Environmental assets tokenization for regenerative finance

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1. Environmental and Trust Crisis

The current climate and environmental crisis we are facing is of such magnitude that it requires profound and decisive action, both from the public and private sectors. They must take concrete and ambitious measures to reverse the situation and regenerate ecosystems.

However, the lack of trust, collaboration, enabling infrastructure, technical capabilities, and the risk of greenwashing pose significant challenges to implementing programs and projects that yield environmental results at the scale and speed demanded by this crisis [1].

In this context, transparency, traceability, and continuous monitoring of the environmental results obtained emerge as structuring elements to build the required environmental trust and integrity. Which enables the establishment of mechanisms that promote and reward environmental action[2].

Moreover, in the absence of these elements, any commitment or claim of environmental action carries significant risks to the credibility or reputation of the organization or jurisdiction making them, as there are insufficient means to adequately assess the evolution and performance of the executed "green" or sustainable activities.

Despite the above, claims and commitments with insufficient evidence and performance tracking are a common practice that extends notably worldwide. Initiatives such as the “Green Claims Directive” from the European Union are emerging to address this issue through guidelines, requirements, and/or regulations. This phenomenon is expected to spread and deepen globally.

As shown in Figure 1, results from a survey performed by Ipsos, a market research institution, show that the prevailing lack of trustworthiness among government ministers and politicians is the highest among other bodies and institutions, which raises significant concerns, eroding confidence in their integrity. This skepticism extends to environmental issues, amplifying the need for rebuilding environmental trust. Transparency and accountability in actions are pivotal to restoring confidence and fostering genuine commitment to ecological challenges.

Thus, without careful and continuous monitoring, it is challenging to report real progress in terms of environmental sustainability, as access to accurate, consistent, and firsthand information plays a fundamental role in building trust in the processes and their corresponding results.

[1] On crisis and emergency: Is it time to rethink long-term environmental accounting? *Critical Perspectives on Accounting,* Tregidga & Laine, 2022.
[2] *Towards an Ontology and Blockchain Based Measurement, Reporting, and Verification for Climate Action,* Kim & Baumann, 2022.

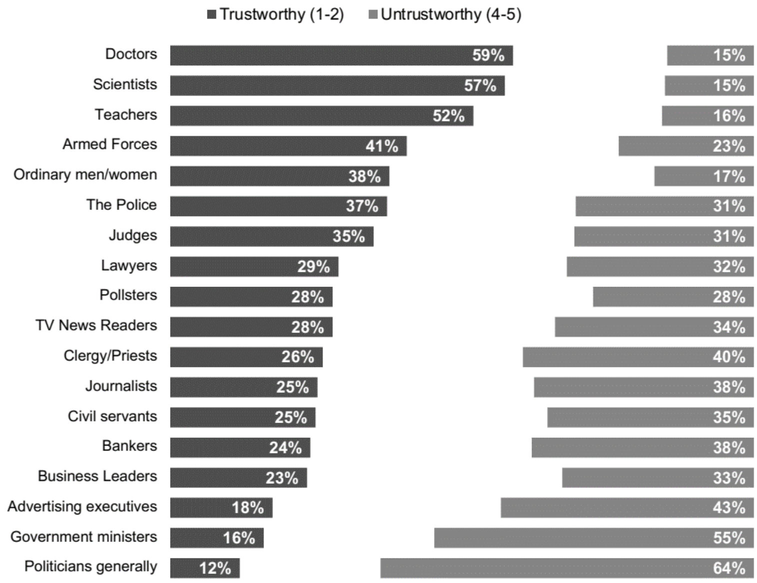

Figure 1: Ipsos Global trustworthiness ranking 2022 comparing integrity among different groups of people[3], being business leaders, advertising executives, government ministers, and politicians the least trustworthy according to the survey.

2. Externalities and Environmental Markets

Environmental externalities refer to the effects caused to third parties not involved in the activity of a particular action or project. These can be both positive and negative, depending on the nature of the generated impact. To address the effects of these activities, regulations and/or mechanisms for internalizing their collateral effects are required. An example of the latter is subsidies as incentives for positive impacts or taxes as penalties for negative impacts.

