Product Passport through Twinning of Circular Value Chains

Deliverable 1.4

Sustainability Balanced Scorecard Framework v2

WP1: Digital Circular Value Chain Framework

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Executive Summary

This deliverable provides the final version of the Sustainability Balanced Scorecard (SBSC) framework of the Plooto project. It describes which KPIs will be taken into and the process of selection and interoperability of these indicators.

The presented KPIs will be taken into account by the pilot partners that selected the more suitable ones for their industrial domain. For clarity and usability, the KPIs are divided in four main categories: Environmental, Social, Governance, Economic and Growth. The responsible partners then collected and analysed the data, feeding the results to Task 3.3 Balanced Scorecard and Sustainability Assessment Service.

In its first section, it is described the concept of Plooto Governance Framework and the specifications of its three main pillars: Business Governance, Data Governance and AI Models Governance. The document then describes the reference frameworks that were taken into consideration and analysed in the definition of the structure of the SBSC. Finally, it also underlines the relations of two tasks – Tasks 1.2 and 1.3 - with the findings and the methodology.

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Acronyms and Abbreviations

Acronym	Description
CDP	Carbon Disclosure Project
CFRP	Carbon Fiber Reinforced Plastics
COD	Chemical Oxygen Demand
CPW	Citrus Processing Waste
CPWW	Citrus Peels Wastewater
CTE	Critical Tracking Event
CTI	Circular Transition Indicators
C2C	Cradle to Cradle
DoA	Description of Action
DoC	Depends on the Case
DPP	Digital Product Passport
DT	Digital Twin
EC	European Commission
EFFAS	European Federation of Financial Analysts Societies
EPR	Extended Producer Responsibility
ERT	European Round Table
ESG	Environmental Social Governance
ESPR	Eco-design for Sustainable Products Regulation
ESRS	European Sustainability Reporting Standards
FAIR	Findable, Accessible, Interoperable, Reusable
FCA	Financial Conduct Authority
GHG	Greenhouse Gas
GRI	Global Reporting Initiative
GT1	Global Traceability Standards
IDSA	International Data Space Association
IMF	Information Modelling Framework
ISO	International Standards Organization
ISSB	International Sustainability Standards Board

Acronym	Description
KPI	Key Performance Indicator
NFRD	Non-Financial Reporting Directive
POV	Proof of Value
Prepreg	Prepreg, or pre-impregnated material, a composite made from reinforcing fibers
SBSC	Sustainability Balanced Scorecard
SDR	Sustainability Disclosure Requirements
SCOR	Supply Chain Operations Reference
WEEE	Waste Electrical and Electronic Equipment

1 Introduction

1.1 Purpose and Scope

The purpose of this report is to give an overview of the Sustainability Balanced Scorecard (SBSC) framework implemented in the Plooto project. Towards this direction, this document introduces the background of this specific framework, the reference frameworks and architectures and the necessities of the use cases that this scheme will tackle. Moreover, it describes the SBSC framework, its architecture and methodology. Finally, it details the selected KPIs inserted in the SBSC.

1.2 Relation with other deliverables

This report is the updated version of D1.3 "Sustainability balanced scorecard framework v1" submitted in Month 12. It is closely linked to deliverable D3.5 "Plooto Balanced Scorecard v1" submitted in Month 18 and its updated version.

1.3 Structure of the document

The rest of the document is structured as follows:

- **Section 2** introduces the Governance Framework, formed by Business, Data and AI models Governance frameworks.
- **Section 3** describes the overall structure of the Sustainability Framework, its mission, and its relation to the other tasks and reference frameworks.
- **Section 4** describes in detail the identified KPIs, the models that are foreseen for this framework and the potential scalability.

1.4 Updates from version 1

The main updates from the previous version are the following:

- New section 2.1 Business Government has been added.
- Section 3.1 Reference Frameworks has been updated with the integration of the newest frameworks and standards (from 3.1.14 onwards).
- Section 3.3 Relations to Tasks 1.2 and 1.3 has been divided into two different sections (3.3 and 3.4) in order to allow partners to better ley down the work performed in these Tasks. Both sections have been completely rewritten to report the work carried out until M24.

2 The Governance Framework

Plooto Governance Framework is structured around three main pillars:

1) The business/collaboration framework: provides the business and operational aspects of the circular supply chains. Mainly, it contains the following:

- The description of the waste value chain along with the definition of the stakeholders, their inputs and outputs.
- The description of the materials/products' flow, along with the necessary conditions for materials transformation.
- The description of the information sharing principles, such as which information is being shared, how information is generated inside the organization and how information is populated in the supply chain.

The work performed for this part of the Governance Framework is reported in deliverable D1.2: Plooto methodological approach and business cases specifications v2. A brief description is given in Section 2.1 of this document.

2) The data governance framework: provides the data ownership principles in line with the International Data Spaces Association (IDSA) principles and specifications. A detailed description is given in Section 2.2 of this document.

3) AI models governance framework: provides the necessary AI models or services liability issues with regards to the ownership of the algorithms, the explainability principles and how users can be engaged in the decision-making process. A detailed description is given in Section 2.3 of this document.

2.1 Business governance

Business governance is about ensuring that all circular and traceability operations are performed in a mutual agreed way ensuring trust and transparency. In the context of Plooto – and following the supply chain Digital Twin (DT) modelling approach adopted in WP2 – the solution should ensure that there is a consensus in all information, asset and Digital Product Passport (DPP) shared among organizations.

This is done through a "negotiation" approach. When a partner requests something (collaboration, shared asset, updates on existing shared asset) this has to be approved by the collaborative party and verified (if needed) from the sender party.

These negotiation flows are applicable in the following actions:

- Collaboration establishment
- Request for shared asset

- edit and update telemetries of shared asset
- DPP template creation (form and info in the DPP to be shared in the supply chain) and shared with the collaborators.

The flows are presented in the figures below:

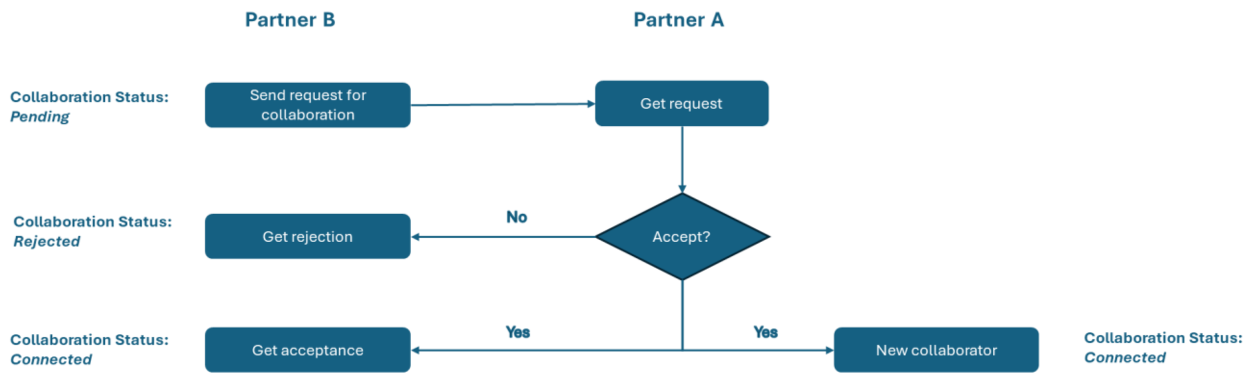

Figure 1: Collaboration establishment

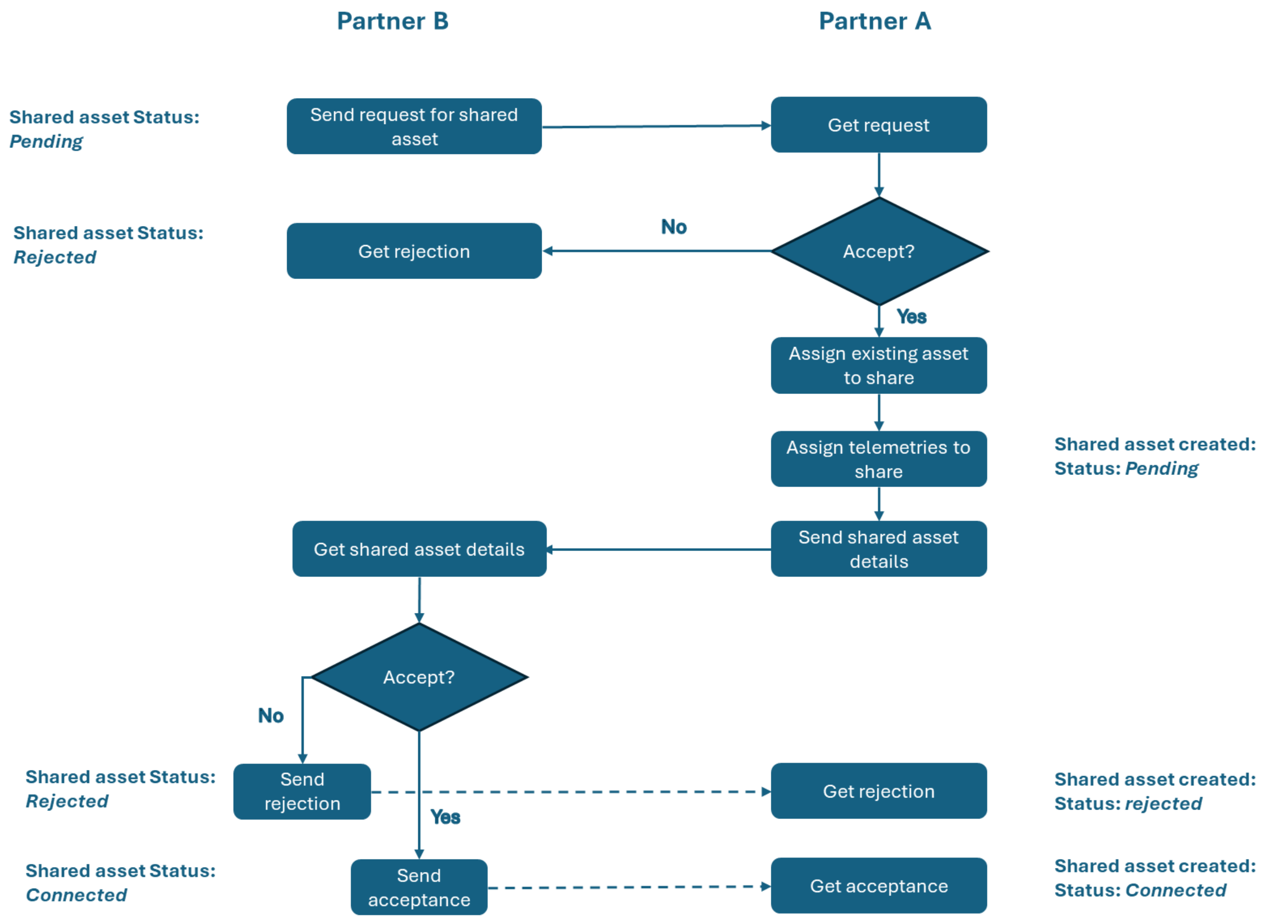

Figure 2: Request for a shared asset

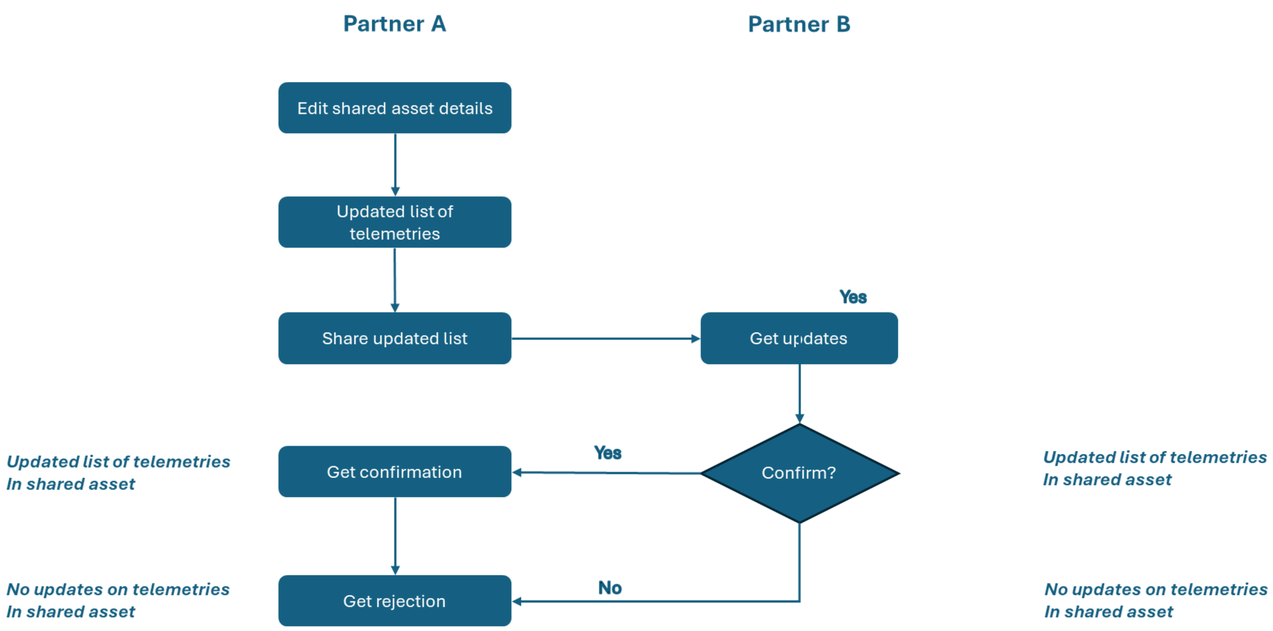

Figure 3: Update list of telemetries in shared asset

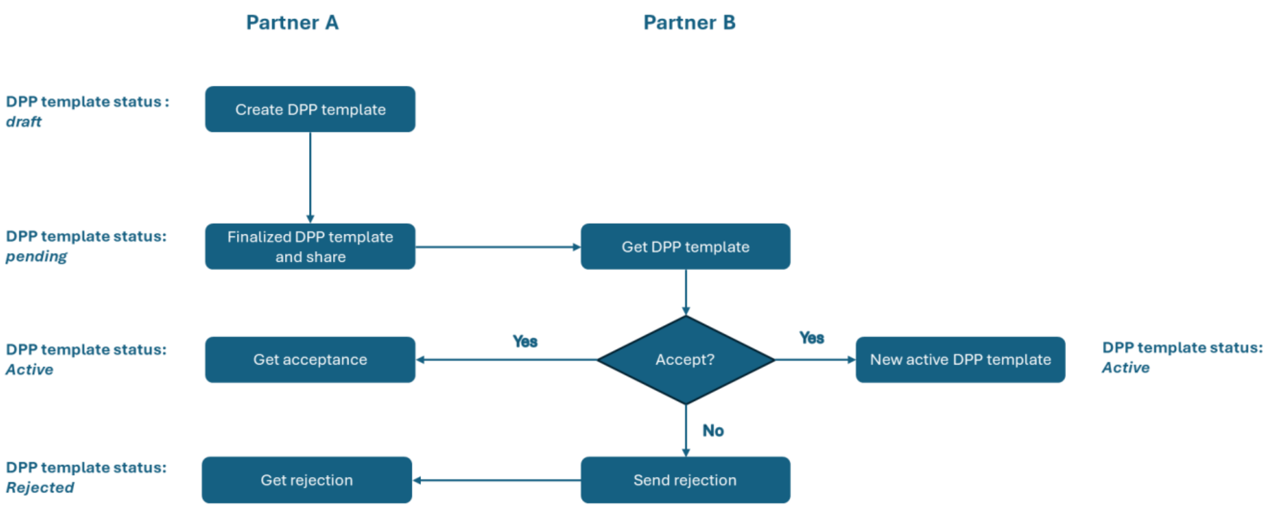

Figure 4: DPP creation

In some cases, the loop request-response can enter loops of request-response. This flow is presented in Figure 5:

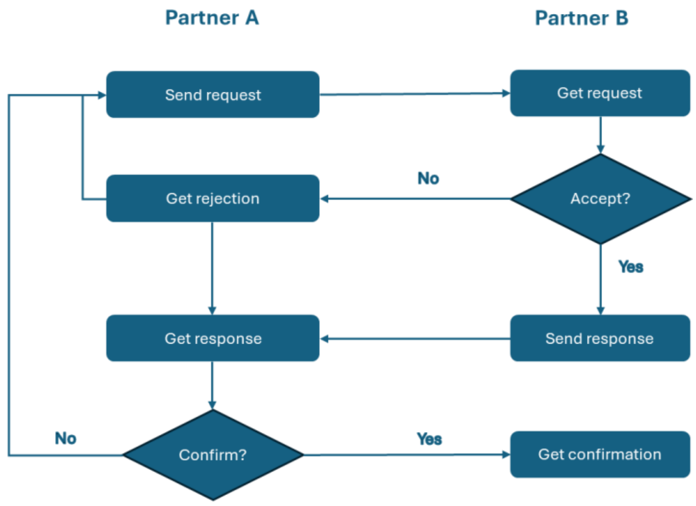

Figure 5: Negotiation loops

2.2 Data governance

Data governance is about liability on the data to be produced, processed and shared. This means that supply chains should encompass a data sharing policy on which ownership and data access is specified. This becomes more critical since Plooto deals not only with monitoring of supply chains but also with the concept of DPP.

