contact with the skin. Advertising, therefore, should start before the launch of the product, to inform future users of this novelty and continue later to update them on all the additional information that will be implemented.

INTEGRATED RFID PACKAGING

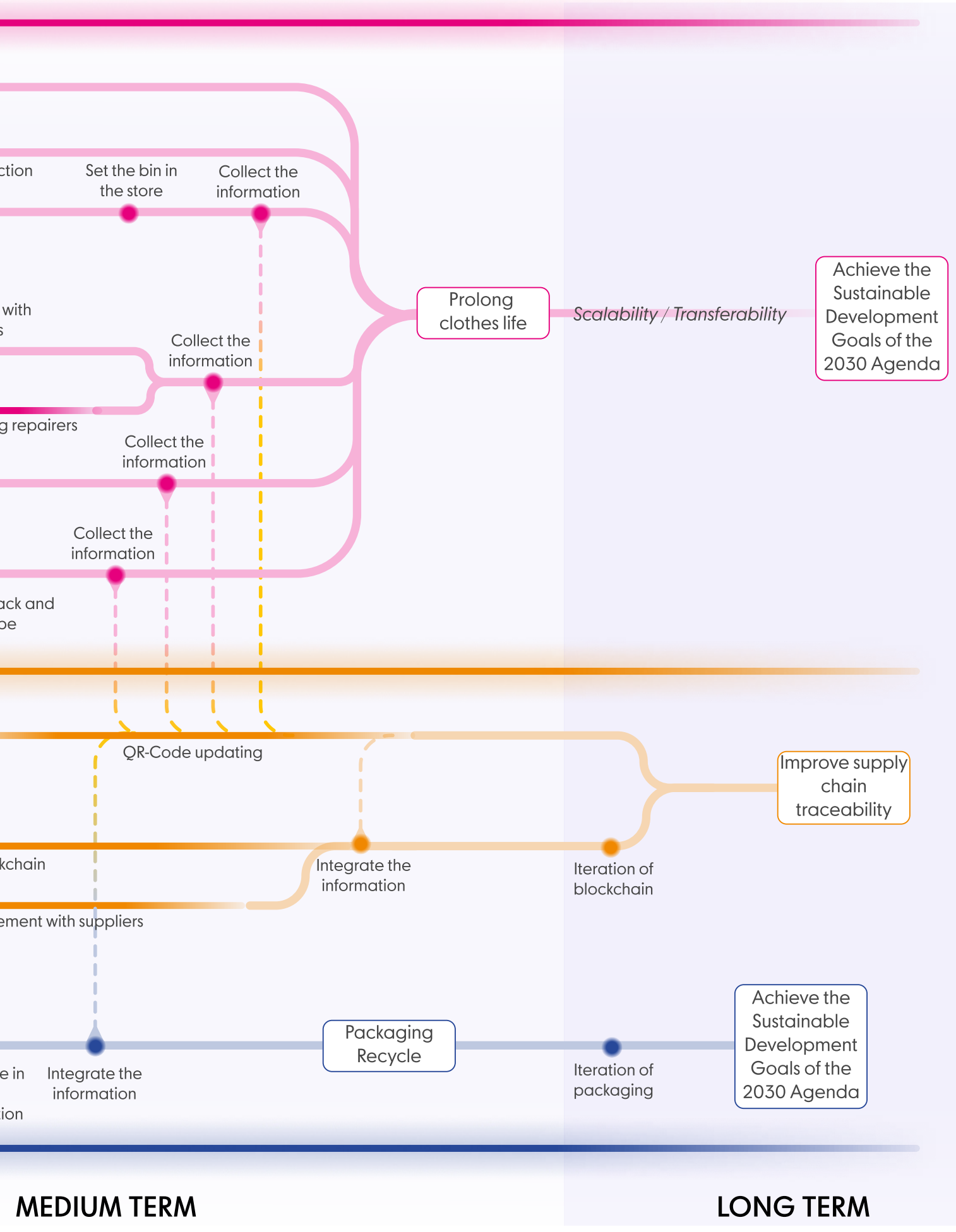
The third solution is not strictly linked to the other two, as the two previously presented are interconnected because the inclusion of an RFID Tag in the packaging does not require the implementation of the other two. In fact, to be able to integrate this solution it is necessary that the company tightens two agreements, one with the logistic partner as it will have to reorganize the delivery system, as it is previewed that the new packaging is returned once the package is been opened. The second collaboration agreement must be signed with the new supplier and packaging producer partner. Once the agreement has been concluded, the design, prototyping and testing of the new packaging begins. Once completed, it can be integrated into the production phase and placed on the market. Obviously there is a correlation between this and the previous solution, linked to the fact that information will be provided to the user about the use of a more sustainable packaging and the new collaboration with the packaging company. This information will be processed and inserted within the QR-Code as this aspect is also part of the production chain and therefore must be traceable, transparent and entirely made in Italy. Thanks to the implementation of this solution, a reusable and easily recyclable packaging is obtained and therefore, in the long term, one of the objectives of the 2030 sustainable development agenda is met. .