Globally, various schemes aim to promote the reduction of negative environmental externalities and incentivize positive ones. Changes in market behavior tend to go side by side with the redirection of resources, complementary financing mechanisms, and additional incentives for implementation.

Moreover, these schemes require monitoring, reporting, and verification (MRV) mechanisms to assess the environmental performance of projects and access established incentives or financing opportunities. Therefore, they must ensure the independence, continuity, integrity, and robustness of their respective processes. In fact, currently, the high costs of traditional MRV pose a barrier to accelerating and scaling carbon markets[4].

We will define environmental markets as regulated systems where emissions allowances or permits for the consumption of natural resources are traded, as well as certificates that are proof of the origin or positive environmental actions based on results. These markets have matured over time, surpassing less flexible mechanisms. In fact, since 2021, the revenue from cap-and-trade emissions trading systems has exceeded the revenue from global carbon taxes,

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[3] Ipsos Global trustworthiness ranking 2022. IPSOS, 2022.
[4] Assessment of Digital Measurement, Reporting, and Verification. A Snapshot of D-MRV in Decentralized Energy, Forestry, and Agriculture, Soini et al., 2022.

with an increase in the price per ton of carbon dioxide due to high demand and more stringent goals. On the other hand, voluntary markets, where ownership of a voluntary environmental action is transferred, have experienced a 47% growth between 2020 and 2021, covering 1% of the planet's emissions[5] .

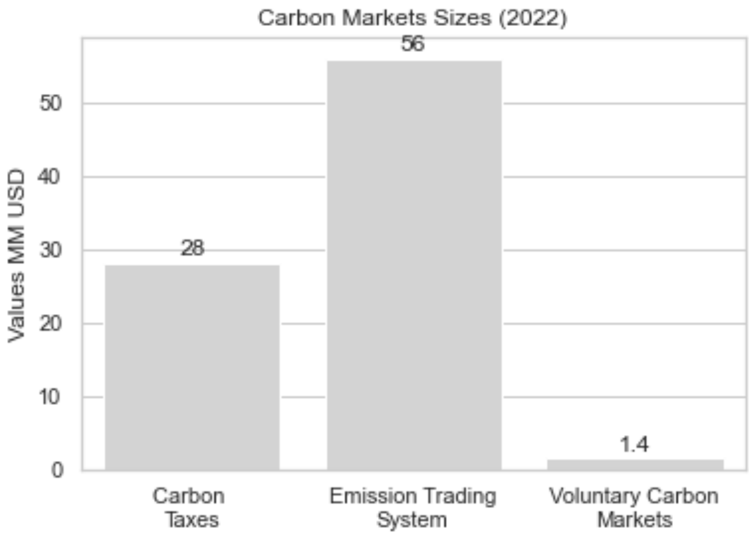

Figure 2: Comparative chart comparing market sizes with tax volumes.

It is expected that carbon markets will experience an exponential increase during this decade, given their compatibility with the fulfillment of Nationally Determined Contributions (NDCs) under the Paris Agreement. This is compounded by a growing number of companies and organizations committing to Net-Zero goals, which require mitigation result transfer schemes to meet their commitments and offset residual emissions (Scope 1 or 2) and/or those of their value chain (Scope 3).

These projections confirm the urgency of accelerating solutions that reduce friction, time, and costs for accrediting emissions reduction and/or the positive environmental impact of projects. Facilitating various financing schemes and their rapid and effective implementation.

3. Monitoring, Reporting, and Verification (MRV) Systems

Monitoring, reporting, and verification (MRV) systems encompass the set of measurements and processes used to quantify and ensure the environmental performance of projects. Once the monitoring, calibration, checks, and necessary calculations are performed, the data's origin and implemented procedures are audited to verify that the reported information and obtained results are correct, intact, and conservative. They must be in compliance with the protocols and/or international methodologies.

[5] State and Trends of Carbon Pricing 2022, The World Bank, 2022.