Based on the collaboration agreements (business collaboration framework) each stakeholder is responsible to generate the data and make it available to the receipt parties to incorporate it. In the case of DPP, an incremental and aggregation approach is adopted. This means that alongside the supply chain, every material/product that is being shared has a DPP that is sent to the next actor in the network (supply chain). The DPP needs to contain **at least** the information agreed for the production of the final product DPP. This aggregation process is described in Figure 6.

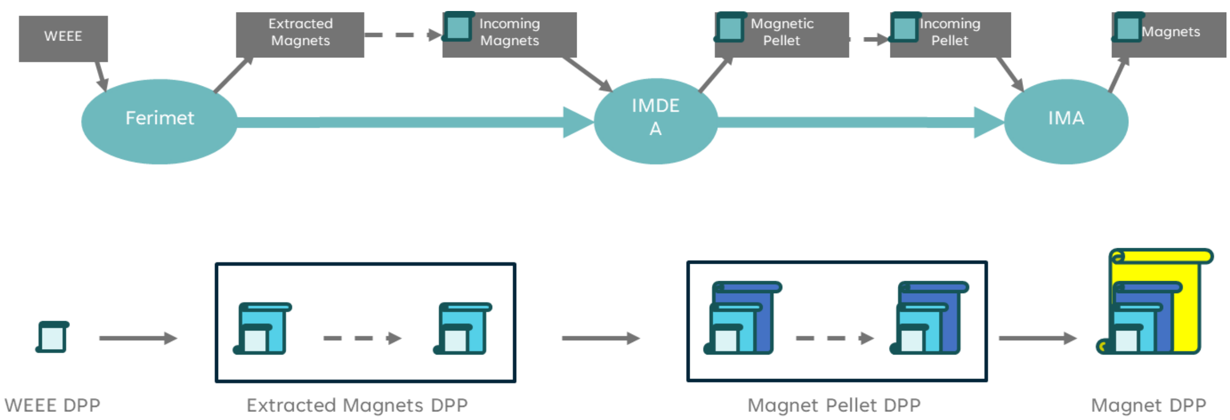

Figure 6: Digital Product Passport aggregation

From a technical perspective, data governance has been implemented following the IDSA specifications. Additionally, Plooto will offer a new functionality of integrating the IDS connector and data sharing principles into a monitoring interface. On this interface, stakeholders will have a complete view of the materials and products' DTs shared within the network. It will also provide tools to monitor access control policies and data-sharing rules defined in the IDS connector. The architecture and technical specifications are analytically described in the CRIS requirements and specifications deliverables (D1.5 and D1.6).

2.3 AI models governance

AI models' governance deals with the principles of liability, explainability and fair operation of the AI models that are embedded in the various services supporting the circular value chains.

Given the fact that value chains can operate different AI-based services, the service provider will have to ensure that the model has the necessary mechanisms for explainability and treatment of the data in FAIR (Findable, Accessible, Interoperable, Reusable) principles. A generic layer for AI services operating under value chains is considered. This layer adopts a user-centric approach in terms of explainability. Besides presenting results in a clear manner, it provides specific information that informs the end user about how the results were produced and under which conditions.

In line with this principle, Plooto delivers the necessary functionality for each provided AI service to create the statement of models' usage and conditions. In the Plooto project, a functionality where every service provider (together with the registration of the service into Plooto) specified and delivered, producing a contextual, explainable form (statement) describing how results were obtained. More specifically, this is a configurable form filled by each AI service provider, including:

- Information on the model statement
- Questions and things to be asked by the AI service (modelled per case). This will create a set of feedback questions to the end users about things the model needs to learn or improve.
- Feedback actionable steps from the end users (during the model execution and/or at the end).

From functionality perspective, the main usage scenarios for such model statement are:

Scenario #1: Upload model statement (from service provider)

The service provider creates an AI statement with the following:

- Versioning
- Model Statement
- Function for user feedback

Scenario #2: Model execution and user feedback

Users will be able to interact with the service and provide feedback when possible, during and after the model execution.

The basic elements of the model statement (supplied by the model provider) are:

- **Maintenance and history**: versioning of the statement and history of updates.
- **Model structure**: provides all information how the model works (basic functionality, flows, inputs, processing and outputs).
- **Data Structure**: any information about the data that the model is trained or updated/evolving.
- **Evaluation info**: any relevant information of how the model has been evaluated and verified along with specific criteria related to basic KPIs such as robustness, performance, etc.
- **Usage requirements**: how the model can be used by the end users.
- **Compliance declaration**: statements of compliance with applicable norms/legislation, EU AI Act, etc.

The model statement acts also like the DPP. It incorporates in every message or information shared in the supply chain (where such information is generated using any AI-based service).

3 The Sustainability Framework

3.1 Reference Frameworks

As nations, organizations, and individuals experience the effects of unsustainable operations every one of them is expected to act responsibly. 2018 was the first year that large public-interest entities employing over 500 persons, were obligated to annually report the "double materiality" regarding sustainability issues, more commonly, to report on Environmental, Social and Governance (ESG) issues. Later, on 21 April 2021, the European Commission (EC) adopted the sustainable finance package, revising the Non-Financial Reporting Directive (NFRD) 2014/95/EU [23], aiming to build an economy that works for people, decoupling the economic growth from resource use and ensure the socially just transition to a sustainable economic system. This undertaking targeted to eliminate the risk that sustainability issues present for companies and vice-versa, the impact of companies on the people and the environment. To assess the performance of this interaction, available relevant information and a common reported framework were necessary, therefore, the ESG framework became one of the critical cornerstones for companies' performance assessment. The increase of scope deployed through the amendment of 2021 implies that over 50.000 companies across EU have to report on ESG issues from 2023 onwards.

According to Deloitte [5], the environmental pillar presents the greatest level of complexity during reporting, since it requires the measurement and management of emissions (GHGs and industry-related), resources (energy, water, virgin materials, land use and other) and waste, also the potential positive sustainability impacts, which may represent the long-term business advantages.

Until today, there is no standardized reporting process on ESG, since no official framework or standards have been proposed. The companies assess the sustainability reporting standards to define the process, the data and the objectives of the reporting, applying one or more available frameworks. Within the scope of Plooto project, extensive research was carried out aiming to define an all-inclusive, comprehensive framework, capitalizing on the available information and work that has been done until today.

In the following paragraphs, the main frameworks, tools and standards that the Plooto consortium considered before devising the sustainability framework are presented, upon which the respective sustainability scorecard is based for assessing the sustainability and circularity of processes and products, along the various steps of their life in a value chain. The full analysis of sustainability standards and framework is presented in Annex 1.

3.1.1 ESG - Environment, Society & Governance (framework)

ESG is a non-financial framework for organizations to disclose their performance in line with a series of standards related to their **Environmental** impact, their **Social** responsibility and their

corporate Governance. Its intent is to help organizations measure their performance across those three aspects so that they can better manage their impact and as a result: improve it. Public reporting of the results is enhancing transparency and therefore increases the sense of responsibility for the organization. It is also enabling better regulatory control and raises awareness among individuals.

Apart from performance, management, transparency and regulatory control, the non-financial ESG reporting is ultimately critical also for the financial future of the company, in term of investments and risk management. Environmental criteria gauge how a company safeguards the environment. Social criteria examine how it manages relationships with employees, suppliers, customers, and communities. Governance measures a company's leadership, executive pay, audits, internal controls and shareholder rights. In sum, ESG is a framework that evaluates a company's day-to-day policies and performance on non-financial issues that could lead to a financial impact in the short and long term. Thus, a solid ESG report can be used as an attractive and convincing card for potential investors.

Table 1 depicts the areas tackled by ESG. The ways to measure the performance are continuously getting more structured and standardized and this is perhaps the biggest advantage and disadvantage of this framework at the same time. On the one hand, the flexibility of non-standardized measures makes them easily adaptable to the activities of any company. On the other hand, this flexibility can lead to greenwashing since it allows companies to self-determine what and how to measure and report their performance.

Table 1 - ESG overview

ESG areas of performance measuring		
Environmental impact	**Social responsibility**	**Governance**
• Climate change • Natural resource use • Energy use • Pollution and waste • General environmental performance • Biodiversity • Product, packaging, material impacts	• Workers' health and safety • Ethical employment conditions • Product liability • Volunteering and community investment • Gender and diversity • Human rights	• Corporate transparency • Conflicts of interest • Corruption and tax avoidance • Business ethics • Regulatory compliance • Lobbying

3.1.2 GRI – Global Reporting Initiative (standards)

Often going hand-in-hand with ESG, Global Reporting Initiative (GRI) provides a wide range of well recognized and widely used standards to measure and report on ESG[1]. They are divided in three categories: Universal, Sector and Topic standards. Organizations deciding to report following the GRI can pick their sector and the topics they want to focus on as per their ESG priorities but they are obliged to report on all universal standards for consistency. Individuals can get certified as

[1] GRI Standards: https://www.globalreporting.org/standards

professionals to conduct reporting based on GRI but a GRI report is not required to be prepared by certified professionals only allowing here as well for flexibility but also mistakes.

3.1.3 IFRS – International Financial Reporting Standards

IFRS Accounting and Sustainability Disclosure Standards are developed using the same due process and are designed to meet investor information needs and enable companies to communicate decision-useful information efficiently to global capital markets[2]. They include standards that apply to all sustainability-related risks and opportunities including illustrative guidance for industry-specific, and climate related metrics. They require disclosure of material information as well as industry-specific disclosures. The IFRS Foundation's International Accounting Standards Board (IASB) and International Sustainability Standards Board (ISSB) are jointly responsible for the **Integrated Reporting Framework[3]**, used to connect financial statements and sustainability-related financial disclosures.

3.1.4 TCFD & TNFD – Taskforces on Climate and Nature-related Financial Disclosures (framework)

TCFD and TNFD are referring to a risk management and disclosure framework[4] for companies to identify, assess, respond to and, disclose their climate- and nature-related issues created by a **market-led, science-based and government-supported global initiative. The framework draws from and feeds into relevant standards, including those of the IFRS (and its sister committee ISSB), the GRI, the EFRAG[5] and others.** Its recommendations are designed to provide decision-useful information to capital providers and other stakeholders, while also helping organisations to identify and assess their climate- and nature-related issues. It is directly linked to the EU Corporate Sustainability Reporting Directive (CSRD) [6].

3.1.5 SDGs - Sustainable Development Goals (framework)

The 2030 Agenda for Sustainable Development, adopted by all the United Nations Member States in 2015[6], provides a shared blueprint for peace and prosperity for people and the planet, now and into the future. At its heart are the 17 Sustainable Development Goals (Figure 7), which are an urgent call for action by all countries - developed and developing - in a global partnership with not only governments but also organizations, businesses and individuals. They are intertwined with the ESG framework and with measurements standards, including multiple KPIs to track the progress in each goal.

[2] IFRS Knowledge hub: https://www.ifrs.org/sustainability/knowledge-hub
[3] Integrated Reporting Framework: https://www.integratedreporting.org
[4] Guidance on the identification and assessment of nature-related issues: the LEAP approach: https://tnfd.global/publication/additional-guidance-on-assessment-of-nature-related-issues-the-leap-approach
[5] Who is EFRAG? : https://www.efrag.org/About/Facts
[6] The 17 Goals for global sustainable development and their history: https://sdgs.un.org/goals

Figure 7: United Nations' Sustainable Development Goals

Apart for these clear 17 goals, the SDG framework includes also 169 targets and 247 indicators. Each goal is followed by distinct targets and indicators that facilitate the evaluation of the success and make the progress towards the goal measurable.

For example, under Goal 13 that calls for urgent action to combat climate change and its impacts, we find 5 targets. Target 13.1 is to strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries, which specifies one of the climate-related actions that need to be taken. This target contains 2 indicators, 13.1.1 Number of countries with national and local disaster risk reduction strategies and 13.1.2 Number of deaths, missing persons and persons affected by disaster per 100,000 people, introducing measurable amounts to achieve the target and by extension the goal.

Therefore, the framework is structured in a thought-out way, in order to make the high-level, universal goals approachable, measurable and manageable at a regional, national and global level. The progress towards the fulfilment of the goals is reported on an annual basis by UN and the input to them is voluntary for each actor.

3.1.6 CDP – Carbon Disclosure Project (framework)

The Carbon Disclosure Project (CDP) was established in 2000, asking companies to disclose their climate impact upon request of the investors, purchasers and city stakeholders. Its disclosure measures are aligned with TCFD recommendations and foster environmental transparency and accountability for tracking progress towards three key areas: a sustainable net-zero, deforestation-free and water secure future. Except for companies, states and cities have also been added in the reports resulting in the creation of a rich data hub to be used as reference.[7]

[7] CDP data and insights: https://www.cdp.net/en/data

3.1.7 SBTi - Science Based Targets initiative (framework)

The SBTi is a partnership between the CDP, the United Nations Global Compact, the World Resources Institute (WRI) and the World-Wide Fund for Nature (WWF). Its goal is to provide a clearly-defined pathway for companies to reduce greenhouse gas (GHG) emissions, helping to prevent the worst impacts of climate change and future-proof business growth. Targets are considered 'science-based' if they are in line with what the latest climate science deems necessary to meet the goals of the Paris Agreement – limiting global warming to 1.5°C above pre-industrial levels. The SBTi Progress Framework8 aims to advance the work done on measurement, reporting and verification (MRV) of science-based targets, by identifying the key factors that need to be standardized to ensure consistency in the way companies measure and report progress against targets, considering decarbonization vis-a-vis other factors that lead to a change in estimated and reported emissions including structural, methodological or data variations. One differentiation point of this framework compared to the ones already mentioned is the focus on the target performance, aiming to explore the types of interventions that can enable entities to make credible decarbonization claims across different activities and emission sources.

3.1.8 GHG - Greenhouse Gas Protocol (standards & tools)

GHG Protocol[9] establishes comprehensive global standardized frameworks to measure and manage GHGs from private and public sector operations, value chains and mitigation actions. It supplies the world's most widely used greenhouse gas accounting standards as well as a variety of tools for calculating emissions (cross-sector, country-specific, sector-specific as well as tools for countries and cities). As implied by its name if laser-focused on GHG emissions measurements as a way to describe and track progress toward climate goals.

3.1.9 CTI – Circular Transition Indicators Framework

Researching for existing resources to be leveraged for the Plooto sustainability framework, circular economy measurement frameworks are of key importance. The Circular Transition Indicators (CTI) framework[10] is measuring circularity that can be applied to businesses of all industries, sizes, value chain positions and geographies and is broadening the GHG impact calculation by adding ways to measure the impact of different recovery strategies to the GHGs reductions. It also quantifies the impact of circularity on nature, where business has a critical role to play in protecting and restoring natural systems. The CTI framework was developed by the World Business Council for Sustainable Development and 30 of its members. A number of its KPIs are also incorporated as they are in the Plooto framework as well.