Below we show how these three solutions integrate with each other, as they are interconnected, outlining a roadmap including all three solutions.

Roadmap



SHORT TERM


ction
Set the bin in the store
Collect the information
with
s
Collect the information
g repairers
Collect the information
Collect the information
ack and
oe
Prolong clothes life
Scalability / Transferability
Achieve the Sustainable Development Goals of the 2030 Agenda
QR-Code updating
Improve supply chain traceability
kchain
Integrate the information
Iteration of blockchain
ement with suppliers
Packaging Recycle
e in
ion
Integrate the information
Iteration of packaging
Achieve the Sustainable Development Goals of the 2030 Agenda
MEDIUM TERM
LONG TERM

4.5 EVALUATE THE SYSTEM

Having outlined the new system and drawn up the roadmap, it is necessary to evaluate the new system, including all three solutions applied together, going to quantify the outcomes of the project and imagine its possible impacts in different thematic areas and operating in terms of timeframes and scales. The term outcomes means a quantifiable or measurable result that emerges from the new systemic model. Impact, on the other hand, refers to consequences that cannot be determined in quantitative terms but can be defined in a qualitative way. Outcomes and impacts can be linked to different thematic areas such as the environment, society, economy and culture. In addition, it is important to evaluate outcomes and impacts by considering their development over time, considering a reference timeframe. Our evaluation was made using the same timeframes used in the roadmap, so shot tem that indicates the first two years, medium term ranging from two to five years and long term ranging from five to ten and more years. Finally, outcomes and impacts have been evaluated based on different scales, micro scales if they involve only the company itself, meso scales if they also involve external actors, macro scales if they impact at the national and international level.

The identification of outcomes and impact was carried out on all three packages of solutions that we are going to analyze in detail.

REUSE SYSTEM OF THE END LIFE OF THE CLOTHES

In short time, the first consequences that the first solution entails are a more efficient use of resources, because by reusing the garments that would otherwise have been thrown away and transforming those not recoverable again into yarn, You don't buy raw materials again. This allows to have an economization of production and a reduction of the expenses that the company must bear, both in terms of supply, in terms of production, that of taxes to be paid for the disposal of waste. This affects both the environment and the economy. The fact that we do not have to produce the same amount of raw materials, as resources that have already been extracted from the ecosystem are being reused in production, This reduces, in the medium term, the weight that the company has on the ecosystem and in the long term this allows you to give time to the ecosystem of regeneration. Thanks to the saving of money that the company has had, it, in the medium term will have a greater investment power that can be invested in research and

development. This investment power can also allow to create new collaborations, also due to the reduction of production costs, allowing to shorten the value chain, making, over time, more resilient system and enhance the Made in Italy.
This solution also generates consequences at the social level, as, by actively involving people increases awareness about environmental protection and reuse issues, going then, in a medium period to change the behavior of people, accustom them to a more conscious consumption and to pay more attention to the environment and to their choices.