The use of MRV systems facilitates the exchange of information through clear rules and processes, promoting trust in the truthfulness, representativeness, and accuracy of the results[6].

That's why MRV is a fundamental component to ensure the results of all types of projects, regardless of their typology and scale, being used in national emission inventories down to the level of corporations and/or projects. Playing an increasingly important role in structuring financing based on environmental performance or green bonds for the energy and ecological transition of countries and companies.

While different types of standards, protocols, and methodologies establish minimum requirements and integrity criteria for adequate monitoring, reporting, and verification, it is also true that there is a certain degree of flexibility and responsibility on the part of the project developer regarding the methods and data sources to be used. This is why the design and implementation of an MRV are by no means trivial. Its execution involves risks associated with potential deviations from guidelines, instrument failures, and data losses, as well as the consumption of a significant amount of resources and time by operation and maintenance teams. Additionally, the information must be unified, processed, and properly backed up before undergoing third-party independent verification.

The audits carried out must verify the correct implementation of the methodology and its corresponding MRV system, ensuring the integrity, quality, and conservatism of the results obtained. This process may require several iterations and additional elements beyond those already considered, directly impacting the difficulty, friction, and total cost of these processes.

With all of the above, the implementation of non-systematized MRVs can pose a barrier to a proper claim of the environmental results obtained by a project, reducing or even eliminating the possibility of accessing complementary incentives and green financing schemes.

This gives rise to the opportunity to leverage the capabilities that technology currently provides to automate processes, centralize information, and strengthen the integrity of collected data. At the same time, it minimizes the risks of manipulation, human intervention, potential biases, and/or unintended deviations, thereby increasing transparency, integrity, and confidence in the results.

[6] Towards an Ontology and Blockchain Based Measurement, Reporting, and Verification for Climate Action, Kim & Baumann, 2022.

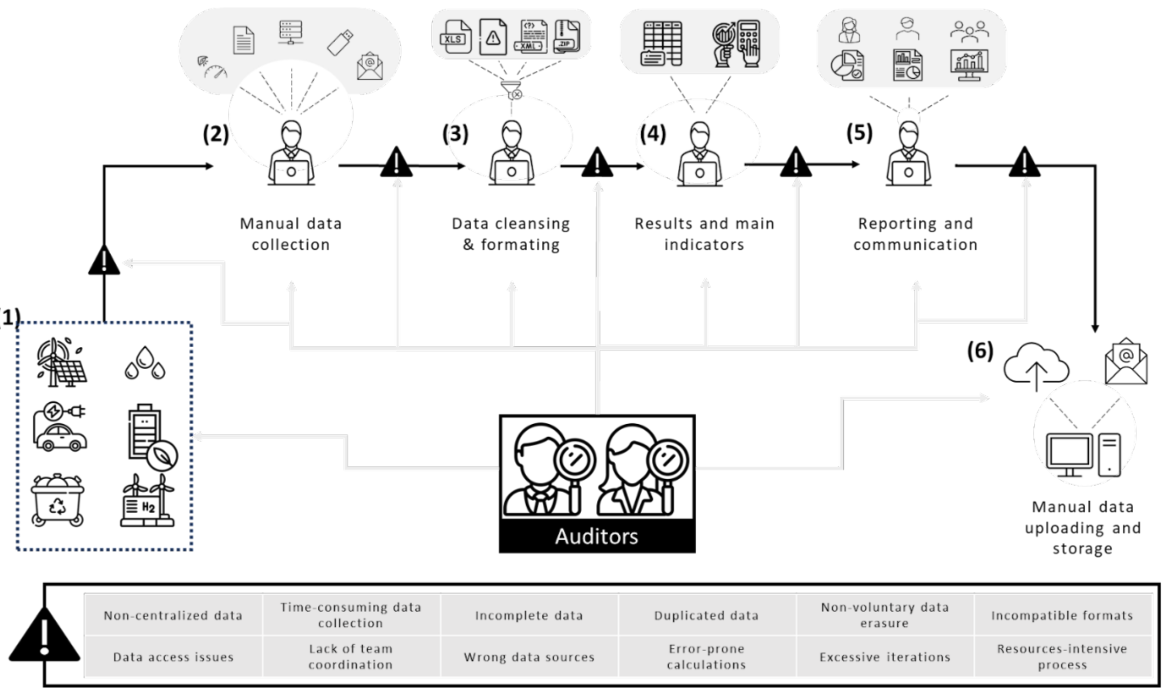

Figure 3: Descriptive diagram of the operation of conventional MRV systems. Source: Own elaboration based on EnergyLab experience.

