UNITED NATIONS DEVELOPMENT PROGRAMME

Designing digital systems for scale: Payments for Environmental Services

Taking a Digital Public Good approach to enhance nature and climate action

July 2024

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About this publication
This report was co-developed by UNDP's Nature Hub and Climate Hub. It was made possible through generous support from SIDA, Norad and Climate Promise donors.

Citation
UNDP (2024). *Designing a Digital System to Enable Payment for Ecosystem Services (PES) at Scale – Taking a Digital Public Good (DPG) Approach to Enhance Nature and Climate Action*. New York, New York.

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Contents

Acknowledgements

This publication was inspired by lessons learnt shared on national Payment for Environmental Services (PES) programmes in multiple countries. In particular we would like to express our gratitude to Gilmar Navarrete and Eduardo Mesén of FONAFIFO (Costa Rica), Vladimir Proaño Raza and Christina Pinto of ProAmazonia (Ecuador), and Nancy Sarrade of Socio Bosque (Ministry of Environment, Ecuador) for generously sharing their experience, insights, visions, and challenges.

We extend our gratitude to United Nations Development Programme (UNDP) colleagues for their support and contributions. Country office and project colleagues German Obando-Vargas, Jose Gabriel Villalta, Jorge Cole Villalobos, and Maureen Ballestero from Costa Rica, Regional Technical Advisors Noelia Jover and José Arturo Santos, not only for sharing their invaluable knowledge but also for their pivotal role in facilitating our relationships with key stakeholders. Our gratitude to Climate and Forest Team Leader Josep Gari and Food and Agriculture Systems Team Leader Andrew Bovarnick for their guidance.

We would also like to thank the external peer reviewer Tim Wood (Co-Develop) and UNDP peer reviewers Radhika Dave, Benjamin Bertelsen, Onno van den Heuvel, Marco Arlaud for their valuable inputs and discussions. Additionally, we thank Pascal Soboll, Managing Director of Daylight, for his support of the user research in Costa Rica and Ecuador. And a special shout out to Tim Clairs, for incubating this work.

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Last but not least, we would like to express gratitude to the Norwegian Agency for Development Cooperation (Norad) for supporting this work through the DPG for Development Project.

Acronyms

AI	Artificial intelligence
API	Application Programming Interface
BIOFIN	The Biodiversity Finance Initiative
DPG	Digital Public Good
DPI	Digital Public Infrastructure
GCF	Green Climate Fund
GIS	Geographic Information System
ID	Identification
IT	Information Technology
M&E	Monitoring & Evaluation
ML	Machine Learning
NDC	Nationally Determined Contribution
NGO	Non-Governmental Organization
PES	Payments for Environmental (Ecosystem) Services
REDD+	Reducing Emissions from Deforestation and Forest Degradation; and the role of conservation, sustainable forest management, and enhancement of forest carbon stocks in developing countries.
SDG	Sustainable Development Goal
SQL	Structured Query Language
UNDP	United Nations Development Programme

Foreword

The UNDP Nature Pledge is our commitment to a future where the world's biodiversity and ecosystems are protected, restored, and valued as a planetary safety net for all of humanity. Empowerment of local communities, farmers and indigenous communities as custodians of nature is key to bringing such change. Payment for Environmental Services (PES) is a long-standing mechanism that enables local action and to shift to an economy where natural capital is valued alongside financial, human, and manmade capital. New digital technologies have the potential to enable the large-scale transformative change needed to achieve the Sustainable Development Goals, and we call out for a collective effort to make this happen.

Midori Paxton
Director, Nature Hub

Nature-based solutions and local action are critical for accelerating the implementation of national climate pledges or Nationally Determined Contributions (NDCs). In some countries, PES is being used to fast-track NDC implementation, directly channelling climate finance to people and communities, recognizing their nature and climate stewardship roles while enhancing their livelihoods. The design of a Digital Public Good can help countries replicate this inclusive climate finance and policy approach, integrating UNDP's value offer on our Climate Promise and Nature Pledge based on collective experience over the years. I look forward to UNDP harnessing the power of inclusive digital innovation to bring scale across the countries we support through the Climate Promise.