INTEGRATE THE QR-CODE LABEL AND BLOCK CHAIN IN SUPPLY CHAIN

The use of the blockchain allows to optimize the logistic processes as there is a greater exchange of information and a continuous monitoring. This, over time allows to increase efficiency and also increases the transparency of the supply chain that leads to a valorization of the territory both because the production will be more sustainable, both because it will move more nationwide, exploiting the excellence of the territory, affecting in a positive way both the environment and national culture.
Thanks to the combined application of the blockchain, which ensures traceability showing a more sustainable production and the presence of the QR-Code that communicates this traceability and sustainability to the user, this allows to increase, in the medium term, awareness of the sustainability of people, because it places the emphasis on the best practices undertaken by the company and also acts on the actions and choices of purchase and consumption that the user undertakes at the time of purchase and end of life of a product. This change in behaviour and in doing more sustainable actions can also have repercussions in other aspects of life, or in other purchasing phases. This new mentality, which is expressed in actions, has repercussions in the long term on a lower impact on the ecosystem and therefore on its improvement.
The use of the blockchain, which involves a transparent statement of how a garment is produced, also declares the working conditions to which workers are subjected. It implies that production takes place in Italy and that therefore working conditions and safety are those laid down by European and Italian regulations. This leads to an increase in the well-being of workers, who, in a healthier and well-being environment, improve their work performance by reducing the risk of mistakes due to fatigue or stress, making the workplace a safer place.
In order for the traceability system based on blockchain technology to be effective, a full collaboration is necessary from all the suppliers of the company, this increases the collaborations and the trust between supplier and company, because the

data inserted in the blockchain are totally transparent, so it also acts as a guarantee for the company on the quality and sustainability of the production of its suppliers. The confidence built up along the supply chain makes the system more resilient in the long run.

In addition, this solution promotes a sustainable fashion and that is based on an entirely Italian production, this involves an exaltation of the quality of Made in Italy and its attention to issues related to sustainability, making this point part of the heritage that this "brand" brings with it.

INTEGRATED RFID PACKAGING

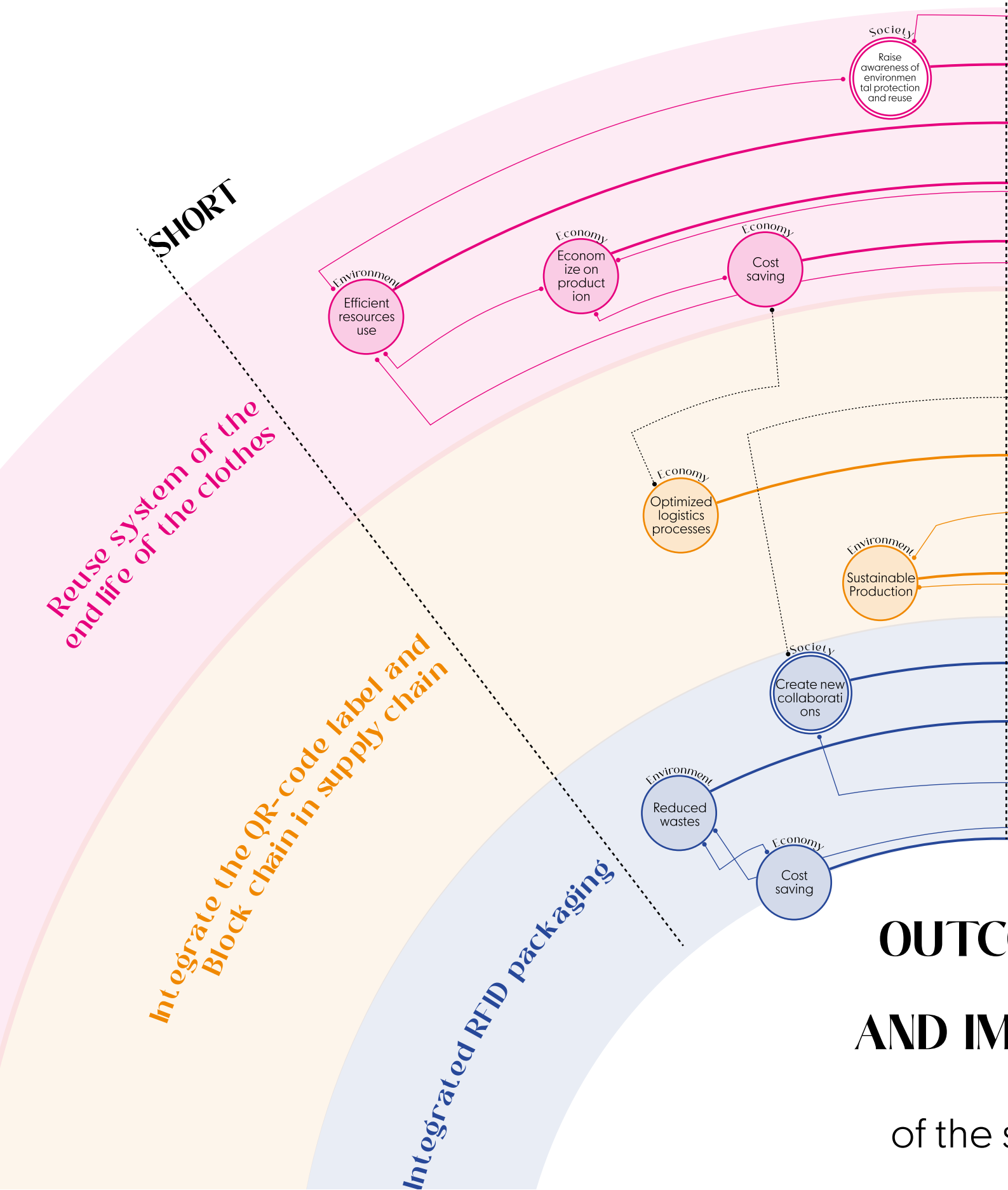
In order for the traceability system based on blockchain technology to be effective, a full collaboration is necessary from all the suppliers of the company, this increases the collaborations and the trust between supplier and company, because the data inserted in the blockchain are totally transparent, so it also acts as a guarantee for the company on the quality and sustainability of the production of its suppliers. The confidence built up along the supply chain makes the system more resilient in the long run.