4. Digitalization of MRV Systems (d-MRV)

A significant portion of the previously described frictions and inefficiencies can be addressed through the integration of technologies such as the Internet of Things (IoTs), artificial intelligence (AI), and blockchain.

To begin with, the digitization of MRV systems involves a comprehensive understanding of information flows at each stage of the monitoring process, creating an environment conducive to the automation and optimization of various processes. It is noteworthy that a significant portion of efforts and resources is invested in data collection and unification tasks, which also represent a source of risks for errors, information losses, or inappropriate manipulation.

While digitalization processes have accelerated in recent years, this has not deeply permeated MRV systems in environmental markets, where practices still rely on spreadsheets, PDF files, and field visits. According to the article "Navigating Blockchain and Climate Action 2022 State and Trends," the main benefits of digital MRV systems are associated with the following elements[7]:

- Simplified collection and review of relevant parameters for different protocols and methodologies.
- Consolidation in a centralized platform for easy access, traceability, and transparency.
- Adaptation to the diversity of projects, maximizing the synergy of applications.

[7] Navigating Blockchain and Climate Action 2022 State and Trends, Kohli et al., 2022.

- Elimination of risk points due to manual interaction with data in the monitoring process.

Thus, through the direct use and connection of sensors and meters linked to the internet, real-time monitoring of projects is ensured. This enhances the robustness of MRV and reduces risks associated with data entry errors, data corruption, and failed versions control. And, with the support of artificial intelligence algorithms, it is possible to systematize unstructured data and processes, securely distribute information, and safeguard against any manipulation by third parties and/or stakeholders.

5. Blockchain and Environmental Assets Tokenization

A blockchain system is defined as a decentralized ledger that exists across a network of computers, facilitating the recording of transactions. As new data is added to the network, a new block is created and permanently linked to this chain. Importantly, it does not depend on a single point or entity[8]. These technologies enable relevant properties by allowing the storage of valuable data in a decentralized and distributed manner. Consequently, they generate significant benefits associated with safeguarding the integrity and trust in the assets and processes monitored by them.

Among the key properties or benefits that blockchain technology contributes to digital MRV systems, the following stand out:

- <u>Immutability:</u> Information written on the blockchain cannot be modified without the consensus of the nodes that make up the network, remaining permanently recorded. Therefore, any asset registered in a network of this kind is backed in an unalterable way.
- <u>Traceability:</u> Changes or adjustments requirement are made by generating a completely new record, which is linked to the previous one. This creates a history of changes without data losses and is immune to errors or computer frauds.
- <u>Transparency:</u> Data is searchable and verifiable. This is because the information stored in the blockchain is protected through a unique and irreplicable code or hash assigned only to the set of the corresponding data. Therefore, the validity of a data package is easily verifiable, regardless of the point in time when it needs to be checked.

However, when designing the blockchain component of a solution, it is essential to consider its energy consumption and associated greenhouse gas emissions. As indicated in the article "Guidelines for Improving Blockchain's Environmental, Social, and Economic Impact" from the World Economic Forum[9], "The word "*blockchain*" is often used as a generic term to refer to all types of blockchain solutions – there are, however, significant differences between blockchains and the solutions implemented on top of them. Key to addressing the energy impact of blockchain solutions is the ability to clearly delineate these differences so that assessments of environmental impact can be compared to one another."

[8] What is Web3? McKinsey & Company, Chui et al., 2023.
[9] Guidelines for Improving Blockchain's Environmental, Social and Economic Impact, World Economic Forum, Cheikosman & Mulligan, 2023.