3.1.10 SCOR – Supply Chain Operations Reference Model

Plooto aims to create a Circular and Resilient Information System by twinning circular value chains. Understanding the processes within the supply chain is therefore fundamental for

[8] Science Based Targets resources: https://sciencebasedtargets.org/resources
[9] GHG Protocol: https://ghgprotocol.org/about-us
[10] CTI Framework: https://ctitool.com/cti-framework-2

improving them and making them as well more sustainable and circular. Besides, Supply Chain Operations Reference Model (SCOR)[11] describes the processes needed to take place in order to satisfy customer demands, by also providing a standardized baseline for improving these processes and creates a standard method for evaluating the supply chain's efficiency and effectiveness to highlight improvement areas. As a standard, companies in any industry with a supply chain use it successfully in order to ensure business viability when making any decision.

3.1.11 Doughnut Economics framework

Quite different from most of the frameworks, tools and standards mentioned so far, the Doughnut Economics framework is not inspired by the need for sustainable growth but for prosperity which may come from different routes. Think of it as a compass for human prosperity in the 21st century, with the aim of meeting the needs of all people within the means of the living planet. Figure 8 visualizes the framework's basic concepts.

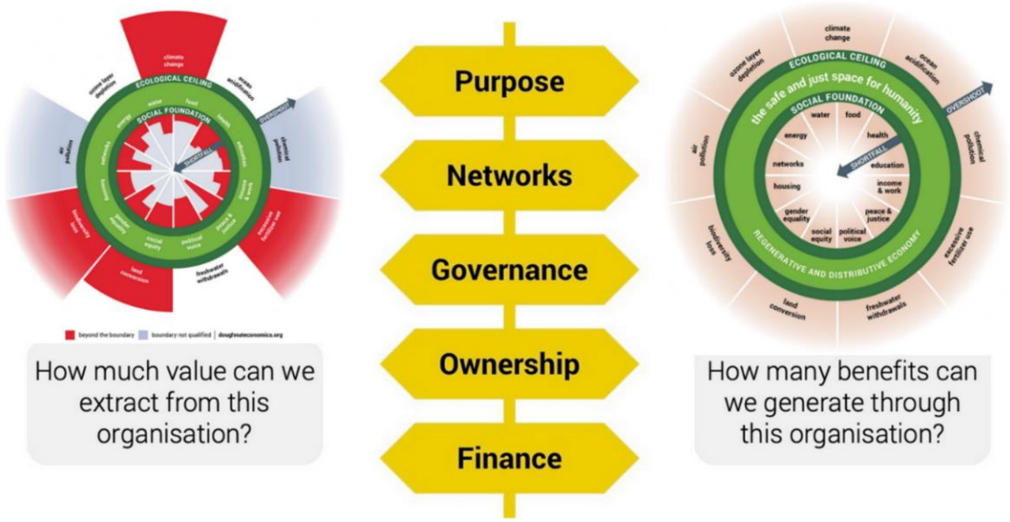

Figure 8: Doughnut Economics overview

The Doughnut consists of two concentric rings: a social foundation, to ensure that no one is left falling short on life's essentials (clean water, food, health, education, income and work, peace and justice, political voice, social equity, gender equality, housing, networks and energy), and an ecological ceiling, to ensure that humanity does not collectively overshoot the planetary boundaries (climate change, ocean acidification, chemical pollution, excessive fertilizer use, freshwater withdrawals, land conservation, biodiversity loss, air pollution, ozone layer depletion) that protect Earth's life-supporting systems. Between these two sets of boundaries lies a doughnut-shaped space that is both ecologically safe and socially just: a space in which humanity can thrive. Until about one year ago Doughnut Economics[12] were focused on cities and states but since 2022 it has created a compass for businesses as well, identifying the key layers

[11] SCOR framework: https://scor.ascm.org/processes/introduction
[12] Doughnut Economics: https://doughnuteconomics.org

of a business design that can make it sustainable and regenerative: Purpose, Networks, Governance, Ownership, and Finance.

3.1.12 Sustainability Scorecard for products

This tool as well is rather different compared to the ones mentioned before since it's one that focuses on products and/or processes rather than businesses. The Sustainability Scorecard takes a different perspective on measurements by zooming in production results and comparing them before and after implementing 4 principles for Managing and Scaling Sustainability: 1) Waste prevention: measuring and comparing waste, space and process intensification metrics; 2) Maximizing efficiency and performance: evaluating material efficiency, environmental health metrics and human health metrics; 3) Renewable inputs: considering renewable carbon-free energy inputs, waste energy utilization and renewable feedstocks; and 4) Safe degradation: tackling persistence of "forever chemicals" in final products, bioaccumulation product lifecycle duration stages in particular its induction and its disposal. It works on a complementary basis with existing business wide frameworks and serves well in innovating the way businesses produce things better [3].

3.1.13 ESRS - European Sustainability Reporting Standards (standards)

The European Sustainability Reporting Standards (ESRS) [7] is a set of standards that were officially established in the EU in July 2023 in the context of the CSRD. ESRS is currently mandatory for large companies and listed SMEs in the EU but is expected to become mandatory also for third countries in the future. What is important is that the companies will be obliged to account for all their providers as well in the context of the new standards.

Environmental, social and governance topics are covered in the new ESRS, targeting all stakeholders. ESRS is characterized by double materiality, meaning that the impact is measured on environment and society as well as in financial aspects, in short-, medium- and long-term horizons. ESRS is built in previously established TCFD, GRI[13] and CDP and considering the technical advice provided by the EFRAG[14].

Table 2 – Categories pf ESRS Standards

ID	Description
ESRS 1	General requirements
ESRS 2	General disclosures
ESRS E1	Climate change
ESRS E2	Pollution
ESRS E3	Water and marine resources
ESRS E4	Biodiversity and ecosystems
ESRS E5	Resources use and circular economy
ESRS S1	Own workforce
ESRS S2	Workers in the value chain

[13] GRI Standards: https://www.globalreporting.org/standards
[14] EFRAG: https://www.efrag.org/en/about-us

ID	Description
ESRS S3	Affected communities
ESRS S4	Consumers and end users
ESRS G1	Business conduct

3.1.14 ISSB - International Sustainability Standards Board (standards)

International Sustainability Standards Board[15] is a set of standards that are subject to national jurisdiction adoption on a global level. ISSB is characterized by single, financial, materiality and targets Investors and providers of financial capital. Consolidated into ISSB are the Integrated Reported Framework[16], the SASB[17] Standard and the TCFD[18], all covering holistically the topics of sustainability.

3.1.15 ISO - International Standards Organization (standards)

In 2024, three new standards were added by the International Standards Organization (ISO) to help companies ensure that their products align with principles like durability, reusability, upgradability, or repairability. They foster consumer trust in shared, recycled, repaired or upcycled goods and components as well as relevant services, and enable collaboration between economic partners.

ISO 59020:2024[19] is focused on measuring and assessing circularity performance.

ISO 59010:2024[20] aims to provide guidance on the transition of business models and value networks.

ISO 59004:2024[21] delves into the path to circularity implementation by offering vocabulary, principles and guidance towards this direction.

3.1.16 C2C - Cradle to Cradle Certified (framework)

The Cradle to Cradle (C2C) Certified[22] is a science-based, multi-attribute standard used globally across industries by designers, brands and manufacturers for designing and making products that enable a healthy, equitable and sustainable future. The C2C Certified Product Standard provides the framework to assess the safety, circularity and responsibility of materials and products across five categories of sustainability performance, as appeared in Figure 9.

[15] ISSB: https://www.ifrs.org/groups/international-sustainability-standards-board/#about
[16] Integrated Reporting Framework: https://www.integratedreporting.org
[17] SASB standards: https://sasb.ifrs.org/
[18] TCFD: https://www.fsb-tcfd.org/about/
[19] ISO 59020: 2024: https://www.iso.org/standard/80650.html
[20] ISO 59010: 2024: https://www.iso.org/standard/80649.html
[21] ISO 59004: 2024: https://www.iso.org/standard/80648.html
[22] Cradle to Cradle standard, from: https://c2ccertified.org/the-standard

Figure 9: The five categories of C2C Certified

Assessing products in these five important sustainability criteria, puts the focus on circularity and makes it possible for materials to be recovered, recycled, or safely biodegraded, on top of encouraging manufacturers to design goods with end-of-life usage in mind. The three primary pillars of circular systems, circular design, and circular sourcing form the basis of the framework's essential needs.

Apart from conforming to the upcoming Digital Product Passport (DPP) [8], this certification guarantees adherence to both US and EU regulations, putting companies ahead of programs such as the EU's Eco-design for Sustainable Products Regulation (ESPR) [18] and the US's Extended Producer Responsibility (EPR)[23] laws.

3.1.17 SDR - Sustainability Disclosure Requirements (directive)

At the end of 2023, the UK's Financial Conduct Authority (FCA) published the Sustainability Disclosure Requirements (SDR) [13] and investment labels regime targeting the marketing of sustainable financial products. On May 2023, in the context of SDR, all FCA authorised firms were required to meet an anti-greenwashing rule, on the grounds of protecting consumers against greenwashing so they can make informed decisions that are aligned with their sustainability preferences. Also, the regime aims to create a level playing field for firms in an evolving market.

[23] EPR Proposals: https://epr.sustainablepackaging.org/

The anti-greenwashing rule was introduced to clarify to firms that sustainability-related claims about their products and services must be fair, clear and not misleading.

3.2 Necessities to tackle

Nowadays, a manager wanting to introduce a Sustainability Framework in their company needs to undertake a long process of selection first. The market is quite full of options for different specific types of company or organisation. However, these frameworks are often focused on the single company in question, without looking at the larger picture. Moreover, most of the frameworks need specialized consultancy and operators in order to be implemented in a company.

The research on this topic – especially considering the whole supply chain - is fragmented, and does not provide meaningful real-life applications of such solutions [22].

Plooto created an easy-to-use framework, manageable also by unskilled workers. This is possible thanks to the close collaboration with the pilot cases, who have been consulted on the SBSC framework since the beginning of its conceptualisation. This co-creation process was put in place specifically to make sure that the framework is usable and that it tackles directly the necessities of the end user.

The SBSC framework is adaptable to different types of industries and is not a field-specific framework, in contrast with many other systems available on the market. This is because most of these frameworks are company/field-specific, while Plooto is more focused on the process and the value chain linked to it.

The reference frameworks that Plooto took as reference for its Sustainability framework – that are detailed in Section 3.1 of this document – were created years ago. They are very complete and each one of them has its own merits regarding methodology, structure and depth of analysis. However, being in the market for many years they lack a fundamental structural feature: they are not designed to be integrated in the current, modern, and complex digital systems. On the other hand, the Plooto framework is has been designed specifically with the new technologies in mind – such as DTs and DPPs. Moreover, this framework is ingested in a SBSC perspective (the details of this process have been described in Section 4.2 of this document and, more extensively, in deliverable D3.5 "Plooto Balanced Scorecard" submitted in Month 18).

On the business perspective, the SBSC framework allows stakeholders to have a wider view on their industry - and also to expand it in the supply chain if needed. The large amount of KPIs (Section 4) present in this framework allow for a flexibility of the tool, that can adapt to many different business scenarios, not only the ones described in our pilot activities. The structure of the framework (Section 3.4) reflects the importance of the business perspective with a whole horizontal layer of KPIs devoted to Economy & Growth.

3.3 Reference Processes and Digital Traceability Strategies (T1.2)

The previous work in this task included three key elements: a) the analysis of the traceability framework, as derived by the World Economic Forum [3], b) the initial approach to assess the maturity of traceability in the Plooto use cases, and c) the traceability process to be followed for the three uses cases of Plooto. Leveraging on the work carried out in the first period (M1-M12), the traceability strategies of all use cases were defined in this second period (M13-M24), finalising 1) the implementation steps, 2) the elements of the traceability strategies for each Plooto use case individually, and 3) the traceability schematic representation of the overall value chain.

Implementation Steps Definition

The implementation steps were built on the analysis of the traceability framework presented by the World Economic Forum and the maturity assessment of each of the Plooto pilot cases. Following the assessment of maturity initiated during the first period of the task (M1-M12) and presented in the previous deliverable, Table 3 gives an overview of the situation in terms of traceability for all use cases, before the implementation of Plooto project.

Table 3 – Maturity Assessment and Analysis of as-is situation

Pilot Use Case	Current Situation	Maturity Level	Involved Stakeholders/ Actors in Plooto	Objectives/Targets per use case
CRFP Waste for Drones *IT Pilot*	Lack of tracing material(s) across the value chain	Low-level	HPC, CETMA, CC, ACCELI	Optimising requalification, initiate traceability
WEEE for Magnets *ES Pilot* Citrus	Initial actions to optimise production, but no traceability strategy	Low-level	FERIMET, IMDEA, IMA	Production Optimisation, refining processes, initiate traceability
Processing Waste for Juice-by products *GR Pilot*	No traceability strategy has been defined	Low-level	ASPIS	Optimise evaporation (molasses, CPW), empower by-product (cattle feed), initiate traceability

The maturity level was defined by a 3-degree score: low-level, medium-level, high-level, where a qualitative approach was followed. The low-level indicates the absence of a traceability plan or initiation within the supply chain(s) of the industrial companies involved, the medium-level represents the initial planning or scheduling to implement a traceability strategy, and the high-level represents the companies that have already defined and deploy a traceability strategy.

Considering that none of the Plooto use cases have defined or initiated to plan a traceability strategy, as derived from their feedback, all the three of them were indicated as low-level.

The implementation steps, therefore, were mainly focused on scheduling and following a step-by-step plan for making the traceability real and adaptable to all the use cases. To this end, the initial step was to connect the traceability with the sustainability business objectives for each pilot, leading to a collaboration ecosystem definition across the value chain; which are the involved actors, which are the relevant activities performed, how this could be depicted through selected KPIs that will indicate the progress per case. The understanding of key-enablers, therefore, is key element, together with the calculation and monitoring of the selected KPIs, that will indicate the level of progress and realisation of the traceability strategies across the supply chains. Figure 10 presents this sequence of steps, that target to make traceability a reality into the industrial chains.

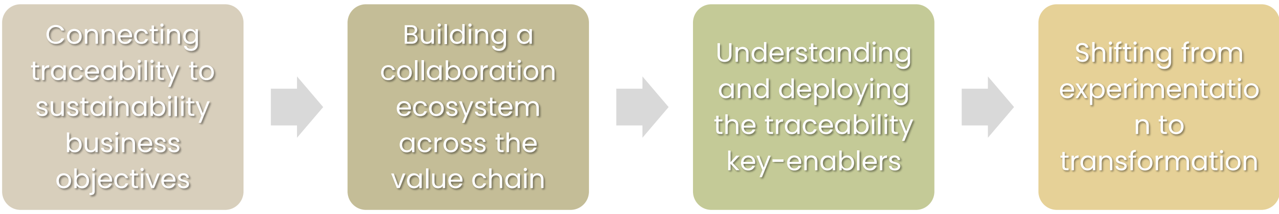

Figure 10: Traceability Strategies Implementation Steps

Traceability Strategies Elements

For the realization of the traceability strategies, the Critical Tracking Events (CTEs) were identified across the Plooto value chains, considering: 1) the involved actors, 2) the processes/activities that taking place, and 3) the interconnection of the different actors and processes across the investigated chains. The CTE approach has been derived by the Global Traceability Standards (GS1)[24], aiming to facilitate the tracking process within a value chain, and then, to identify the necessary traceability data, in order to realize traceability across the investigated chain. According to the GT1, the CTEs may include "*actual events that occur to traceable objects such as transforming, packing, shipping, transporting, receiving of a material*, etc."

In Plooto use cases, the CTEs for each of the involved value chains were identified and collected, together with the involved actors and their roles in Plooto, as presented in the next tables.