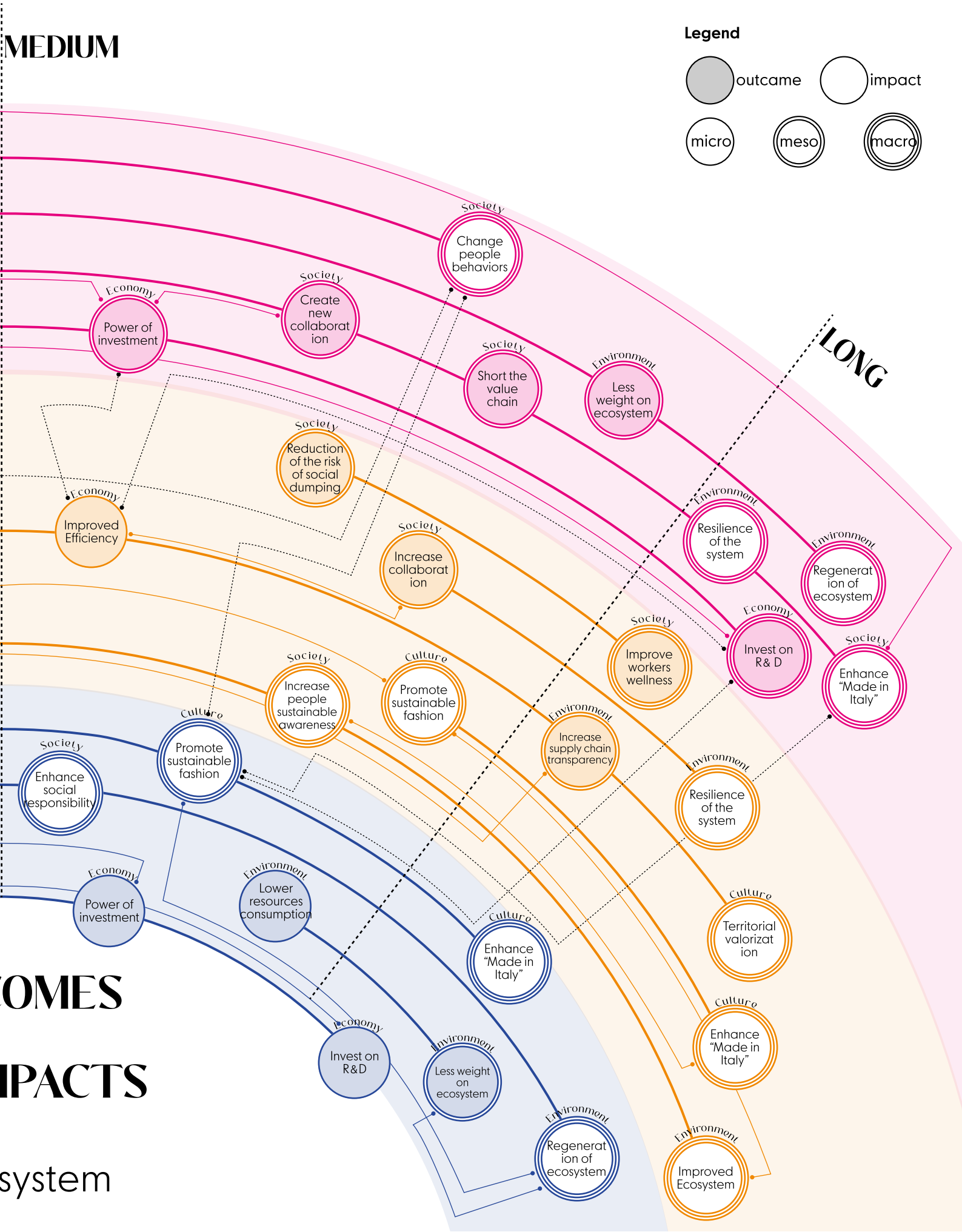
In addition, this solution promotes a sustainable fashion and that is based on an entirely Italian production, this involves an exaltation of the quality of Made in Italy and its attention to issues related to sustainability, making this point part of the heritage that this "brand" brings with it.