It is in this aspect that the consensus mechanism of the blockchain is one of the key components in the trade-off associated with the data robustness and defining the environmental impact and corresponding carbon footprint it entails, "proof of stake (PoS) chain and can be several orders of magnitude more energy efficient than the proof of work (PoW) consensus process, they are different implementations of the PoS algorithm, each of which requires a different methodology in calculating carbon footprint"

However, there are many other consensus alternatives depending on the specific application case. As shown in the report from the World Economic Forum, some of these alternatives include:

Table 1: Energy consumption according to each of the consensus algorithms. Source: Own elaboration based on "Guidelines for Improving Blockchain's Environmental, Social and Economic Impact", World Economic Forum.[10]

Consensus algorithm	**Proof of work**	**Proof of activity**	**Proof of burn**	**Proof of capability**	**Proof of elapsed time**	**Proof of authority**	**Proof of stake**	**Practical byzantine fault tolerance**	**Proof of history**
Energy consumption	*High*	*Medium-high*	*Low-medium*	*Low-medium*	*Low*	*Low*	*Low*	*Low*	*Low*

Thanks to all the above, this technological tool allows the construction of a robust and reliable environment to digitally represent what occurs in the physical world. Which may be duly complemented with the execution of smart contracts on the blockchain to create tokens associated with the respective environmental assets and various monitored vintages.

6. Green Tracker: Environmental Assets Tokenization

Green Tracker is a blockchain-as-a-service (BaaS) that enables an environment to implement digital Monitoring, Reporting, and Verification systems (d-MRV), addressing all the necessary stages and steps for assuring results and facilitating their management as environmental assets.

The different stages of d-MRV are established based on international methodologies and protocols for monitoring environmental projects, while the collection and verification of information are automated using existing sensors, internet of things (IoT) devices, and artificial intelligence (AI) algorithms for unstructured data. Ensuring the environmental integrity, truthfulness, and completeness of the foundational information for the subsequent processes.

The system employs distributed information storage protocols to safeguard its immutability and permanence over time. It utilizes a hybrid blockchain system, public-private, and based

[10] Guidelines for improving blockchain's environmental, social and economic impact. World Economic Forum, Cheikosman & Mulligan, 2023.

on "proof of stake" and "proof of authority" consensus protocols, achieving the lowest possible operating costs, energy consumption, and environmental footprint.

Environmental results can be audited with tools that facilitate and expedite the process, becoming publicly available for subsequent communication and/or review by all types of stakeholders.

In this way, Green Tracker enables developers of environmental projects to recover and materialize the benefits generated by these activities, making them available as assets representing the added value or positive externality of their operation. This is expected to improve the profitability indicators of their management, facilitate compliance with commitments to stakeholders and regulatory entities, and accelerate the scaling of solutions that benefit the planet.

Below are some of the main features of the design and technological integration enabled by Green Tracker:

- Comprehensive coverage of a wide range of MRV processes by the system.
- Automation of data collection, validation, and storage.
- Assurance of the immutability and truthfulness of data over time.
- Environmental results are automatically obtained.
- Facilitation and acceleration of verification audit processes, executable in manual, semi-automatic, or automatic mode.
- Results are converted into environmental assets, managed by project owners through a public registry.
- Strengthening and reduction of costs and time for MRV processes for project owners, regulators, and auditors.

Next, a simple infographic is presented to broadly explain the steps involved in the operation of Green Tracker for different project typologies:

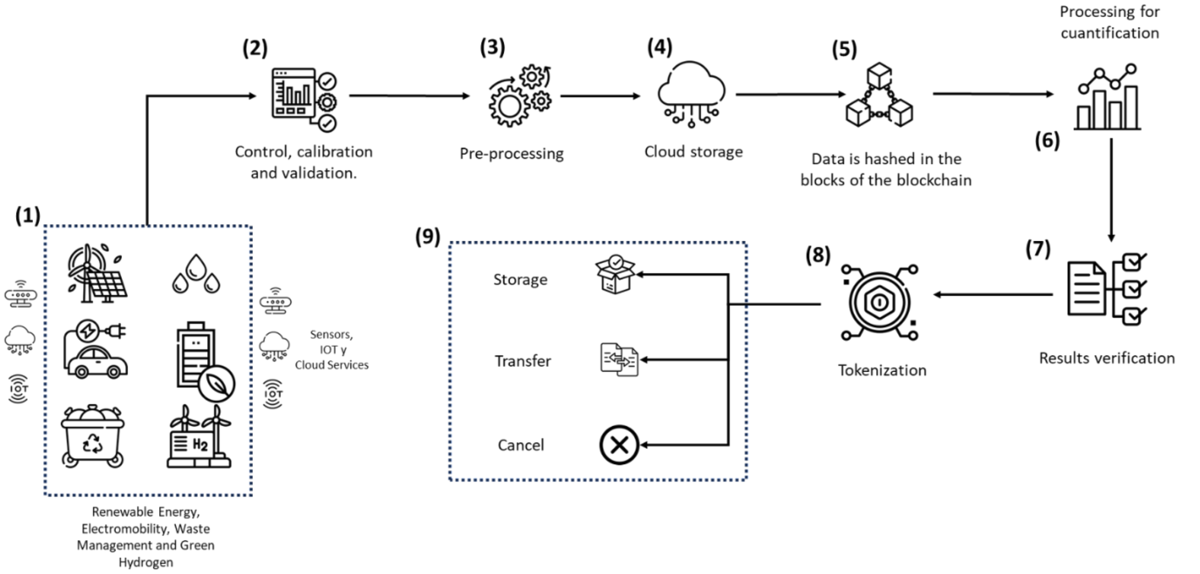

Figure 4: Different components of the Green Tracker system and how they interact. Source: Own elaboration.

Table 2: Description of each stage in the processes carried out by the system.

(1) Through the use of sensors, IoTs, and AI, data is collected from monitored sources such as renewable energy generation, electric fleet usage, energy efficiency, energy consumption savings, and material management and recycling, among others.
(2) The collected data, along with various controls, calibrations, and validations, are defined within the system, based on what international methodologies and protocols establish for environmental projects.
(3) The pre-processing of the data is also carried out based on the guidelines set by international methodologies and protocols.
(4) The previously processed and reviewed data is stored in the cloud, ensuring its safeguarding and allowing for the option to eliminate dedicated physical infrastructure for the d-MRV.
(5) Additionally, the data is hashed and stored in blocks on the blockchain, ensuring its safeguarding and immutability over time.
(6) Positive environmental impacts are automatically obtained by the system at a predetermined frequency, and they are accessible at a preliminary level through queries through the web system.
(7) The results undergo verification audits in accordance with international methodologies and protocols. The process is supported by algorithms that facilitate reviews and controls, offering options for manual, semi-automatic, and automatic audits.
(8) The audited results that receive favorable verification are tokenized and deployed in the project owner's account, enhancing transparency, traceability, and ownership of the environmental asset.
(9) The project owner manages their results from Green Tracker's public registry, where they can store, transfer, and/or cancel assets. This registry is built on blockchain, ensuring the information and any token operations.

7. Main benefits associated with the use of Green Tracker

The design and technological integration implemented in Green Tracker address challenges such as the lack of reliable, transparent, public, and traceable information regarding the environmental performance of projects that generate positive environmental impacts. This reduces the risks of greenwashing, double claiming, double counting, or even double selling of the environmental assets associated with these initiatives:

- Reliability: Most of the information used is obtained from meters or devices connected directly to the system, eliminating risks of errors or manipulation. Additionally, the data is distributed and backed up in the blockchain, reducing the risks of subsequent losses or hacking.

- Transparency: Raw information and environmental results are verified through the system and/or independent auditors, who have access to a complete record of the background, parameters, and data controlled by the system.
- Public: All projects have a public view with corresponding descriptions of their environmental actions, its MRV system, and the results obtained.
- Traceable: Any deviation, error, or correction is recorded within the system, as well as the emission and transfer of the generated environmental assets. These are also properly backed up in the public blockchain and accompanied by a certificate that facilitates their traceability in it.