Table 4 - Actors' roles and identification of Critical Tracking events for the Spanish Use Case

[24] GT1: https://www.gs1.org/standards/gs1-global-traceability-standard/current-standard#1-Introduction+1-1-Objective

Pilot	Actors	So	Involved in Plooto	Critical Tracking Events
WEEE for Magnets ES Pilot	FERIMET	Disassembler, magnet retriever	Yes	CTE1. Incoming WEEE into the supply chain CTE2. Selection of magnets to be reused CTE3. Other type of wastes out of the supply chain CTE4. Selected magnets are transformed to IMDEA
	IMDEA	Sorting, demagnetisation, uncoating (Sr-ferrite), crushing, mixing	Yes	CTE5. Incoming selected magnets from FERIMET CTE6. Selection of bonded magnets (Sr-ferrite & NdFeB) CTE7. Selection of sintered magnets (Sr-ferrite) CTE8. Sintered NdFeB & contaminated magnets as waste out of the chain CTE9. Selected magnets are transported to IMDEA Processing CTE10. Incoming magnets (bonded) to be processed in IMDEA CTE11. Incoming magnets (sintered) to be processed in IMDEA CTE12. Tested magnets (remanufactured) to be transported to IMA
	IMA	Mixing, injection, magnetisation, quality control, packing, storing	Yes	CTE13. Incoming magnets from IMDEA CTE14. New magnets produced CTE15. New magnets are transported to customer
	Customer/ Retailer	Customer/end user	No	CTE16. Customer placed the order CTE17. Final product received by the customer

The Spanish pilot involves the three main partners of Plooto project (FERIMET, IMDEA & IMA) and the end user, which is the customer or retailer. The customer has the role of an individual body, who receives the final product from IMA. It is considered in the traceability strategies, however, since it is not part of the Plooto project, the available information or data are limited for his transactions and activities. That means it is included in the traceability strategy visualisation, but all the involved with this actor activities, are not part of the calculations or the Plooto solutions and services.

Nevertheless, seventeen (17) critical tracking events are identified in this value chains, connecting the actions took place for the magnet retrieving, until the final product to be delivered to and received by the customer. In order to monitor the traceability capacity across the value chain, selected KPIs were integrated into the generic list from Plooto framework, as presented in D1.3. Those KPIs were connected with the CTEs identified at each value chain, in order to be calculated in the Balanced Scorecard (T3.3). The result/calculation from the Balanced Scorecard will provide an overview of the company's traceability capacity and status, indicating points for improvement within the actors, activities and CTEs of the chain.

Table 5 - Actors' roles and identification of Critical Tracking events for the Italian Use Case

Pilot	Actors	Role	Involved in Plooto	Critical Tracking Events (CTEs)
CRFP Waste for Drones *IT Pilot*	HPC	CFRP producer, provider of prepreg scraps	Yes	CTE1. Incoming prepreg into the supply chain CTE2. Composite component is transported to customer CTE3. Prepreg scrap processing CTE4. Expired prepreg to waste CTE5. Prepreg scrap is transported to CETMA
	CETMA	Responsible for waste analyses and requalification	Yes	CTE6. Incoming prepreg scrap from HP CTE7. Material requalification CTE8. Prepreg assessed and go to waste CTE9. Requalified material goes to CC
	CC	Remanufacturer	Yes	CTE10. Incoming material from CETMA CTE11. Drone component is manufactured CTE12. Drone component is transported to customer (ACCELI)
	ACCELI	Customer/end user	Yes	CTE13. ACCELI places the order CTE14. ACCELI receives the drone component

The Italian pilot has the closest representative example for end-to-end traceability since the supply chain encloses almost all the actors that are responsible for the remanufacturing of the CFRP components from the recycled prepreg. HPC is the CFRP produced and the provider of the prepreg scraps, CETMA is responsible for the requalification, and CC is the remanufacturer of CFRP using the prepreg scrap from HPC. ACCELI, as the end-user and the customer that requires CFRP custom-made components drones, places the order in the first place, and receives at the end the required component for its drones.

In this value chain fourteen (14) CTEs were identified. Those CTEs are connected to the selected KPIs to monitor the traceability across the value chain. The results that will occur from the Balanced Scorecard will provide the overall assessment for the value chain of the Italian use case.

Table 6 - Actors' roles and identification of Critical Tracking events for the Greek Use Case

Pilot	Actors	Role	Involved in Plooto	Critical Tracking Events
Citrus Processing Waste for Juice-by products *GR Pilot*	Producer	Oranges producer, supply chain feeder	No	CTE1. Producer provides the raw material (oranges) to ASPIS
	ASPIS	Orange juice, molasses, orange oil and cattle feed producer	Yes	CTE2. Incoming oranges into the supply chain CTE3. Oranges being processed to a) orange juice, b) molasses, c) cattle feed, d) liquor CTE4. Final products are transported to the customers
	Customer/ Retailer	Customer/end user	No	CTE5. Customer/retailer placed the order CTE6. Final product is transported to customer

Last but not least, in the Greek pilot, six (6) CTEs are identified, which enclose the events relevant to orange producer and the end-user, too. Since those two actors are not part of the Plooto project, the traceability in this chain focuses mainly on the orange juice producer, and the activities take place within ASPIS industry, such as the processes that produce the orange juice, the molasses, the cattle feed and the liquor.

Traceability Schemes and KPIs

The analysis in Table 4, Table 5 and Table 6 demonstrates the virtualisation of the traceability system across all Plooto value chains. To this end, three schematic figures have been created, one per use case, indicating the actors involved, the critical activities and the critical tracking events – CTEs identified.

WEEE for Magnets In the case of the magnets' recovery and remanufacturing from WEEE, three main actors, four activities and seventeen tracking events are identified as presented in Figure 11.

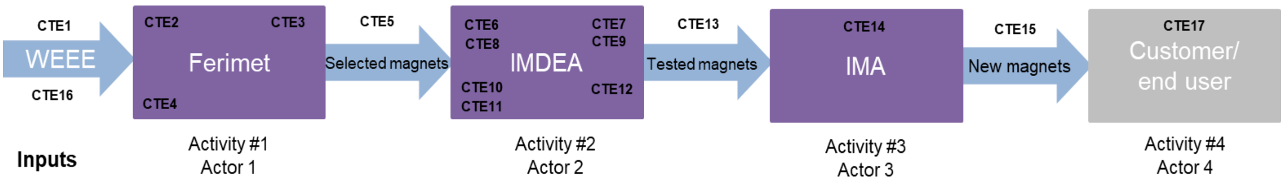

Figure 11: Traceability across the WEEE for magnets supply chain

The arrows indicate the inputs (WEEE) and intermediate goods (selected recovered magnets, tested material and new magnets), and the boxes the main actors, each of them performing a main activity as an entity of the chain. Within the boxes, the CTEs presented in Table 4 have been placed, according to the actor that performs them. The end user is identified as actor within Plooto project, but since he does not participate in the project, his contribution is not taken into consideration, either in Plooto traceability or for the calculation of the traceability KPIs.

Following the principles and pillars of the Sustainability and Governance framework, as defined in the previous version of this deliverable (D1.3), a number of KPIs have been selected to monitor the traceability across the chain. Table 7 categorises the KPIs according to the pillar they represent (environment, society, economy & growth, governance and pilot specific KPIs), and indicates also the CTEs that each KPI can be found, and from which CTEs it will be calculated. This step is crucial for the KPI calculation by the Sustainability Balanced Scorecard.

Table 7 - KPIs for traceability assessment and monitoring in Spanish use case

KPI	Description	Pillar	Critical Tracking Events Involved
Carbon Dioxide (CO_2)	Amount of CO_2 released from the activities across the supply chain	Environment	CTE5, 13, 15, 6-12, 14
Water stress/ consumption	Amount of water consumed across the industrial processes		CTE2-4, 6-12, 14

KPI	Description	Pillar	Critical Tracking Events Involved
Transportation Processes	Consumptions related to the transportation/logistics (i.e., energy)		CTE1, 5, 13, 15
Use of biodegradable materials	Amount of biodegradable materials produced/used		CTE14
Electronic Waste	Amount of electronic waste		CTE1, 2-4
Scrap Waste	Amount of scrap waste		CTE1-4, CTE6-9
Consumption of virgin raw materials	Amount of virgin raw material consumed		CTE14, CTE17
Resource Utilization	Percentage of use of non-renewable resources across the supply chain		CTE1-4, 6-12
Product safety and quality	The industrial company meets the standards for product safety and quality	Society	CTE1-17
Transparency within the Supply Chain	The level of transparency regarding the quality and origin of the materials, the processing, etc.		CTE1-17
Supply Chain Liability	The legal responsibility of the industrial company for actions or shortcomings across its supply chain		CTE1-17
Anti-competitive practices	Number of practices that an industrial company follows to gain an advantage in the market (i.e., price fixing, market allocation, etc.)	Governance	CTE1-17
Business ethics	Number of practices for ensuring ethical principles i.e., environmental responsibility, quality and safety		CTE1-17
Usage of SRM (bonded NdFeb, Sr-Ferrite) in PM magnet pellets' production (%)	Percentage of use of SRM (bonded NdFeb, Sr-Ferrite) in PM magnet pellets' production (%)	Pilot specific	CTE6-12, 14, 17
Recycling from leftovers and disregarded magnets (%)	Recycling from leftovers and disregarded magnets (%)		CTE1-14

CFRP Waste for drones

Four main actors, four main activities, and fourteen critical tracking events are identified in the Italian use case.

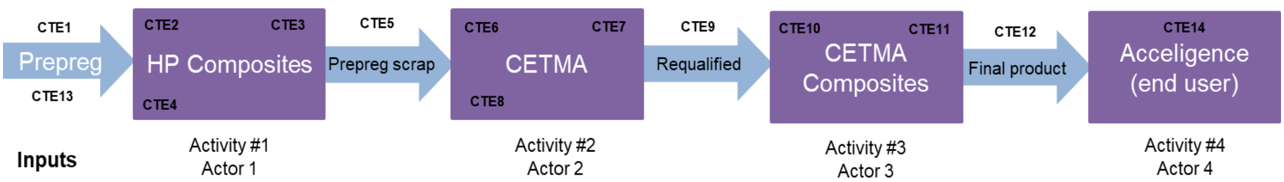

Figure 12: Traceability across the CRFP waste for drones' supply chain

The arrows in Figure 12 indicate the inputs (prepreg), intermediate goods (scrap, requalified material) and final products that are transferred from the one actor to the next one until the end of the chain. The four boxes represent the four main actors of the chain, and the connected CTEs at each activity.

Table 8 - KPIs for the monitoring and assessment of the traceability across the value chain

KPI	Description	Pillar	Critical Tracking Events Involved
Carbon Dioxide (CO_2)	Amount of CO_2 released from the activities across the supply chain	Environment	CTE1-14
Energy Consumption	Amount of energy consumed across the supply chain		CTE1-14
Transportation Processes	Consumptions related to the transportation/logistics (i.e., energy)		CTE1, 5, 9, 12
Green Logistics	Amount of emissions during logistics activities (warehousing and transportation)		CTE1, 5, 9, 12
Recycling Rate	Amount of recycled plastics		CTE1-14
Scrap Waste	Amount of scrap waste		CTE1-3, 6-8
Consumption of virgin raw materials	Amount of virgin raw material consumed		CTE1-3, 12, 14, 16, 17
ISO59020 for measuring and assessing circularity	ISO Certification that the company/industry meets the certification standards		CTE1-14
Transparency within the Supply Chain	The level of transparency regarding the quality and origin of the materials, the processing, etc.	Society	CTE1-14
Anti-competitive practices	Number of practices that an industrial company follows to gain an advantage in the market (i.e., price fixing, bid rigging, market allocation, etc.)	Governance	CTE1-14
Business ethics	Number of practices for ensuring ethical principles i.e., environmental responsibility, product quality and safety		CTE1-14
Prepreg disposal in HP	Prepreg disposal in HP	Pilot specific	CTE1-14
Unused CFRP waste in the production of composite materials (%)	Unused CFRP waste in the production of composite materials (%)		CTE1-14

<u>Citrus processing waste for juice by-products</u>

The citrus processing waste use case in Plooto, focuses mainly on the processes that take place within the orange juice production company, ASPIS, since it is the only actor of this value chain that participates in the Plooto project (Figure 13). The traceability in this use case, is deployed for the activities and CTEs within ASPIS. Therefore, the inputs are the incoming oranges, and the outputs the final products, which the company considers valuable: orange juice, molasses, orange oil and cattle feed.

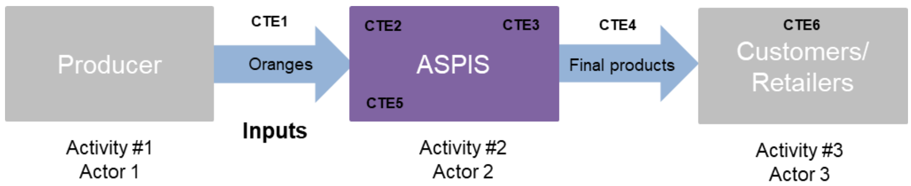

Figure 13: Traceability across the Citrus Processing Waste for Juice-by products supply chain

The selected KPIs for the traceability assessment and monitoring at this case, are connected only to ASPIS, and are calculated through the CTEs that identified for this actor, as presented in the following Table 9.

Table 9 - KPIs for traceability assessment and monitoring in Italian use case

KPI	Description	Pillar	Critical Tracking Events Involved
Carbon Dioxide (CO_2)	Amount of CO_2 released from the activities across the supply chain	Environment	CTE2-4
Water stress/ consumption	Amount of water consumed across the industrial processes		CTE2-4
Energy consumption	Amount of energy consumed across the supply chain		CTE2-4
Packaging materials and waste rate	Amount of waste from packaging material		CTE3
ISO22400 for KPIs in Manufacturing Operations Management	ISO Certification that the company/ industry meets the certification standards		CTE1-5
ISO59020 for measuring and assessing circularity	ISO Certification that the company/ industry meets the certification standards		CTE1-5
Product safety and quality	The industrial company meets the standards for product safety and quality	Society	CTE1-5
Privacy and data security	The industrial company runs in compliance with the regulations for privacy and data security		CTE1-5
Supply Chain Liability	The legal responsibility of the industrial company for actions or shortcomings across its supply chain		CTE1-5
Net cost savings due to circular activities (only for pellets, not for molasses or liquor)	Assessment of savings that coming from circular activities (i.e., re-use of materials or secondary raw materials, treatment of water to enter the process, etc.)	Economy & Growth	CTE3
Anti-competitive practices	Number of practices that an industrial company follows to gain an advantage in the market (i.e., price fixing, market allocation, etc.)	Governance	CTE1-5
Production of animal feed	Amount of animal feed produced from circularity activities	Pilot specific	CTE3
Production of high-quality molasses	Amount of high-quality molasses produced		CTE3

Conclusions

Leveraging on the work deployed until M12 and considering the robust Sustainability and Governance framework that presented in D1.3, the traceability strategies in Plooto project target to materialise, assess and monitor the traceability capacity, by deploying a structured step-by-step path. Starting from the identification of business objectives of each use case, and going further to understand and deploy the traceability key-enablers, Task 1.2 aims to shift the traceability from experimentation to realisation. To do so, selected KPIs that are able to monitor and/or assess traceability have been detected and integrated into the Plooto generic list of KPIs (D1.3). The thorough analysis of each value chain in the main actors, activities, and CTEs, interconnects the KPIs with the key processes and activities of each chain, and provides a clear path to the Sustainability Balanced Scorecard Tool (Task 3.3) for assessing the traceability capacity of each investigated value chain within the Plooto project.

3.4 Information Modelling Framework (T1.3)

Task 1.3 created the required semantic framework for supporting all of the circular value chain typologies and scenarios based on the information collected from Task 1.1 and Task 1.2 and also the pilots. Task 1.3's output will serve as an interoperability enabler for the functional and business components of Plooto integration. The construction of Knowledge Graphs will be facilitated by both top-level and domain-specific ontologies (based on Industry commons), which will also aid in the development of analytical, optimisation, simulation, monitoring, and decision support tools. Semantic framework lifecycle features like scalability, maintainability, and adaptability will be guaranteed at every turn.