Below we show the map of outcomes and impacts related to the three solutions, dividing them on the basis of time, and scale. In addition, the main connections between outcomes and impact are shown, that is, the consequentially direct connections, and also indirect connections are shown, that occur both between the impacts and outcomes generated by the same solution but also between different solutions, so but show the evaluation in its entirety, on all the new system that has been designed.

analysis of the system

Evaluate the system




MEDIUM
Legend
outcame
impact
micro
meso
macro
LONG
Society
Change people behaviors
Economy
Power of investment
Society
Create new collaborat ion
Society
Short the value chain
Environment
Less weight on ecosystem
Society
Reduction of the risk of social dumping
Economy
Improved Efficiency
Society
Increase collaborat ion
Environment
Resilience of the system
Environment
Regenerat ion of ecosystem
Economy
Invest on R& D
Society
Enhance "Made in Italy"
Society
Improve workers wellness
Society
Increase people sustainable awareness
Culture
Promote sustainable fashion
Environment
Increase supply chain transparency
Culture
Promote sustainable fashion
Society
Enhance social responsibility
Environment
Resilience of the system
Economy
Power of investment
Environment
Lower resources consumption
Culture
Territorial valorizat ion
Culture
Enhance "Made in Italy"
Economy
Invest on R&D
Environment
Less weight on ecosystem
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Enhance "Made in Italy"
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Regenerat ion of ecosystem
Environment
Improved Ecosystem
COMES
IPACTS
system

4.6 A MORE SUSTAINABLE FASHION: PRESENT AND POSSIBLE FUTURE

Second hand fashion in recent years, especially after the increased awareness of sustainability following the COVID-19 pandemic, is a growing and evolving market, as evidenced in the Vestiaire Collective Report with the Boston Consulting Group of 2022. The report estimates the value of the second-hand fashion and luxury market at 100-120 billion dollars, three times higher than in the previous three years, assuming an increase of 20-30% per year. This type of market is driven by the younger generation who seek to go beyond seasonal trends and embrace circularity. [320]
According to Maria Carmela Ostillio, professor of brand management at Bocconi University in an article by Elle, the socio-economic motivations of the revaluation of Luxury second hand have become "una pratica di stile di vita sostenibile" (a sustainable lifestyle practice) also because "la longevità intrinseca nei beni di lusso supporta l'economia circolare [...] per le imprese che devono in qualche modo contribuire alla transizione ecologica in atto" (The inherent longevity in luxury goods supports the circular economy [...] for businesses that have to somehow contribute to the ongoing ecological transition). [321]
Companies can not only reduce water and fabric waste and CO2 emissions by acting on production and distribution, but also by acting on the end of product life.
The same semantic enhancement of the concept of "second hand" that becomes "pre-owned" or "pre-loved" attests to an implicit recognition of the value that luxury clothing maintains over time, deserving revaluation and new life. Even large stores like La Rinascente, with its temporary "Vintage is calling" space, have opened a corner dedicated to used goods. [322]
In the world there are many companies linked to the world of fashion that are following eco-sustainable paths. In Italy companies such as WILDTEE [323] and OWN [324] use recycled yarns in whole or in part.
A wider range of action has RIFÒ [325], which collects wool, cashmere or jeans garments even at home and makes them regenerated yarns or reintroduces them on the market through the network of second hand shops AND Circular. [326]
The work of collecting and sorting is carried out by a social cooperative investing also on people to make integration an additional factor of development.
A further step in reviving second-hand garments is taken by ARTKNIT Studios, which with its IMPERFECT SELECTION repairs and refurbishes garments with imperfections, made or used for photo shoots. Reconditioned, modified or sampled garments thus acquire their own uniqueness. [327]
In the solution regarding the reuse system proposed in the thesis it is assumed that any changes and repairs on a used garment of high fashion, made in laboratories of the brand itself, would satisfy the desire for rarity or even uniqueness that the buyer of a garment signed research, so that the