Additionally, Green Tracker possesses relevant attributes in terms of flexibility, cost-effectiveness, and integrity:

- Flexibility: It can support the implementation of any type of d-MRV, as long as there are devices and/or methods to collect the structured and unstructured data required by the international methodologies or protocols that define the scope of the MRV.
- Cost-effectiveness: The system allows for reducing the costs of MRV processes for project owners and verifying entities, thereby reducing the scale required for a particular initiative to monitor, materialize, and capitalize on its environmental benefits.
- Integrity: In line with maintaining low implementation and operation costs, the system prioritizes the use of existing instruments and IoTs in installations, making it feasible to connect to a wide range of devices and APIs.
- Profitability: Once the results are verified, the tokenization of environmental assets increases the possibilities for profitability and monetization, as they become available in a registry that ensures their control and ownership until the owner decides. This contributes to ensuring the proper use and corresponding claiming of environmental benefits.

8. Uses and Applications of Green Tracker

Green Tracker allows monitoring and materializing a wide range of environmental assets, among which the following stand out:

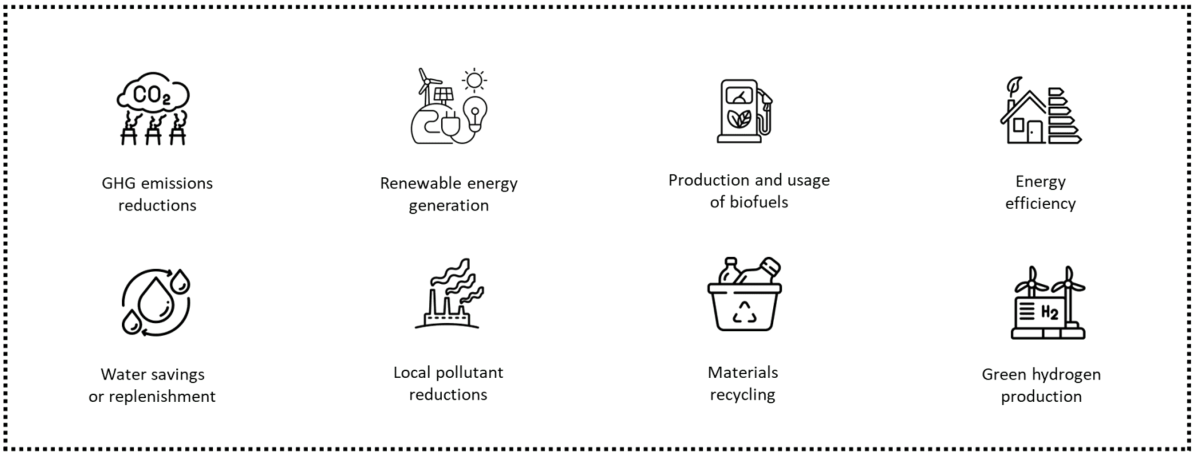

Figure 5: Different types of tokens or environmental assets to be monitored and tokenized (among others). Source: Own elaboration.

Here are the types of users of Green Tracker and how they can address the main challenges they face when developing projects, public policies, and/or financing schemes that generate positive environmental benefits:

Figure 6: Different type of actors and actions to be benefited by Green Tracker. Source: Own elaboration.

At the corporate and institutional level, Green Tracker offers an attractive alternative to transfer positive environmental results throughout the value chain. It promotes the generation of "green" attribute certificates, showcases leadership through verifiable claims, and provides an option to access reductions in environmental impact beyond organizational boundaries.

Indeed, thanks to the tokenization or certification of positive environmental impact, it represents a quantifiable added value that is indexable to the price of a particular product or service. Some examples of this include:

- Origin of renewable energy and/or biofuels (regardless of the energy/fuel type supplied by the grid).
- Reduction of greenhouse gas emissions or local pollutants transferred to a specific customer (with greater sensitivity and/or willingness to pay to capitalize on that reduction).
- Certificates of recycled origin for certain suppliers.