Specifically, the contribution of Task 1.3 and the developed models will be help on delivering the right information to the Plooto platform in order to calculate the different indices such as the sustainability balanced scorecard (SBSC). Furthermore, based also with the requirements for the calculation of the SBSC the different models will be enriched in order to assure that they cover the required information. Below it is presented the Information Modelling Framework (IMF) model for both the function and product aspect for all stakeholders of the Spanish pilot. Each of the boxes represent a function which each function will have several attributes, those attributes will be the requirements for each of the Plooto components, such as the SBSC.

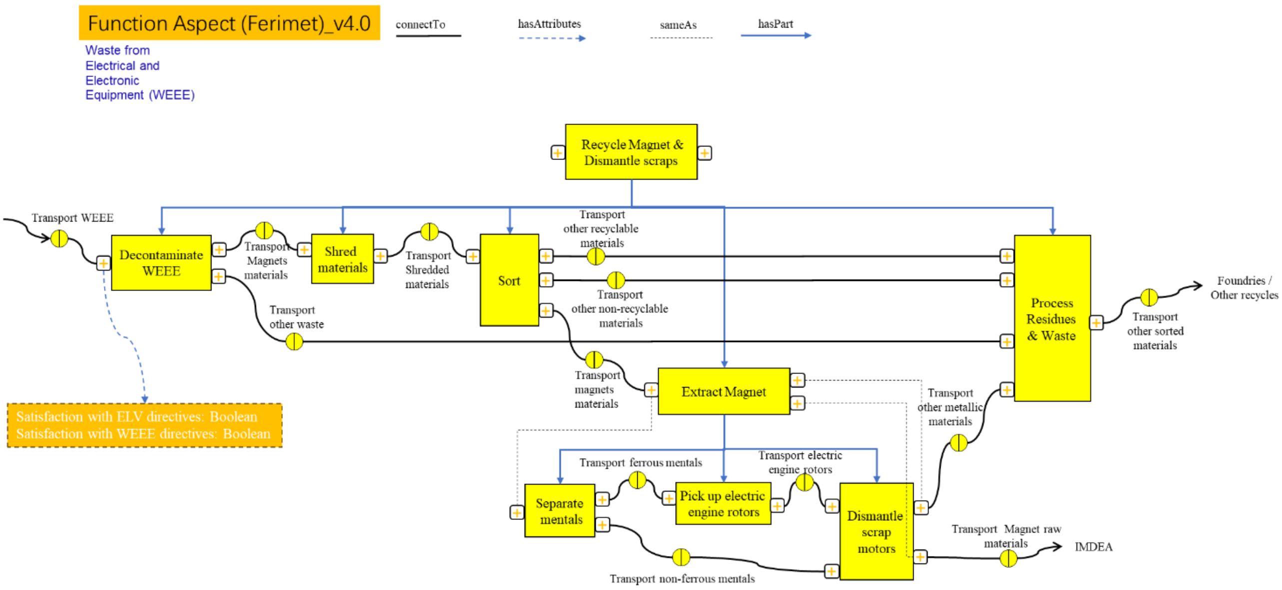

Figure 14: Function Aspect for the FERIMET node in Spanish pilot 1/2

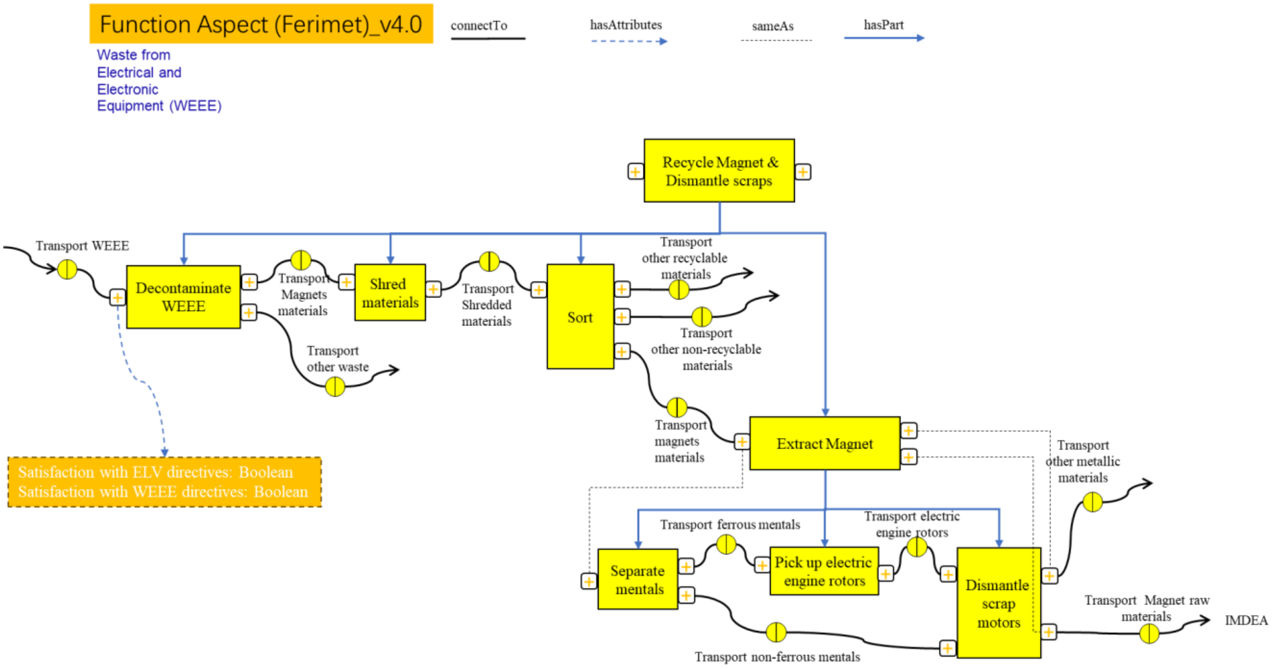

Figure 15: Function Aspect for the FERIMET node in the Spanish pilot 2/2

- **Name of the model:** Function aspect of magnet recycle manufacturing process

- **Overview, purpose and scope of this model:**

The scope of this model is established for Ferimet's production requirements. Taking the overall business function of the enterprise - recycling magnets and dismantling WEEE waste - as the top node, we further decompose the functional requirements that need to be implemented, and obtain the system's hierarchical structure, overall process, key business functions, interrelationships between functions, and attribute settings. Build a conceptual foundation for the next step of ontology construction and reasoning.

The creation of the Function aspect ensures the coherence and integrity of the overall business of the system from the demand side, and provides the prerequisite for the construction of the product aspect and the final system solution.

- **System elements:** function block; function terminal; function interface point; function attribute; connectedTo relationship; hasAttributes relationship; sameAs relationship; hasPart relationship;

- **Industry area:** Magnet recycling industry

- **Key input/output of constructing the model:** Magnet recycling process description, process information collection/system functional requirements analysis results, system functional business formal description

- **Model description:** function aspect indicates requirements of the involved processes, so all the elements should be intended activities, including function blocks， terminals, as well as interface points.

From a vertical perspective, the model breaks down the functional requirements of the system from the top overall requirements, including decontamination of WEEE, shredding of raw materials, sort and separation process of mentals, dismantling of motors and process of other wastes. From a horizontal perspective, the input terminal of the function block is on the left side of the function block, and the output terminal is on the right side of the function block. It is easy to start from the left side of the model to understand the entire process, system element boundaries, and interactions between elements. The system process starts with the input of WEEE, along with a series of attributes that the raw materials need to have (the types of attribute values can be defined). The first required process is decontamination. After treatment, harmful elements in the raw materials containing magnetic materials are removed. This process includes one input and two outputs. The magnetic materials enter the next stage of the crushing process, while other unusable waste is transferred to other places for disposal or handed over to other recyclers with processing capabilities. It can be seen that each function block represents a key process. Its scope and boundaries are very clear. And some functional requirements can directly correspond to specific devices. Magnetic materials go through a selection process with different guidance, and other recyclable and non-recyclable materials are screened out and transferred externally for processing. Materials containing usable magnets were selected into two categories: ferrous and nonferrous, and the resulting motor rotors were disassembled, respectively. The final scrap is also used as one of the scrap outputs of the system. The final processed secondary raw material is the finished product of the model and is exported to other magnet processing workshops for further processing.

- **Attribute description:** Terminals in the function aspect can define attributes. In this model, the shopfloor structure determines the connection between requirements through the transfer of materials to achieve the connection between processes. In addition, as shown in the properties of the interface point on the far left, the model supports type definition of attribute values.

- Interactions/dependencies with other models: this model can be easily combined with the function aspect of magnet pellets manufacturing (IMEDA), as its input part. Many activities in the function aspect can be fulfilled by elements in the following product aspect elements, which will be clarified in the further stages.

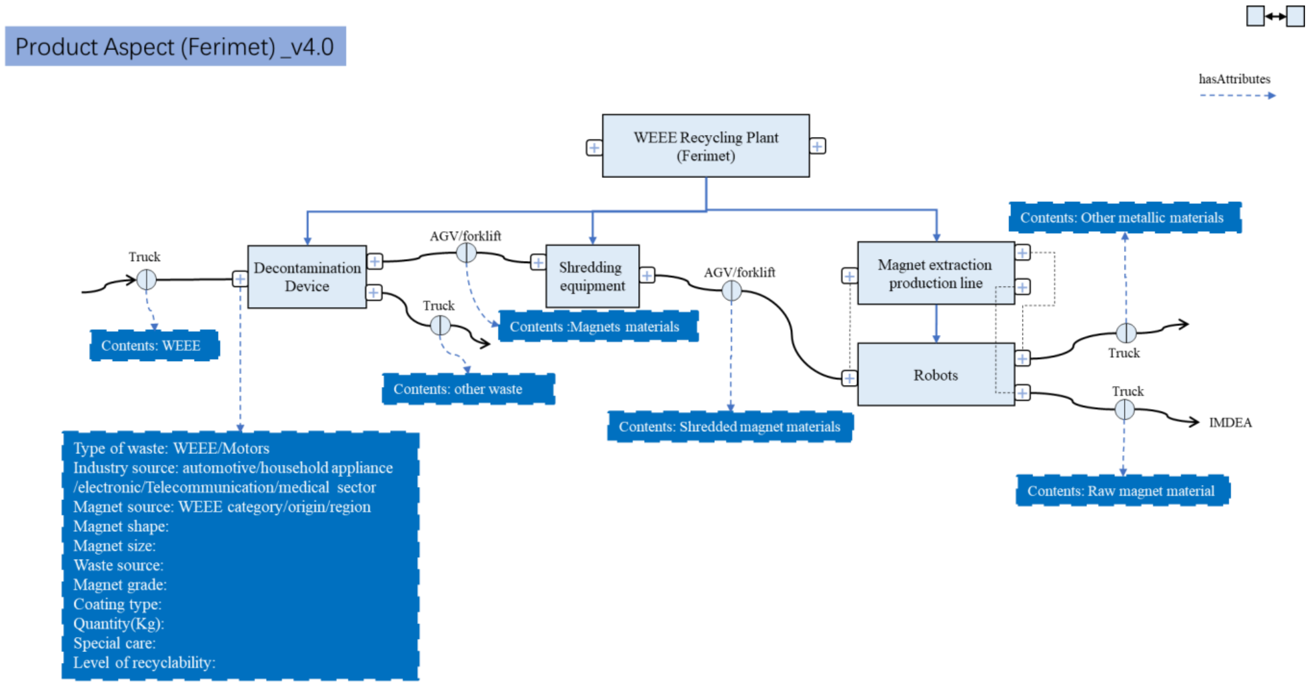

Figure 16: Product Aspect for the FERIMET node in Spanish pilot case

- **Name of the model:** Product aspect of magnet recycle manufacturing process

- **Overview, purpose and scope of this model:**

The scope of the model design is products or equipment related to the process flow in the WEEE recycling plant. Taking the WEEE recycling plant (taking FERIMET as an example) as the top node, the instantiation process of the system from design to implementation is described. The purpose is to perform an efficient configuration of the system. A block has at least one input and one output. Two terminals may be the same, but one terminal cannot represent more than one element.

- **System elements:** product block; product terminal; product interface point; product attribute; connectedTo relationship; hasAttributes relationship; sameAs relationship; hasPart relationship;

- **Reference stakeholders:** Magnet recycling companies and upstream and downstream partners

- **Key input/output of constructing the model:** function aspect, related equipment research information/formal description of system configuration

- **Model description:** The product aspect shows the specification of the artifact. The connection between each two terminals needs to pass through an interface point, which are mostly transportations in this case. Their attributes all include contents to be delivered between each process. According to the system Functional requirements define the equipment needed for the recycling process including: Decontamination Device, Shredding equipment and magnet extraction devices. The extraction process mainly relies on robots provided by upstream equipment manufacturers. Similarly, two terminals need to be connected through an interface point. Due to most of the transfer requirements in the process, this model assumes that all internal transfers are achieved through AGV/forklifts, and all external transfers are achieved through trucks. The process starts with the purification process of WEEE. After the shredding process, the magnet can be broken down and extracted. sameAs relationship only appears in the hierarchical structure of the parent-child relationship, in order to clearly indicate that the two terminals are exactly the same.

- **Attribute description:** Block, interface point and terminal in the product aspect can all define attributes. In the model, the essential attribute of the interface point is the content of the transfer. The attribute definition of the first input terminal of the process has been given in the model.

- Interactions/dependencies with other models: this model can be easily combined with the product aspect of magnet pellets manufacturing (IMEDA), as its input part.

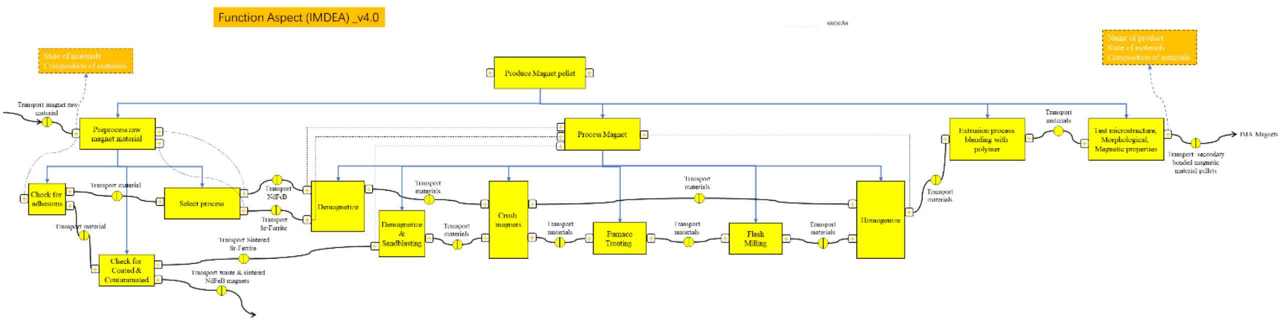

Figure 17: Function Aspect for the IMDEA node in Spanish pilot case

- **Name of the model:** Function aspect of magnet pellets manufacturing process

- **Overview, purpose and scope of this model:**

The scope of this model is established based on IMDEA's production needs. Taking the overall business function of the enterprise – Produce Magnet pellet - as the top node, we further decompose the functional requirements that need to be implemented, and obtain the system's hierarchical structure, overall process, key business functions, interrelationships between functions, and attribute settings. Build a conceptual foundation for the next step of ontology construction and reasoning.

The creation of the Function aspect ensures the coherence and integrity of the overall system business from the demand side, and provides the prerequisite for the configuration of the product aspect and the final system solution.