Cassie Flynn
Director, Climate Hub

About this publication

Payments for Environmental Services (PES), also known as Payments for Ecosystem Services, is a results-based financing mechanism to promote environmental conservation and restoration by the hands of local communities, farmers, and Indigenous communities, providing cash benefits for acting as custodians of nature. This innovative mechanism has been growing over the years, but has not fully benefitted from the recent rapid advancement in digital technology, leaving complex PES management processes to manual work and outdated systems.

The objective of this report is to inform national PES practitioners, policymakers, financiers, Non-Governmental Organizations (NGOs), and digital innovators about the opportunities that digital technologies can unlock. In particular, the report is a call for action to make a collective effort with a Digital Public Good (DPG) approach. This entails collectively building a modular, replicable digital system with open-source technology, open data standards and a community of solutions for countries to choose and contribute to rather than a one-size-fits-all system. The research was conducted through interviews with UNDP practitioners, frontrunner countries with national PES schemes, and with inputs from DPG and Digital Public Infrastructure (DPI) experts. The report outlines how PES works (Chapter 1), technological opportunities and barriers to enable effective PES implementation (Chapter 2), and suggests a practical system and data architecture that is scalable and flexible (Chapter 3, 4).

For countries that are developing an IT system for PES management, the report will inform the system architecture, readiness assessment, and technology roadmap. For countries and practitioners that are in the process of creating a new PES scheme, this report will show a future vision for digitally-enabled PES, which can help to design better processes and regulations. For donors and financers, the report will serve as an invitation for digital cooperation and investment opportunities toward open-source, open data, and local nature and climate action.

1 Introduction to Payments for Environmental Services (PES)

This section provides an introduction to the PES scheme, including examples of PES programmes supported by UNDP, and general steps that countries take to establish and manage a PES scheme.

What is PES?

Local stakeholders such as farmers, local communities and Indigenous Peoples play a critical role as custodians and guardians of many key environmental services. This includes biodiversity, carbon sequestration, or regulation of the water cycle provided, for example, by watersheds, native forests, savannas, and grasslands. Several incentives exist to empower and enable local community engagement through sustainable farming practices, conservation, or restoration of native ecosystems.

One such type of incentive is the PES. **PES is a results-based, conditional financing mechanism that compensates farmers and local communities for the environmental services provided**, due to specific actions and efforts undertaken by these stakeholders in their land. Under PES schemes, payments are conditional upon performance—that is to receive cash transfers, participants must achieve outcomes by doing (or refraining from doing) certain activities.

Across the world, various PES schemes, or PES-like schemes have emerged to incentivize farmers and local communities to maintain forests or watersheds on their land or avoid agricultural expansion into nearby forest areas.[1] According to a recent study, there are more than 550 active programs around the globe and an estimated US$36–42 billion in annual transactions.[2] This includes a variety of arrangements through which users of environmental services, from watershed protection and forest conservation to carbon sequestration, reward communities or individuals whose lands provide these services with payments or monetary compensation, including cash transfer.

PES has been critical especially in forest landscapes, given the forests' essential role for over 1.6 billion people's livelihood, as well as serving as the 'lungs' of the Planet.[3] If deforestation is stopped and degraded forests were stored, forests can provide a third of the carbon emission reductions and removals needed to avoid the most severe impacts of climate change.

Paying for the benefits of natural ecosystems is a way to recognize their value and ensure that these services continue to be provided well into the future. In the current economy, the strongest financial incentive given to farmers and local communities encourages them to convert nearby forests and forest patches on their land into agriculture fields to increase production, and hence increase household income. This is the trend that PES is trying to counter.