repair becomes added value of the object.
As for haute couture, Gucci is active on many fronts related to sustainability and the second life of products and materials of the past. It has created a global network of service centers for repairs carried out by experienced craftsmen. The Gucci Vintage line is made up of old clothes that have been refurbished. The Maison has been among the leading players in the luxury secondary market, in 2020, it partnered with TheRealReal for a temporary used clothing online store and partnered with Gucci Preloved with Vestiaire Collective to trade selected Gucci items in 28 stores across Europe. The Denim Project of the Maison is related to the production of jeans with partly recycled materials, partly produced in an eco-sustainable way and labeled with digital passport that traces the path from raw materials to production, in addition to providing information on product care and repair services and deserved the "Ellen MacArthur Foundation Award for Circular Economy" at the CNMI Sustainable Fashion Awards 2023. [328]
Digital labels to access the Digital Product Passport are also used by the company Save the Duck in order not only to authenticate their garment, but also to make automatic and immediate for the customer the connection with the eBay platform inviting in this way to re-enter the market the garment abandoned instead of turning it into waste. [329]
A company that declares its commitment to the environment also in its name, as well as in the use of used materials, testifies to its high standards of social and environmental performance, transparency and accountability also having obtained the B Corp certification.
Within the network of companies with B Corp certification there is also SEAY, which applies the circular economy model Re3 that reduces the environmental impact of used garments. The QR-Code on the tag allows the buyer of a new garment to trace the destination of the old garment left in the "Give it back bin" in the store or returned free of charge online. The customer is tempted to join as this way gets a discount. Used garments can be resold as vintage, donated to charity or regenerated to produce new products. [330]
Even a legendary Maison like Valentino created in 2021 a circular system in which customers could exchange their Valentino dresses in seven selected vintage boutiques: this is the Valentino Vintage initiative, in Milan, Tokyo, New York, Los Angeles and is back in a second edition also in London, Paris and Seoul. [331]
The company par excellence in the recovery of its used clothes is definitely the American Patagonia.
Already between 2016 and 2018 countless Patagonia garments have been repaired and put back on sale in the brand's pop-up stores in London, Berlin and Milan.
The next choice was to open, in 2022, a permanent Worn Wear space in the Patagonia store in Berlin, for both adults and children, with the intention of extending, in the future, the initiative in other stores around the world.
The policy of giving priority to repair over replacement means that repair centres can be found in the Patagonia shops in Berlin, Stockholm, Amsterdam and Milan, which customers can use.
In all Patagonia stores it is however

possible to bring the garment to be repaired that will be shipped to one of the specialized European centers of the brand.
If recovery is not possible, the Patagonia team contacts the customer to propose possible options for recycling at the end of life. [332] [333]
The philosophy behind this company policy is that a repaired product brings with it and tells a story, "repairing" even the emotional relationship between itself and its owner. Although it is no longer perfect, the object acquires an added value, as could happen to the haute couture garment repaired creatively by craftsmen of the brand itself and that in that way, from "must have" object, becomes truly unique and therefore even more exclusive.