- System elements: function block; function terminal; function interface point; function attribute; connectedTo relationship; hasAttributes relationship; sameAs relationship; hasPart relationship;

- **Industry area:** Magnet production industry

- **Key input/output of constructing the model:** Magnet production process description, process information collection/system functional requirements analysis results, system functional business formal description

- **Model description:** Function aspect indicates requirements of the processes involved, so all the elements should be intended activities, including function blocks, terminals, as well as interface points. The overall requirement of the process is to recycle the magnet after the first stage of processing Raw materials are processed into secondary magnetic material pellets. This requirement is broken down into four main activities: material preprocessing, magnet processing, extrusion mixing process, and testing. Among them, the preprocessing of raw materials includes two inspection and selection. The magnet processing process is divided into two different processes based on the type of magnet material. Similarly, sameAs relationship indicates the same relationship between input and output terminals between the upper and lower levels. Two Function terminals need to be connected through an interface point. The main connection requirement in this process is the transfer of materials.

- Interactions/dependencies with other models: this model can be easily combined with the function aspect of new magnet manufacturing (IMA), as its input part. Many activities in the function aspect can be fulfilled by elements in the following product aspect elements, which will be clarified in the further stages.

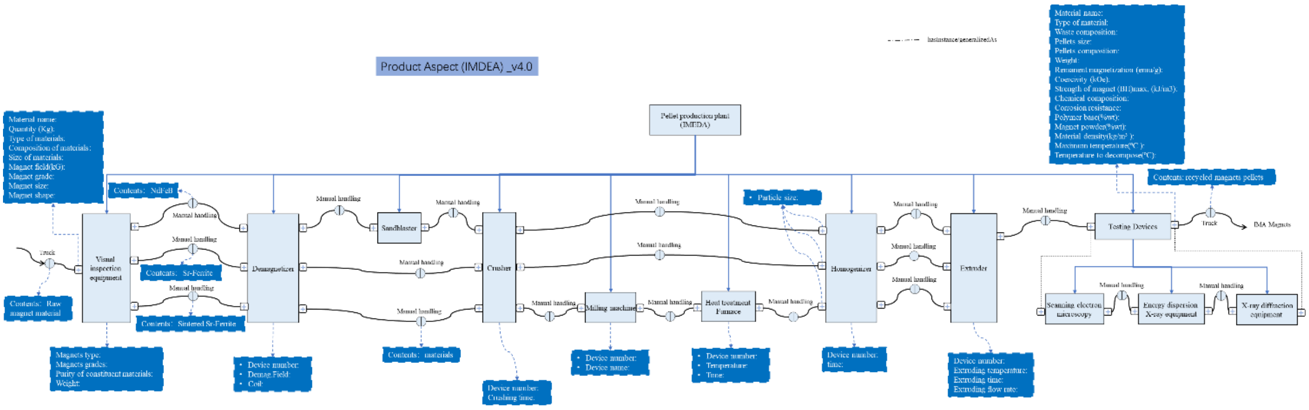

Figure 18: Product Aspect for the IMDEA node in Spanish pilot case

- **Name of the model:** Product aspect of magnet pellet manufacturing process

- **Overview, purpose and scope of this model:**

The scope of the model design is the products or equipment related to the process flow in the IMDEA magnet processing factory. Taking Pellet production plant (taking IMEDA as an example) as the top node, describe the instantiation process of the system from design to implementation. The purpose is to perform an efficient configuration of the system. A block has at least one input and one output. Two terminals may be the same, but one terminal cannot represent more than one element.

- **System elements:** product block; product terminal; product interface point; product attribute; connectedTo relationship; hasAttributes relationship; sameAs relationship; hasPart relationship;

- **Reference stakeholders:** Magnet processing and manufacturing companies and upstream and downstream partners

- **Key input/output of constructing the model:** function aspect, related equipment research information/formal description of system configuration

- **Model description:** The product aspect shows the specification of the artifact. The connection between each two terminals needs to be through an interface point, which are mostly transportations in this case. Their attributes all include contents to be delivered between each process. The main feature of this model is that the process flow of different types of magnet materials is different, which can be seen intuitively. Another feature is that although the process technology is different, the production lines they use, that is, the related instruments (Visual inspection equipment, Demagnetizer, Crusher, Homogenizer, Extruder, Testing Devices) are the same. In addition, for the test devices decomposed into three parts, the *ConnectTo* relationship in the first level is not connected to the decomposed second level, which indicates that there is no requirement for the order of use of the three test devices and they can be operated in parallel. The *sameAs* relationship only appears in the hierarchical structure of the parent-child relationship, to clearly indicate that the two terminals are exactly the same.

- **Attribute description:** Block, interface point and terminal in the product aspect can all define attributes. Terminals, interface points and blocks can all have attribute definitions. Product blocks attribute definition indicates the specifications of the device. The attributes of Terminals define constraints on the input and output products or materials. The attribute definition of interface points includes the material content of the transshipment and the restrictions on the transshipment carrier. The interface points should be the tools or equipment used in the actual transportation process, but because they are all handled manually, they are all marked as manual handling. Basically, each interface point should have attribute descriptions in order to avoid confusion caused by too many elements in the model and redundant descriptions. Not all properties are drawn in the model. But this does not mean that the element does not have this attribute. They all have the attribute "contents" and the attribute value is "materials". Finally, the attributes that the process's initial input products, final output products, and intermediate process products need to have been given in detail in the model.

- Interactions/dependencies with other models: this model can be easily combined with the product aspect of new magnet manufacturing (IMA), as its input part.

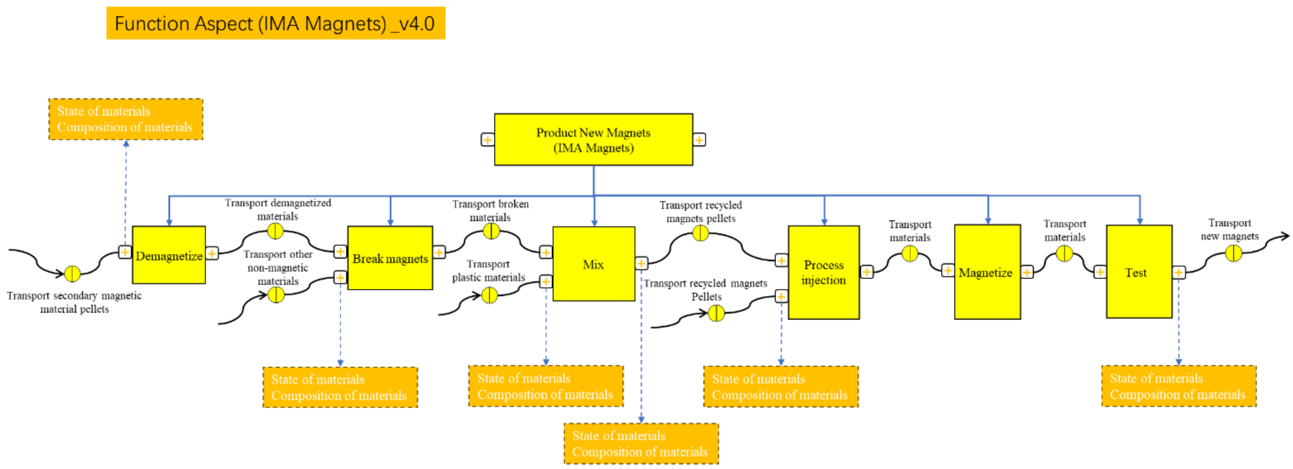

Figure 19: Function Aspect for the IMA node in Spanish pilot case

- **Name of the model:** Function aspect of new magnets production

- **Overview, purpose and scope of this model:**

The scope of this model is established for the production needs of IMA Magnets. Taking the overall business function of the enterprise - Produce New Magnet - as the top node, we further decompose the functional requirements that need to be realized, and obtain the system's hierarchical structure, overall process, key business functions, interrelationships between functions, and attribute settings. Build a conceptual foundation for the next step of ontology construction and reasoning. The creation of the Function aspect ensures the coherence and integrity of the overall system business from the demand side, and provides the prerequisite for the configuration of the product aspect and the final system solution.

- **System elements:** function block; function terminal; function interface point; function attribute; connectedTo relationship; hasAttributes relationship; hasPart relationship;

- Industry area: Magnet production industry

- Key input/output of constructing the model: Magnet production process description, process information collection/system functional requirements analysis results, system functional business formal description

- **Model description:** function aspect indicates requirements of the involved processes, so all the elements should be intended activities, including function blocks, terminals, as well as interface points. For a function block, input terminals should be on the left and output terminals should be on the right. Two Function terminals need to be connected through an interface point. The main connection requirement in this process is the transfer of materials. The overall need of the process is to utilize recycled magnet pellets to produce new magnets that can be used in a variety of industries. The decomposition of the model only includes the first-level layered structure, including the functional requirements and process activities of degaussing, crushing, mixing, injection molding, magnetization and testing. In addition, this model is characterized by a large number of external inputs. For the function blocks of key activities, the requirements that input and output materials need to meet are defined with varying degrees of attributes.

- Interactions/dependencies with other models: this model can be easily combined with the function aspect of new magnet manufacturing (IMA), as its output part. Many activities in the function aspect can be fulfilled by elements in the following product aspect elements, which will be clarified in the further stages.

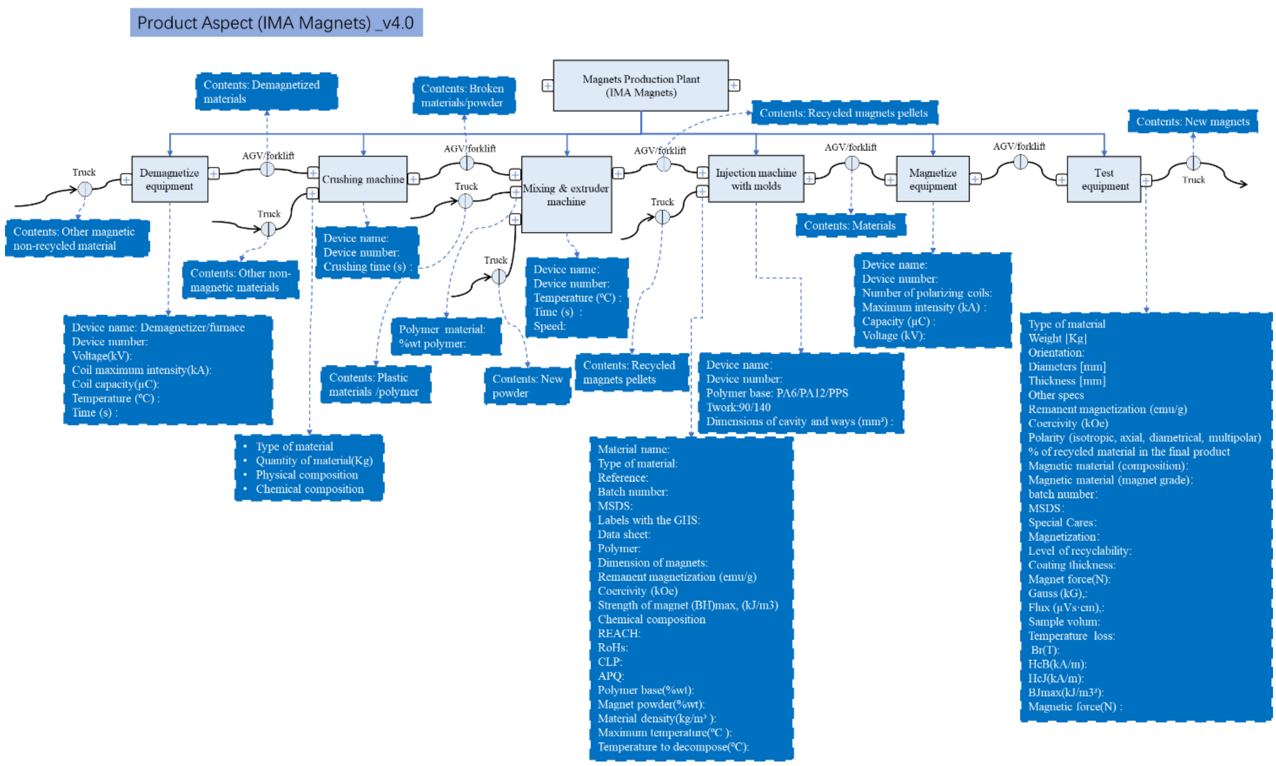

Figure 20: Product Aspect for the IMA node in Spanish pilot case

- **Name of the model:** Product aspect of new magnets production

- **Overview, purpose and scope of this model:**

The scope of the model design is the products or equipment related to the process flow in the IMA magnet processing factory. Taking Magnets Production Plant (taking IMA Magnets as an example) as the top node, the instantiation process of the system from design to implementation is described. The purpose is to achieve effective configuration of the system. Product block has at least one input and one output. Two terminals may be the same, but one terminal cannot represent more than one element. The hasPart relationship can contain multiple attributes.

- System elements: product block; product terminal; product interface point; product attribute; connectedTo relationship; hasAttributes relationship; hasPart relationship;

- Reference stakeholders: Magnet processing and manufacturing companies and upstream and downstream partners

- **Key input/output of constructing the model:** function aspect, related equipment parameter information, production process design constraints/formal description of system configuration

- **Model description:** The product aspect shows the specification of the artifact. The connection between each two terminals needs to be through a product interface point, which are mostly transportations in this case. Their attributes all include contents to be delivered between each process. In the model, the interface points that physically represent external transport are marked as "*truck*", while the interface points that represent internal transport are marked as "*AGV/forklift*". The key process equipment involved in the process is not complex and does not require secondary decomposition.

- **Attribute description:** Block, interface point and terminal in the product aspect can all define attributes. Due to the sufficiency of information collection, the overall property settings of terminals and interface points in this process are relatively detailed. The attribute definitions of Product blocks indicate the specifications and parameter constraints of the device. The attributes of all decomposed product blocks should include "device name" and "device number". The attributes of Terminals define constraints on products or materials in the process. The attribute definition of interface points includes the material content of the transportation and the restrictions on the carrier. All interface points constraints include the "*contents*" attribute.

- Interactions/dependencies with other models: this model can be easily combined with the product aspect of new magnet manufacturing (IMA), as its input part. In them meanwhile, it also serves as output part of the product aspect of magnet pellets manufacturing process (IMDEA).

3.5 Structure of the Plooto Sustainability Framework

In general, the goal of the reference frameworks is to capture all the non-financial risks and opportunities that are essential to the daily activities of a company. Therefore, ESG framework focuses on environment, society and governance, excluding the financial and growth perspectives.

The Plooto Sustainability Framework integrates different concepts and KPIs present in the various Reference Frameworks, detailed in Section 3.1, and literature, detailed in the References, in order to obtain a more up-to-date and more complete system.

Plooto aspires to have a positive and measurable impact on value chains circularity, sustainability, and resiliency. To be aligned with these objectives, requires the integration of financial aspects into the **Plooto Integrated Framework**, which has been based on two *main pillars*, a) the **Sustainability Framework**, which includes the ESG plus financial & growth perspectives, and b) the **Governance Framework**.

To these selected KPIs will be added new ones as will be described in detail in Section 4. Moreover, the pilot partners contributed to the definition of the framework and gave suggestions allowing for the system not only to enhance its flexibility, but also to better adapt to their specific process and product domain. The Plooto Sustainability framework is represented here below:

Figure 21: Plooto Sustainability Framework structure

The structure clearly echoes the one from the ESG framework, with the same division of the KPIs between Environmental, Social and Governance KPIs. This is intended to ensure more clarity in the KPIs definition and management. The same is true for the subdivisions in clusters of KPIs such as "Carbon footprint" or "Resources". The horizontal layer of Economy & Growth was integrated in the structure in order to give a better business perspective, that is also including the whole supply chain of the interested stakeholder. More importance has been given to this point of view adding also the "Opportunity" driven KPIs in each vertical domain [26].

The number of indicators present in the framework is large and the pilot partners have been encouraged to add new KPIs that are relevant to their industrial domain, throughout the supply chain. This large number of indicators aims at ensuring a great flexibility for the end user, that will then select and study the KPIs more suitable for its specific case. The growing number of indicators could have brought to a lack of clarity in the framework. However, thanks to the division in clusters, the framework remains easy-to-navigate also with high numbers of criteria.

The specific KPIs present in the Plooto Sustainability Framework are described in detail in Section 4 of this document.

4 Key Performance Indicators

Key Performance Indicators (KPIs) play a critical role in Plooto, especially in developing and delivering the Sustainability Balanced Scorecards (SBSC) and connecting the pertinent inter-relations among the waste treatment operations and waste value chains.