In addition to preserving natural resources, PES has the potential to improve livelihoods as it can transfer needed cash resources directly to impoverished groups.[4] In addition to being widely used to cushion the economic damage from sudden shocks, conditional direct cash transfers have long been recognized as an effective tool for poverty reduction worldwide, yielding benefits to health, education, employment, and overall well-being. Targeted direct cash transfers have been highlighted in a recent UNDP report as a highly relevant policy tool in dealing with the crises triggered by COVID-19.[5] Despite the promising impact of PES, several barriers exist for PES schemes to be successful. The lack of efficient management systems is one of the major barriers, alongside the lack of long-term finance sources and coordination with similar incentive mechanisms.

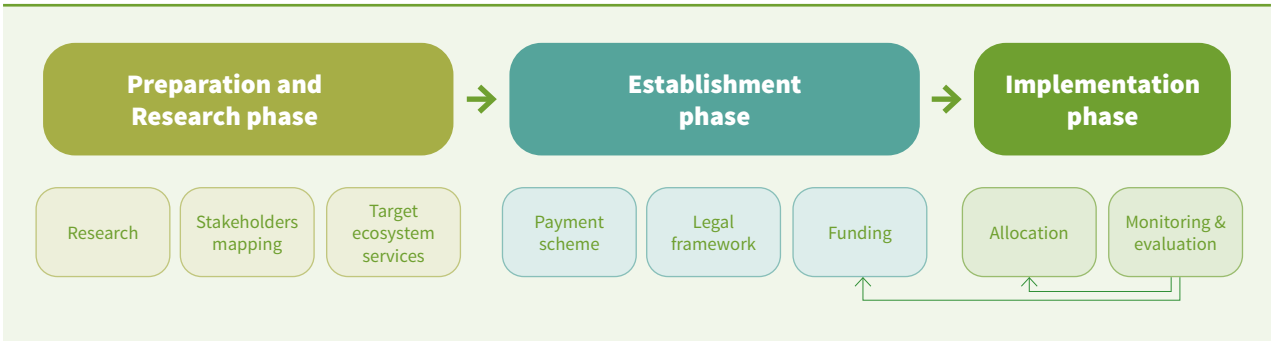
The PES life cycle: from research to scheme implementation

Generally, PES schemes start from a preparation phase which includes an environment valuation study and feasibility study, stakeholder engagement and a process to define the target ecosystem services. Based on the research, a PES scheme is established.[6] Specifically, this phase includes the designing of the programme and payment scheme, preparation of a legal framework and fund mobilization, which may be secured through international funding or national sources.[7] Thereafter, implementation will start across years, which entails the conditional payments to individuals or communities, monitoring and evaluation of the programme, and funding replenishment.

The above diagram outlines the major steps required for establishing and implementing a PES scheme. Although not an exhaustive list, these steps serve as important benchmarks throughout the process and contribute to the overall success of the PES scheme. Further details on the first two phases are provided in the Annex.

Although earlier stages can also benefit from new data analytics and technologies, the remainder of this study will focus on the digitalization opportunities during the implementation phase, given that this phase is where the number of users is largest, and has a scalability effect.

Fig 1. **PES life cycle**



PES country examples

UNDP has been working with countries to establish new PES schemes, as well as to improve and enhance the implementation of existing PES schemes around the world. To further illustrate the benefits of PES, this section provides some examples of PES from countries.

For example, as an accredited entity to the Green Climate Fund (GCF), UNDP has an emerging portfolio of $320 million related to reducing deforestation and forest degradation emissions, conservation, sustainable management of forests, and enhancement of forest carbon stocks through 'Reducing Emissions from Deforestation and Forest Degradation; and the role of conservation, sustainable forest management, and enhancement of forest carbon stocks in developing countries (REDD+)'. A significant portion of this portfolio is dedicated to PES. With GCF funding, UNDP supports Brazil, Costa Rica, and Ecuador in delivering PES mechanisms and Indonesia in delivering community forest management programs.