In addition to complying with the obligations related to current legislation, companies engaged in the field of eco-sustainability pay great attention to the packaging of their products, with innovative solutions at the forefront.
Rifò has created Fluffypack, an eco-sustainable and reusable packaging in regenerated felt that gives new life to textile waste composed of non-recyclable mixed fibers for clothing, saving them from landfill. Fluffypack is tested to protect Rifò purchases from water and weather during expeditions. [334]
Artknit Studio uses a completely plastic-free packaging, in a recycled cardboard box wrapped in a biodegradable envelope, for online shopping shipments. [335]
The Maison Gucci, in addition to using recycled polyester handles for the packaging of products purchased in boutique dyed paper paste and to avoid the use of glue, provides dustbag in recycled cotton with details in recycled polyester. In addition, it employs for e-commerce, reusable cotton tote bag, all the paper comes from responsible sources. The box used is reversible, in order to be reused for the eventual return, and has been designed so that its volume serves to optimize the bulk in transport, to reduce the environmental impact of the movement of vehicles used for deliveries. [336]
The Maison Valentino also uses 100% recycled cotton dustbags and paper from "sustainably managed forests" or recycled; the white paper used for greeting cards consists of bamboo and cotton fiber, as well as pendants. [337]

Many companies are therefore working in the direction of sustainable production, exploitation of resources, the reduction of waste generation through the reuse and regeneration of its products also increasing customer awareness in their purchasing and consumption choices. It is therefore conceivable and desirable that more and more companies in the fashion world implement behaviors in line with sustainability, also adopting the solutions designed in this thesis.


Legend
Known at italian level
Known worldwide
Of the company
Out of the comany
Brand popularity
Recycled yarn
Repair service
Take back service
Sell second hand garments
Second hand e-commerce platform
QR-Code label
Recyclable Packaging
WILDTEE
OWN
RIFÒ
ARTKNIT
Gucci
Save the Duck
SEAY
Valentino
Patagonia

In the last chart, we conducted a detailed analysis of multiple brands in terms of sustainability and circular economy. This analysis included various dimensions such as brand popularity, the use of recycled yarn, provision of repair services, take-back services, second-hand garment sales, second-hand e-commerce platforms, QR code labels, and recyclable packaging. Through a comprehensive evaluation of these dimensions, we found that Gucci, Valentino, and Patagonia performed the best in these areas. Gucci, as a globally recognized brand, excelled in all evaluated dimensions, including the use of recycled yarn, provision of repair and take-back services, sales of second-hand garments, and the adoption of recyclable packaging. Valentino exhibited similar comprehensiveness, although it lacked in the second-hand e-commerce platform area. Patagonia, not only renowned worldwide, but also excelled in every evaluated dimension, demonstrating their strong commitment to sustainability.

Other brands like Rifò, ARTKNIT, SEAY, and Save the Duck, despite their high popularity in Italy and good performance in areas like recycled yarn, repair services, take-back services, and recyclable packaging, still have room for improvement compared to Gucci, Valentino, and Patagonia. WILDTEE and OWN, although invested in recycled yarn and recyclable packaging, do not have as comprehensive a sustainability strategy overall.

Based on these analysis results, we can conclude that Gucci, Valentino, and Patagonia are the most comprehensive in terms of sustainability and circular economy, aligning closely with our system strategy. These brands can further utilize our system strategy to enhance their competitiveness in the field of sustainability, thereby securing a more favorable position in the global market. This not only helps improve their brand image but also ensures long-term success in an ever-changing market environment.

4.7 CONCLUSION

In a world where the drive to consumerism has led to a continuous search for the new, the latest model, there has been an overproduction of goods that has resulted in huge damage to the ecosystem, since one of the main problems of our time is the generation of waste. They could be considered reusable resources but are thrown away as if their value were non-existent. This also happens for products whose intrinsic value is also qualitative, at the time of purchase was very high, such as the products of the fashion world Made in Italy. In addition, each product purchased has its own packaging which in turn becomes a waste and often provides only part of the information that would be useful or of interest to the customer.
The systemic approach, from which the systemic design is derived, identifies the relations between the parts of a system as elements that generate the system itself, in which the whole is greater than the sum of the single parts. The value of a system, in fact, is not only linked to the individual nodes that constitute it but also by the relationships between them. This approach focuses on the flow of matter, energy and information, so that we can develop a system that, inspired by nature, does not generate waste, because in nature nothing is a waste and everything has value because the output of one process becomes input for another.
The systemic approach outlines a design methodology that allows to analyze complex systems within its own context, detect their problems and outline solutions that allow to create a new system based on sustainability, connections and people. For these reasons, the systemic methodology can be a valuable ally to address the problem in question in its complexity.