The European Round Table (ERT) for Industry has declared since 2021 that decision-makers call for data-driven evidence to initiate the implementation of suitable policies and strategies, aiming at measuring, among others, industrial performance, through quantifiable targets derived from concise sets of KPIs [9]. This concise list of KPIs is used to measure the success level in delivering industrial competitiveness, one of the main targets during Europe's Digital Decade [8].

Despite the robust-structured approach of ERT for activating the EU Industrial Strategy [10], Plooto foresees to adopt a comprehensive methodology in setting KPIs, following the approach of the Governance Framework and Sustainability Framework that presented in the previous sections (2 and 3), aspiring to shape an integrated framework for the SBSC. The SBSC will serve as a performance assessment, aiming to cover all the four pillars (environment, society, governance, economy & growth) by structuring an all-inclusive list of indicators.

Main objective of this list is to be capable of easily adaptation and expansion by every industrial value chain, following a cause-and-effect model and empowering the replicability and scalability potential of Plooto project.

4.1 Methodology for KPIs identification

Plooto's integrated approach aims to structure a comprehensive framework that ensure sustainability, circularity and growth of industrial, among others, supply chains. This integrated framework showed the path for developing a two-fold KPIs catalogue: a generic list of KPIs, adjustable and flexible to be integrated into every industrial supply chain, and the three tailored Plooto cases' KPIs lists, each one including the suitable indicators selected from the generic list, accompanied with the specific KPIs indicated in the DoA.

The generic list of KPIs is structured following the Plooto Sustainability Framework, delivering, therefore, indicators from four main pillars/categories: **environment, society, governance** and **economy and growth.** Moreover, extended research was conducted in available literature, targeting to identify and enclose representative indicators that will sufficiently depict the improvements and goals of the pilot use cases in terms of sustainability and circularity of supply chains.

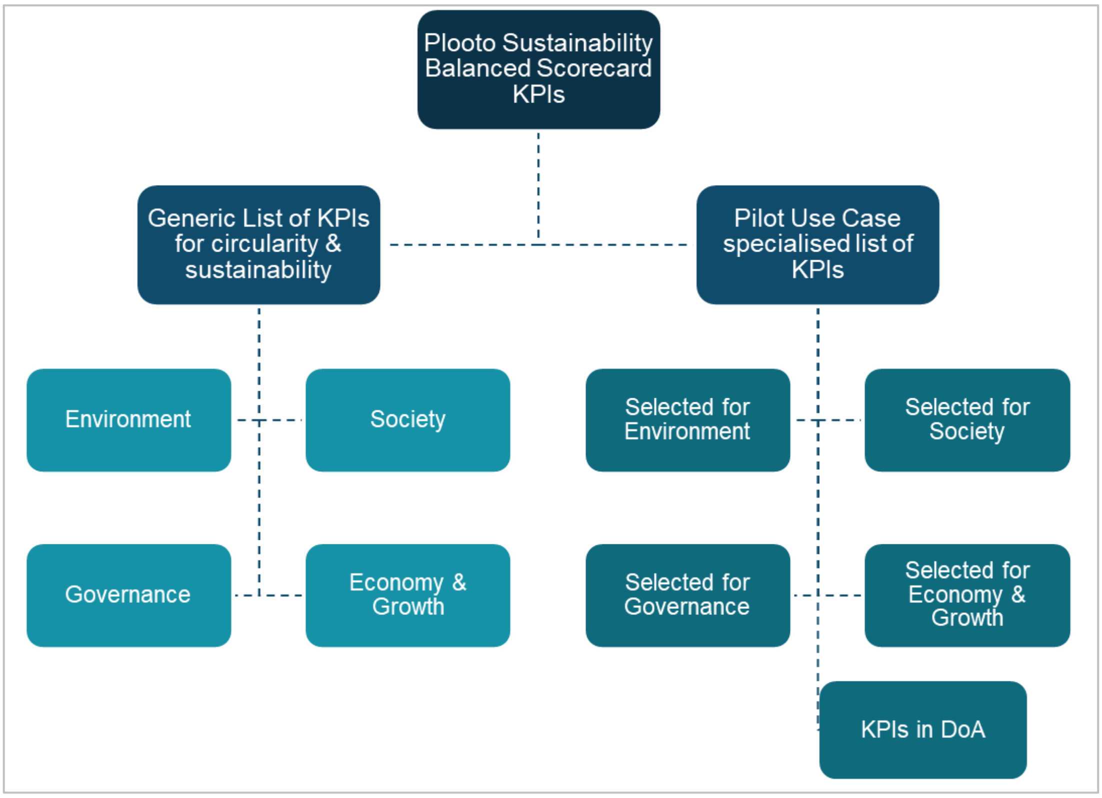

Figure 22: Plooto Sustainability & Governance Framework KPIs

The KPIs identification was based on the Plooto Sustainability and Governance Framework, which structure an integrated approach, the Sustainability Balanced Scorecard Framework, to be the core element for developing the SBSC within WP3. This framework targets to be adaptable and scalable from all value chains in industrial sector that aspire to be sustainable, resilience and circular, gain economic advantage and achieve transparency and promote traceability practices.

The extended KPIs list was a consequence of the comprehensive character of the framework. During the implementation phase and for delivering the final iteration of the Balanced Scorecard Framework through the D1.4, some adjustments may occur, according to the pilot's use case technical requirements.

4.2 Cause-and-effect Model and Scalability

Cause-and-effect analysis is used to identify the core possible causes that can influence an event. To represent this systemic relation of core causes and the investigated event, Kaoru Ishikawa developed the CE (cause-and-effect) diagram, by examining a specific topic (driving time) and the major causes that can influence and trigger this event (traffic, vehicle, speed limit, distractions).

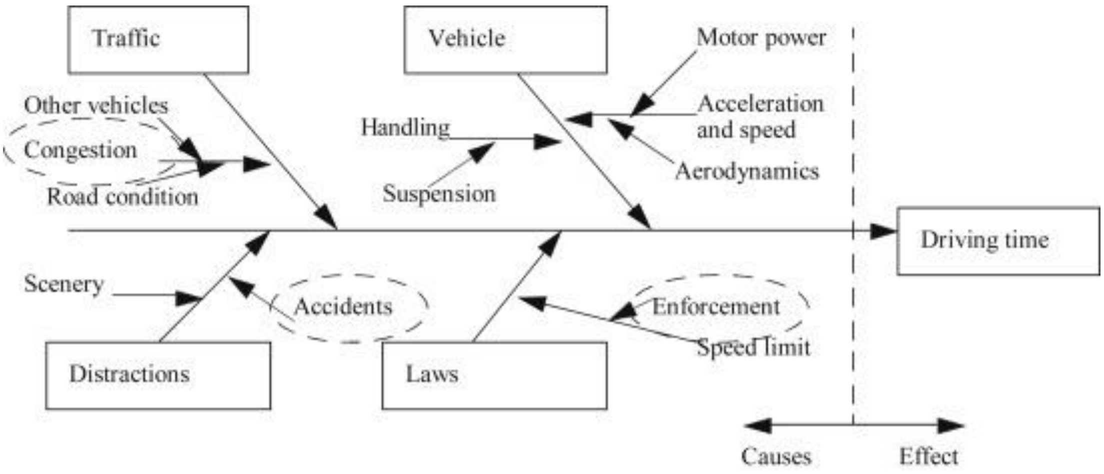

Figure 23: Example of a cause-and-effect diagram

Note: When constructing the diagram, factors can both reduce and increase the effect. Any cause can be subdivided into finer factors. Source: https://www.sciencedirect.com/topics/engineering/effect-diagram

The cause-and-effect analysis can contribute to the identification of all likely causes of a problem or difficulty or situation, providing the opportunity to target, focus, face and address effectively this situation and consequently, to solve the problem or address the difficulty or improve the situation.

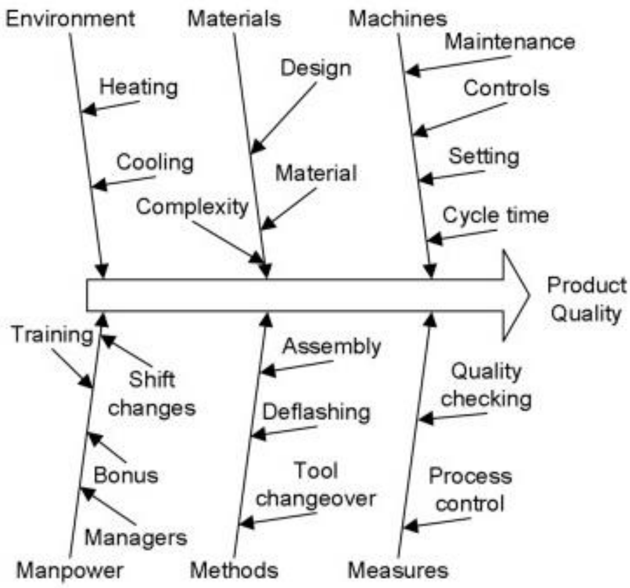

Figure 24: Example of cause-and-effect chart for production

Source: https://www.sciencedirect.com/topics/engineering/effect-diagram

In Plooto, the cause-and-effect model was followed in the identification of the KPIs that come along with and support the Sustainability & Governance Framework. Through the framework for Circular Value Chains that has been developed and reported in D1.1, and the corresponding activities (interviews, questionnaire, business canvas, etc.) several critical outcomes derived, including the information regarding the relationships among pilot's participants to draft governance strategies and to identify the relevant KPIs to assess the value chain performance. As reported in D1.1, circular value chains support critical sustainability and economic requirements for creating closed-loops systems, including *natural resources and raw material conservation, waste reduction and extended lifecycle, resilience to supply chain disruptions*.

Governance models and the Sustainability Balanced Scorecard Framework have been the basis of the "closing-the-loop" industrial value chains, bringing in the frontline the circularity of value chains, which is reinforced by the traceability and transparency strategies, and reference processes, as presented in Section 3. For developing and delivering viable value chains, the aspects of ***economic advantage***, ***resiliency***, ***sustainability***, ***traceability***, ***transparency*** and ***circularity*** were critical components in the Circular Value Chains Framework that derived from Task 1.1.

To this end, the cause-and-effect analysis in Plooto project's KPIs, focuses on the main target of creating viable value chains and transforming any industry into a green and competitive facility, identifying as essential aspects the economic advantage, resiliency, sustainability, traceability, transparency and circularity. Those features were integrated into the methodological approach of KPIs identification (presented in the previous sub-section). Thus, each one of the KPIs selected to measure and perform an assessment of the industry/company with regards to the aforementioned aspects.

4.3 Environmental KPIs

A great number of studies have been undertaken attempting to measure the environmental performance of industries deepening into their supply chains' assessment, exploiting models and frameworks such as the SCOR model [17], the ESG framework [15], practice-based theories [25] and many other methods under the Green Supply Chain Management (GSCM) approach. Critical component and objective are to empower sustainability and circularity throughout the industrial supply chain, bringing therefore, in the frontline the environmental performance.

Following the Plooto Sustainability Framework, the KPIs enclosed in the environmental pillar are divided in several sub-categories, such as the *carbon footprint*, *resources*, *pollution, and waste*, *Life Cycle Assessment (LCA),* and *opportunities and innovation*.

- **Carbon Footprint:** this category includes the KPIs relevant to the measurement of greenhouse gases, enclosing the carbon dioxide (CO_2) and methane (CH_4).
- **Resources:** this category includes the indicators that represent the resources consumption across the value chain, such as the energy, the water, the fossil fuels depletion, and other.
- **Pollution**: the KPIs of this category referred to the different types of waste (electronic waste, scrap waste packaging materials, etc.) and the relevant indicators depicting their

management (i.e., mass of reused component as feedstock to manufacture a product, etc.).

- **LCA**: the KPIs of this category are indicators used for assessing the Life Cycle of the industry, referring to them that are not included in the resources and carbon footprint categories i.e., land use.
- **Opportunities and Innovation**: this category of KPIs include indicators that assess the performance or use of Greener Technology, Greener Building Structure/Management and Sustainable Energy Source/Management.

Table 10 below presents the full list of environmental KPIs per eligibility category.

Table 10 – Environmental KPIs

KPI Name	Description	Unit	Eligible for category	Cause-and-effect
Carbon Dioxide (CO_2) [2] [20]	Amount of CO_2 released from the activities across the supply chain	kg_{eq}	Carbon footprint	Sustainability
Methane (CH_4) [27] [28]	Amount of CH_4 released from the activities across the supply chain	kg_{eq}	Carbon footprint	Sustainability
Water stress/ consumption [27] [28]	Amount of water consumed across the industrial processes	kg	Resources	Sustainability
Amount of water reused [28]	Amount of water reused across the industrial processes	kg	Resources	Sustainability, Circularity
Amount of water treated [28]	Amount of water treated before returning to the ecosystem	kg	Resources	Sustainability, Circularity
Energy consumption [27]	Amount of energy consumed across the supply chain	kWh	Resources	Sustainability
Use of RES/RES integration [1]	Amount of energy produced by RES	kWh	LCA/Resources	Sustainability, Resiliency
Fossil fuels depletion [11] [28]	Amount fossil fuels reduction (or energy from RES) in consumed energy mix	kg or kWh	LCA/Resources	Sustainability, Resiliency
Transportation processes [28]	Consumptions related to the transportation/logistics (i.e., energy)	DOC	Resources	Sustainability
Green logistics [16]	Amount of emissions during logistics activities (warehousing and transportation)	kg	Resources	Sustainability, Resiliency
Supply chain waste [22]	Amount of distributed plastics	kg	Pollution and Waste	Circularity
Recycling rates [20]	Amount of recycled plastics	kg	Pollution and Waste	Circularity

KPI Name	Description	Unit	Eligible for category	Cause-and-effect
Use of biodegradable materials	Amount of biodegradable materials produced/used	kg	Pollution and Waste	Circularity
Packaging materials and waste [1]	Amount of waste from packaging material	kg	Pollution and Waste	Sustainability
Electronic Waste [2]	Amount of electronic waste	kg	Pollution and Waste	Sustainability
Scrap Waste [2]	Amount of scrap waste	kg	Pollution and Waste	Sustainability
Resource Utilization [20]	Percentage of use of non-renewable resources across the supply chain	%	Resources	Sustainability, Resiliency, Circularity
Consumption of virgin raw materials [25]	Amount of virgin raw material consumed	kg	Resources	Sustainability, Resiliency, Circularity
ISO 22400 for traditional manufacturing [27]	ISO Certification that the company/industry meets the certification standards	-	Opportunities and Innovation	Sustainability, Resiliency, Transparency
ISO 59020 for measuring and assessing circularity	ISO Certification that the company/industry meets the certification standards	-	Opportunities and Innovation	Circularity

4.4 Social KPIs

Addressing the social issues in business strategies has become an essential segment towards the sustainability and circularity of any industry or company [17]. More specifically, the aspects of human rights and equity, as well as the policies and actions of an industry that has impacted the individuals, groups and society, play a significant role in its overall performance. It considers topics such as working conditions, product safety, human rights, community relations, and in supply chain transparency, which is crucial in the Plooto project and its objectives.

The social feature represents the willingness of the organisation to meet the human obligations in operations, supply chains and local societies. Representative indicators of social performance are among others the diversity, income equality, workplace injury rates, philanthropy.[25] The indicators of this pillar are mainly qualitative indicators, reflecting the performance of the industry in the local community.

Following the Plooto Sustainability Framework, the KPIs regarding social performance are divided in four sub-categories: *human capital, product assessment, stakeholders* and *opportunities.*

- **Human Capital**: this category of KPIs includes the indicators regarding health and safety, work management, training and staff development, labour standards, inclusion, and diversity.

[25] https://www.onetrust.com/blog/esg-101-what-does-social-in-esg-mean/

- **Product Assessment**: this category of KPIs includes the indicators for safety: chemical, financial product safety, product safety and quality, privacy data and security.
- **Stakeholders**: this category refers to the KPIs that are related to the external stakeholders (suppliers, other connected companies, etc.) such as the controversial sourcing and the supply chain liability.
- **Opportunities**: the KPIs of this category include the assessment to health care, the access to finance, opportunities in nutrition and health, and work-life balance.