Costa Rica's Payment for Environmental Services Program (PSA) was first established in 1995, and it is an example of an outstanding mechanism. PSA is a system of voluntary contracts through which a

well-defined land-use practice likely to secure an environmental service is paid for if, and only if, the participants conduct the agreed sustainable land-use practice.

Roughly 75 percent of Costa Rica's $54 million projects approved by the GCF for REDD+ results-based payments for emission reductions achieved in 2014 and 2015 went directly to strengthening Costa Rica's PES Program, benefiting, in particular, women and Indigenous Peoples. Over the past few years, funds from the GCF have become a critical resource for funding the PSA program. These funds have supported a financial diversification strategy to maintain the program, which was largely dependent on a national fuel tax and water fee to support it during its first 25 years.

Therefore, under the ambitious commitments Costa Rica has set up in its NDC and Decarbonization Plan (as its 2050 long-term strategy), funds from the GCF, the World Bank´s Forest Carbon Partnership Facility, and potentially voluntary carbon markets are now critical resources to partly sustain and transform the PSA programme to avoid its dependency on fossil fuel taxes and to focus on carbon capture, as one of the main ecosystem services that trigger climate finance.

These diversified sources of finance also contribute to expanding the land covered by PSA, including more indigenous territories, and keep strengthening the transfer of needed cash resources directly to impoverished groups.

In **Ecuador**, Socio Bosque Programme provides financial incentives to individual and community landowners who voluntarily commit to conserving native forests for 20 years. A GCF and REDD+ results-based payment project was supported through a $60 million investment to implement Ecuador's REDD+ Action Plan through a Programme named ProAmazonia. As of June 2020, Socio-Bosque has been able to enroll an additional 259,000 hectares into the programme, benefiting 175,000 people, the majority of whom are Indigenous Peoples of the Amazon.

Closely related to the PES is a national strategy titled, Ecuador Premium and Sustainable, that seeks to enhance the sustainable production of prime commodities in the country with a certification

mechanism for exporting deforestation-free coffee. These are complementary incentive schemes, which may also have the potential to share or coordinate ground data collected by farmers.

In **Brazil**, Floresta+ is a new and innovative program that aims to provide incentives for the provision of ecosystem services to family farmers, traditional communities, and Indigenous Peoples in the Amazon region. The pilot phase of Floresta+ is being funded by the first results-based payment proposal approved by the GCF in 2019 for $96 million. $80 million from the payment for REDD+ results achieved by Brazil in the Amazon biome in 2014 and 2015 are committed to supporting the Floresta+ initiative. The aspired number of beneficiaries is 40,000 people in three years.

More countries are looking into the PES scheme, with initial funding from Global Environment Facility (GEF) or other donors, as part of climate change adaptation efforts or for biodiversity conservation impact, including but not limited to **Côte d'Ivoire**, **Ethiopia**, and **Sierra Leone**.

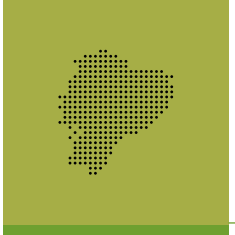
Support to PES schemes is not limited to the actual programme. UNDP's Biodiversity Finance Initiative (BIOFIN) has been providing catalytic support to earlier stages of PES schemes. For example, in **Kazakhstan** BIOFIN supported new legislation that became the legislative basis for PES, widening the scope of how ecosystems are defined under the law and allowing funds to be derived from companies that use forests for their benefit. BIOFIN also worked with **Costa Rica** to strengthen women's participation in the PES scheme, opening up $26 million in funds to be accessed by women, and is working on a PES for the power generation sector to take part in ecosystem conservation in **Sri Lanka**.

Now, with these examples and their anticipated environmental benefits, financial scale and beneficiaries in mind, let us look at how digital technologies can potentially assist countries to achieve their nature and climate visions.