Adopting the entire Italian territory as the boundary of the system, the thesis project aimed to investigate the problems and potential of the Italian fashion industry and the packaging it uses, to identify design strategies for more sustainable and conscious production and consumption.
Therefore, two fields of analysis have been defined: the context of the fashion world in relation to the Italian national territory and the functions and technological applications on packaging. This has allowed to understand the functioning of the fashion system by means of a Holistic Diagnosis and to identify a framework of good practices already put in place by companies to solve the emerging problems.
By linking critical issues and opportunities that have emerged from the two fields of analysis, the following areas of intervention have been identified:

- Communication and traceability: on garments, the information generally provided is often reduced, as they do not have a permanent packaging apart from the label. Because of this, the information provided is limited to those required by law, including the declaration of origin of the product, which states

where it was produced. This aspect, however, due to the regulations currently in force, does not fully state where the product has actually been processed, as the words "Made in Italy" can be legally applied if only two of the production steps have been carried out in Italy. This unclear statement, leads to "delude" the user on the real ways of production and where they happened, declaring a quality and sustainability production actually implemented only in part. The limited communication between the user and the manufacturer leads to a misinterpretation of the little information provided, putting on the same level companies that adopt a sustainable production with others that do not. Furthermore, there is no clear indication regarding the end of life of the garment, so the user often does not know where to throw the garments, opting to throw them in the bin of general waste.

- End of life: the continuous production of new garments dictated by the seasons of fashion leads to a rapid change of garments inside the user's cabinets implying the disposal of garments still in perfect condition. Linked to the problems of disposal, there is also a lack of knowledge, by the user, of the ways in which it is possible to dispose of the garment, causing it to act, even if in good faith, in the wrong way. This "waste" of resources still perfectly usable is even more aggravated by the fact that, due to the low production of raw materials on the Italian territory, They are imported at low cost from countries far away from Italy that have less restrictive environmental policies than those in the European Union.
- Packaging: the packaging has many functions that it must perform, such as containing and protecting the product, but also providing an unforgettable experience to the user when opening, especially following an online purchase. This leads to an excessive use of materials, such as the use of over packaging applied by delivery companies, or is used to elicit the "wow effect" in the user when unpacking. All this overuse of matter, finished its short period of utility, turns into waste.

The subsequent definition and selection of opportunities arising from the fields of intervention have led to the definition of three strategies that can be integrated. These strategies are based on the systemic principles of sustainability and the creation of connections, putting people at the center.
The communication and traceability strategy involves the application of a smart technology applied to the garment label, in order to: make accessible the information regarding the traceability of the production process guaranteed by the use of blockchain, provide a method of authentication and put the emphasis on sustainable practices implemented by the company, helping you make more informed choices.
The end-of-life strategy aims to extend the life of the product as long as possible by means of a collection, repair and return system. In addition, a repair service is provided in order to postpone as much as possible the

moment of disposal of the garment.
Finally, it provides for the adoption of regenerated yarns instead of virgin raw materials for imports.
Finally, the packaging strategy includes a return and reuse service of the packaging used for e-commerce thanks to the integration of a technological solution on a recyclable packaging.
This technology allows the reuse of such packaging thanks to the possibility of modifying the dematerialized information contained in the technological implementation, without going to customize the packaging that otherwise could not be used for other deliveries.

The objective of these strategic solutions that, while acting on different aspects of the value chain are integrable and complementary, is to make the production of the fashion world more responsible and sustainable, emphasizing the peculiarities and the quality of Made in Italy manufacturing. The proposed solutions provide an overview of possible ways a company could take to reduce its environmental impact.
This thesis has in fact maintained a wider vision of the problems and the solutions, not dwelling on a specific company, as the latter would have presented specific challenges and needs.
The next step to be taken to make these solutions concrete would be to apply them to a particular situation in a more limited territory, so as to select and develop, among all the possibilities proposed, an ad hoc strategy for a single reality in its specific context.

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