Table 11 – Social KPIs

KPI Name	Description	Unit	Eligible for category	Cause-and-effect
Health and Safety [25]	Assessment health and safety conditions in the industrial company	Qualitative	Human Capital	Resiliency
Gender equity, inclusion, and diversity [25][2]	Assessment of gender equity issues, inclusion and diversity in the industrial company (i.e., proportion of women/ men employees)	Qualitative	Human Capital	Transparency
Training and Staff development [25]	Availability and implementation of training programs and staff development activities	Qualitative	Human Capital	Resiliency
Chemical safety [25] [2]	The industrial company meets the standards for safety from chemical materials	Qualitative	Product Assessment	Resiliency, Transparency
Product safety and quality [25] [2]	The industrial company meets the standards for product safety and quality	Qualitative	Product Assessment	Resiliency, Traceability
Privacy and data security[25] [2]	The industrial company runs in compliance with the regulations for privacy and data security	Qualitative	Product Assessment	Transparency
Transparency within the Supply Chain [20]	The level of transparency regarding the quality and origin of the materials, the processing, etc.	Qualitative	Product Assessment	Transparency
Controversial Sourcing [25]	Origin of materials or products (involvement in harmful or unethical practices)	Qualitative	Stakeholders	Transparency, Traceability
Supply Chain Liability [11]	The legal responsibility of the industrial company for actions or shortcomings across its supply chain	Qualitative	Stakeholders	Transparency, Traceability
Customer satisfaction [25]	Level of satisfaction of costumers from the product use	Qualitative	Stakeholders	Resiliency

KPI Name	Description	Unit	Eligible for category	Cause-and-effect
Employee satisfaction [25]	Level of satisfaction of employees in the company	Qualitative	Human Capital	Resiliency
Access to Health Care [25] [2]	Level of access of employees to medical services, treatment, and healthcare resources	Qualitative	Opportunities	Resiliency
Access to Finance [25] [2]	Level of access to external funding (i.e., research funding programs, loans, etc.)	Qualitative	Opportunities	Economic Advantage, Sustainability
Work-Life Balance [2]	Level of balance between professional responsibilities and personal time	Qualitative	Opportunities	Resiliency

4.5 Governance KPIs

Since 2009, the European Federation of Financial Analysts Societies (EFFAS) has defined nine topical areas which apply to all sectors and industries and has specified the list in five ESG-related sectors, considering this approach as a standardised and comprehensive framework.[26] With regards to governance, the EFFAS proposed two specific categories of KPIs: the Litigation Risks and the Corruption. According to the Plooto Governance Framework (Section 2), governance KPIs shall belong in categories such as the regulatory compliance, risk management, ethical business practices, board compensation, etc. representing corporate governance aspects, corporate behaviour aspects, etc. To this end, the governance KPIs in Plooto are divided into the following categories:

- **Corporate Governance**: this category of KPIs includes the indicators regarding the rules and processes that a company is being directed and managed, including the structure of the company, the ownership, the advisory board, and others.
- **Corporate Behaviour**: this category of KPIs includes the indicators for ethical standards, values and social responsibility of the company to its customers, stakeholders, local society.
- **Litigation Risks and Corruption:** this category refers to the KPIs that are related to the issues that a company faces in terms of addressing and minimizing litigation risks and corruption incidents.

Table 12 – Governance KPIs

KPI Name	Description	Unit	Eligible for category	Cause-and-effect
Board diversity [2]	Level of differentiation in backgrounds, skills and characteristics of an	Qualitative	Corporate Governance	Transparency

[26] https://ec.europa.eu/docsroom/documents/1547/attachments/1/translations/en/renditions/native

KPI Name	Description	Unit	Eligible for category	Cause-and-effect
	industrial company's board of directors			
Anti-competitive practices [2]	Number of practices that an industrial company follows to gain an advantage in the market (i.e., price fixing, bid rigging, market allocation, etc.)	Number of practices applies in a year	Corporate Behaviour	Transparency
Tax transparency [2]	Frequency of openly disclosing information of the industries about tax payments and strategies	Number of sharing information in a year	Corporate Behaviour	Transparency
Business ethics [2]	Number of practices for ensuring ethical principles i.e., environmental responsibility, product quality and safety	Number of practices applied in a year	Corporate Behaviour	Transparency
Expenses and fines on litigation incidents [27]	Expenses and fines on filings, lawsuits related to anti-competitive behavior, anti-trust and monopoly practices	€	Litigation Risks and Corruption	Transparency
Litigation risks payments[28]	Payments for addressing litigation incidents	€	Litigation Risks and Corruption	Transparency
Percentage of revenues in regions with TI corruption[30, 29]	Percentage of revenues in regions with TI corruption below 0.6	%	Litigation Risks and Corruption	Transparency

4.6 Economy and Growth KPIs

Economy and Growth have been one of the main segments in every business prosperity plan, therefore has been considered as a critical one within the Plooto Sustainability Framework, also following the aspects and characteristics of the frameworks analysis and identification presented in Section 3.1.

The Economy and Growth pillar encloses the categories of *financial, customer* and *growth perspective.*

- **Financial**: this category includes KPIs related to the economic performance of the company, such as the market share, the revenue growth, also more circularity-specific indicators such as the net cost savings due to circular activities,

[27] EFFAS, KPIs for ESG, European Federation of Financial Analysts Societies, Version 1.2, DVFA, 2009
[28] Science Based Targets resources: https://sciencebasedtargets.org/resources
[29] Transparency International, Corruption Indexes, available at: https://www.transparency.org/en/cpi/2022/index/ita

- **Customer**: this category includes KPIs related to the customers' contribution into the economic performance of the industry, such as the customer retention, customer profitability, and other.
- **Growth perspective**: the KPIs of this category target to depict the growth potential of the industry, including indicators such as the revenue growth, employee retention, the employee productivity, and other.

Table 13 – Economy and Growth KPIs

KPI Name	Description	Unit	Eligible for category	Cause-and-effect
Market share [3]	The percentage of sales of a product related to all sales of that product for a specific time period i.e., per month, and for a specific geographic area (i.e., at national level)	Depends on the case/ available data, usually in € per specific month, per specific area	Finance	Economic advantage
Asset utilization[29]	How effectively uses a company its own assets to generate revenue	Qualitative	Finance	Economic advantage, Resiliency
Net cost savings due to circular activities	Assessment of savings that coming from circular activities (i.e., re-use of materials or secondary raw materials, treatment of water to enter the process, etc.)	€	Finance	Economic advantage, Circularity
Customer acquisition [3]	Number of new incoming customers per year	No	Customer	Economic advantage
Customer retention[30]	Perception of customers remaining or leaving, per year or specific period	% (±)	Customer	Resiliency
Customer profitability[29]	Assessment of net profit generated by individual customers	€	Customer	Economic advantage
Employee retention[29]	Perception of employees remaining or leaving, per year or specific period	% (±)	Growth perspective	Resiliency
Productivity growth[29]	Percentage of increase in output/value generated per unit, for a specific time period	%	Growth perspective	Economic advantage, Resiliency
Revenue growth[29]	Percentage of increase in revenues/sales generating income, for a specific time period	%	Growth perspective	Economic advantage

[30] https://ec.europa.eu/docsroom/documents/1547/attachments/1/translations/en/renditions/native

KPI Name	Description	Unit	Eligible for category	Cause-and-effect
Compound Annual Growth Rate (CAGR)[31]	Annual growth rate of an investment over a specific period of time, longer that 1 year[32]	%	Growth perspective	Economic advantage, Resiliency

4.7 Specific KPIs per Pilot Case

In section 4.6, a generic list of KPIs was presented, including indicator lists that are capable of being adapted, expanded, readjusted, and applied to a wide variety of industrial companies, including the ones serving as pilot use cases in the Plooto project. Those generic indicators could be measured or assessed for presenting the overall performance of the Plooto pilots in terms of environment, society, governance and economy and growth, following the sustainability framework developed and presented in section 3.

Nevertheless, the comprehensive list of KPIs of the Plooto project is necessary to include the KPIs that is contractual obligation to be measured, also the key points defined in Task 1.1 and presented in D1.1, following the cause-and-effect approach.

Therefore, the following tables include both the KPIs per pilot use case and the main outcomes of Task 1.1, demonstrating the current value (baseline) and the outcome achieved through the Plooto's contribution (ex-post).

Table 14 – KPIs for *CFRP Waste for Drones*

KPIs and Description	Baseline	Ex-post
Prepreg shelf life	6 months	12 months
Prepreg disposal in HP	30 tons/year	10 tons/year
Value of uncured prepreg scraps for HP	-300€/tons	+300€/tons
New Jobs in partners facilities related to exploiting uncured prepreg scraps	0	5
Unused CFRP waste in the production of composite materials (%)	Not currently measured	At least 20% reduction of the existing unused CFRP waste
KPIs identified from interviews within Task 1.1 (output of D1.1)		
Reduce of the existing unused CFRP waste	-	-

Table 15 – KPIs for *WEEE for Magnets*

KPIs and Description	Baseline	Ex-post

[31] https://www.investopedia.com/terms/c/cagr.asp

[32] CAGR is measure by the formula CAGR=((Ending value/Starting Value)^(1/Number of years)-1)*100

Reduction of WEEE landfilled (for the bonded materials' part)	24,8 tn/year	16,12 tn/year
Usage of SRM (bonded NdFeb, Sr-Ferrite) in PM magnet pellets' production (%)	Not currently measured*	At least 30% increase
Number of types of validated materials	0	3
Recycling from leftovers and disregarded magnets (%)	60%	At least 75%
KPIs identified from interviews within Task 1.1 (output of D1.1)		
Improve the quantity of leftovers and disregarded magnets entered into the transformation process	-	-
Increase the usage of SRM (bonded NdFeb and Sr-ferrite) in PM magnets pellets' production	-	-
Increase the usage of Sr-ferrite crushed pellets in magnets production	-	-
KPIs from internal technical meetings for defining KPIs list		
Minimisation of raw materials insertion	-	-

**Specific measurement will take place to define the baseline value at the first year of the project.*

Table 16 – KPIs for *Citrus Processing Waste for Juice By-products*

KPIs and Description	Baseline	Ex-post
Production of animal feed	10.000-15.000 tn	At least 20.000 tn after project lifetime
Production of high-quality molasses	2.000-2.500 tn	3000-3500 tn after project lifetime
Production of d-Limonene	0.5-1.5 tn	At least 2 tn within project lifetime
Volume of CPWW (Citrus Peels Wastewater)	150.000-250.000tn	At least 10% decrease
COD of CPWW	10000	At most 2000
Volume of CPWW that goes to biological treatment	100% (after 1+ cycles)	At least 40% decrease
Revenues from animal feed	1 M	2 M
KPIs identified from interviews within Task 1.1 (output of D1.1)		
Improve energy savings	-	-
Improve cost savings	-	-

Conclusions

The activities carried out in Work Package 1, and especially in Tasks 1.2, 1.3 and 1.4, lead partners to the definition of a first version of the Plooto Sustainability Balanced Scorecard (SBSC) Framework.

The information collected - in the form of necessities to tackle and established frameworks to use as references – gave a specific direction to the Plooto framework, which has been assessed and validated by the use cases of the project. From the high-level framework, specific KPIs were identified that tackle specific needs in the different industrial domains of the use case partners. A comprehensive list of KPIs has been defined and updated, from which every pilot case will be able to freely choose the ones that are more suitable to its specific industry/domain/supply chain necessities. The indicators selected from this list by each use case partners are detailed as an attachment of Deliverable D3.5, submitted in Month 18 of the Plooto project.

This document is the second and final version of the deliverable D1.3 "Sustainability balanced scorecard framework v1", that was submitted in Month 12.

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Appendix A: Sustainability Standards Analysis

Name	Type	Focus	*Features*
		Reporting Standards	
SASB – Sustainability Accounting Standards Board[33]	Standards	Sustainability Accounting, Environmental, Social and Corporate governance	Industry-specific disclosure standards across ESG Topics, available for 77 industry types
CDBS – Climate Disclosure Standards Board[34]	Standards	Climate and natural capital reporting towards sustainable financing	Compliance with EU policies – Corporate Sustainability Reporting Directive (CSDR), SDG 13, 15, 17, supports 12
IFRS – International Financial Reporting Standards Foundation[35]	Standards	Development and promotion of accounting standards	International Sustainability Standards Board for sustainability-related standards (IFRS-S)
PCAF – Partnership for Carbon Accounting Financials[36]	Standards	Facilitating financial industry alignment with the Paris Climate Agreement	Industry-led initiative to enable financial institutions to consistently measure and disclose the GHG emissions financed by their loans and investments
ISO Standards – International Organisation for Standardisation[37]	Standards	Helping to meet the UN Sustainable Development Goals	ISO 26000:2010 - Guidance on social responsibility ISO 14001:2015 Environmental management systems
		Reporting Frameworks	
GRI – Global Reporting Initiative[38]	Framework	Understand and communicate the impacts on issues such as climate change, human rights, and corruption	Provides the world's most widely used sustainability reporting standards

33 https://sasb.org/standards/download/
34 https://www.cdsb.net/sites/default/files/cdsb_framework_2022.pdf
35 https://www.ifrs.org/projects/work-plan/general-sustainability-related-disclosures/#published-documents
36 https://carbonaccountingfinancials.com/en/standard#the-global-ghg-accounting-and-reporting-standard-for-the-financial-industry
37 https://www.iso.org/developing-sustainably.html
38 https://www.globalreporting.org/how-to-use-the-gri-standards/gri-standards-english-language/

Name	Type	Focus	*Features*
CDP – Carbon Disclosure Project[39]	Framework	Investors, companies, cities and governments in building a sustainable economy by measuring and acting on environmental impact	New five-year strategy: Accelerating the Rate of Change was launched 2021
TCFD – Task Force on Climate Related Financial Disclosures[40]	Framework	Risks mitigation of climate change and advancing transparency in companies	Committed to market transparency. Climate-related financial disclosure recommendations
Equator Principles[41]	Framework	A financial industry benchmark for determining, assessing and managing environmental and social risk in projects	Common baseline and risk management framework for financial institutions to identify, assess and manage environmental and social risks
Science Based Targets[42]	Framework	Science-based targets provide companies with a clearly-defined path to reduce emissions in line with the Paris Agreement goals – commit, develop, submit, communicate, disclosure	Targets are considered 'science-based' if they are in line with what the latest climate science deems necessary to meet the goals of the Paris Agreement
Natural Capital Coalition[43]	Framework	By 2030 the majority of businesses, financial institutions and governments will include the value of all capitals in their decision-making	Global multi-stakeholder collaboration that brings together leading global initiatives and organizations to harmonize approaches to natural capital
Greenhouse Gas Protocol[44]	Framework	Greenhouse Gas Protocol provides standards, guidance, tools and training for business and government to measure and manage climate-warming emissions	Calculation tools and guidance https://ghgprotocol.org/calculation-tools-and-guidance

39 https://www.cdp.net/en/supply-chain
40 https://www.fsb-tcfd.org/recommendations/
41 https://equator-principles.com/about-the-equator-principles/#EquatorPrinciples
42 https://sciencebasedtargets.org/step-by-step-process
43 https://capitalscoalition.org/capitals-approach/
44 https://ghgprotocol.org/standards

Name	Type	Focus	*Features*
IR – Integrated Reporting[45]	Framework	Integrated Reporting Framework is used to improve quality of information, promote a more cohesive and efficient approach, enhance accountability, support integrated thinking, decision-making and actions for value creation	The Integrated Reporting Framework and Integrated Thinking Principles are maintained under the auspices of the IFRS Foundation
Sustainable Development Goals[46]	Framework	Indicators and a Monitoring Framework for the Sustainable Development Goals	Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development

[45] https://www.integratedreporting.org/resource/international-ir-framework/
[46] https://sdgs.un.org/goals