On the government front, Green Tracker emerges as an option to monitor progress and compliance with the Nationally Determined Contributions (NDC) at the project level. It also serves as an alternative for the eventual accreditation of mitigation results for incentive programs or intersectoral result transfers at the national level (via tax credits). Additionally, it can be considered at the international level (Internationally Transferred Mitigation Outcomes or ITMOs, under Article 6.2 of the Paris Agreement) within the framework of bilateral cooperation.

In the context of international collaboration, quantifiable, verifiable, and traceable environmental results hold significant value for regulatory bodies seeking to manage their inventory of climate actions. This promotes the development of new technologies or initiatives that go beyond what is committed in the NDC. Assets described in this document could be directly traded insofar as they are recognized by the respective governments.

Finally, it is relevant to mention regenerative finances and financing schemes through green bonds or other equivalent mechanisms. Which may benefit from a technology that enables reliable and independent traceability of the results generated by the funded project portfolio. Results could be indexed to the interest rate of the issued debt, thus rewarding companies or project developers that meet or exceed their initial commitments.

9. Contribution of Green Tracker to the Sustainable Development Goals (SDGs)

SDG 6: Ensure availability and sustainable management of water and sanitation for all

Materializing, transferring, and/or commercializing reductions in water consumption to capitalize on reputational benefits and/or enable other users in the same basin to take advantage of these reductions. This has the potential to improve equity in the distribution of the resource.

SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all

Materializing, transferring, and/or commercializing the attributes of renewable energy and/or reductions in CO_2 emissions produced by different sources as an independent asset from the generated energy. This enhances the profitability indicators of renewable energy projects, as well as facilitating the allocation and marketing of their positive externalities to customers through market methods.

SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

Facilitating the implementation of technological innovations that reduce the environmental impacts of industry and infrastructure, enabling schemes for the capitalization and transfer of reductions throughout the value chain. Enhancing elements associated with energy, water, and emission management, among others.

SDG 11: Make cities and human settlements inclusive, safe, resilient and sustainable

Facilitating the implementation of solutions that enhance the sustainability of cities and communities, enabling schemes for monitoring and transferring results to the end-user. Especially associated with the management of energy, water, waste, and electric or sustainable transportation, among others.

SDG 12: Ensure sustainable consumption and production patterns

Facilitating the implementation of technological innovations and solutions that promote responsible production and consumption, through monitoring and transferring results along the production chain (Scope 3), potentially reaching even the end consumer. Enhancing elements associated with energy, water, emissions, and especially waste generation and materials management, among others.

SDG 13: Take urgent action to combat climate change and its impacts

Accelerating and scaling up the transition to markets that connect GHG reductions associated with project development with demand (whether voluntary or regulated). Impacting and scaling a wide variety of sectors, along with enhancing international collaboration and results transfer schemes proposed through Article 6 of the Paris Agreement.

10. Conclusions

A proper integration of technologies, over a robust d-MRV system based on international methodologies, has the potential to address the main problems and inefficiencies observed in current environmental markets. It also contributes effectively to the transparency of the process and builds trust among directly and indirectly involved parties.

The traceability, transparency, and trust generated in a cost-effective manner enable its potential implementation in a wide range of project typologies and scales. This increases the possibility of materializing and capitalizing on the positive externalities that these initiatives produce, which would otherwise not be technically viable or economically feasible.

With the democratization of solutions like Green Tracker, there is a goal to trigger a mass response to environmental challenges, leveraging the virtues of markets while safeguarding against the risks associated with greenwashing. This solution aims to transparently and verifiably support claims, transfer results between actors (based on offsetting and insetting), and generate monetary incentives to improve project profitability, thus maximizing their scaling potential.

Finally, the integration of technologies like Green Tracker into an industrial ecosystem or in the context of international collaboration spaces, which various jurisdictions are currently seeking to promote to increase climate ambition, represents an effective and efficient way to convey reliable environmental information and results. This could be a key element in accelerating the implementation of projects that contribute to the achievement of Sustainable Development Goals.

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