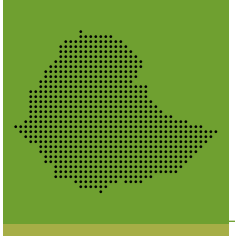
Brazil (Floresta+)
$96 million to incentivize activities that help protect, conserve, and restore forests

Costa Rica
Enhancing women's participation in PES scheme, opening up $26 million funds for access by women

Côte d'Ivoire
Piloting PES for forest restoration and conservation



Ecuador
Socio Bosque program, which aims to conserve forest ecosystems through incentives for landowners and communities



Ethiopia
Exploring PES schemes as part of climate change adaptation or biodiversity conservation efforts

Kazakhstan
Support to legislative base for PES and other incentive mechanisms

Sierra Leone
Exploring PES schemes as part of climate change adaptation or biodiversity conservation efforts

Sri Lanka
Developing a PES scheme for the power generation sector to participate in ecosystem conservation

2 Opportunities and key concepts for digitalizing PES schemes

This section outlines how recent advancements in digital technologies and key concepts such as Digital Public Goods and Digital Public Infrastructure bring opportunities for PES and other similar innovative incentive mechanisms to be brought to scale.

Lessons learnt from earlier PES information management systems

Information management systems have been used for PES scheme implementation in earlier years. Interviews with managers of several front-runner national PES programmes surfaced three common challenges of earlier technology and approaches.

1. Need for a holistic approach

Community data collection, forest monitoring, and payments are often developed as separate, non-interoperable solutions that do not effectively exchange information. This leads to extensive manual work for programme management and execution, as data has to be entered multiple times, with different devices.

2. Limited ability to update to new technology options

Once a country has a working system, there are limited opportunities to upgrade to newer and more cost-efficient (or free) technologies as they arise, such as mobile data collection or e-payments.

3. Lack of interoperability and open data policies

Interoperability is a relatively new concept, which, in simple terms, means that different data systems can exchange data in a seamless manner. Interoperability in a PES context may mean that various systems such as the global and national forest monitoring system, national climate transparency system, or private sector supply chain management systems can speak to each other, exchanging open data while ensuring sensitive data are secured and only available to those with access rights. Existing systems are not built with interoperability in mind, leading to duplication of effort and data.

Recent advancements in technology can help address some of these lessons learnt. In the following sections, we look at evolving affordable technologies and digital concepts.

Digital technology to support PES

1. Application Programming Interface (API) for interoperability

APIs are sets of protocols and tools that allow different software applications to communicate and share data and functionalities seamlessly. It is a direct way of solving the 'interoperability' issue.

Most PES management systems pull data from different databases and overlay geospatial information. When done manually, this process is very labour-intensive and prone to errors. However, it is nearly impossible to integrate all related national systems into one overarching platform. Building federated systems that talk to each other, allowing for real-time updates, is key to nimble yet seamless data processing.

2. High-resolution satellite imagery and remote sensing

Satellite imagery and remote sensing allow better data collection, particularly in remote locations or large-scale implementation. Where field data collection is challenging, remote sensing can provide a first rapid assessment of land use, while field data acts as primarily a verification exercise, saving in-person trips. It is also critical for monitoring results at scale and particularly useful for identifying canopy coverage in forest landscapes. However, it is not a panacea. In addition to local ground proofing needs, ecosystem qualities, such as biodiversity, cannot be determined from satellite imagery and require a combination of different technology and/or human research.

3. Mobile phones

Simple technology can significantly improve and reduce the cost of field data collection, encourage user enrolment, ease cash payment and add possibilities for new ways of verification by the beneficiaries themselves. Enumerators are able to efficiently collect georeferenced information on farmers, communities, their land, and forests cover on their land. Various open-source data collection apps exist to assist depending on the type of environmental service. They also can support distributed ownership of this data and allow for wider use. In areas where connectivity is an issue, it is critical to have a way of storing data locally for upload when connection is stored.

4. Artificial intelligence (AI)

AI can support the automation of farm boundary detection, differentiation between arable and forest land, eligibility criteria verification, monitoring of the forest, and decision-making on whether critical elements of the PES agreement were fulfilled. Currently, most of these analyses are done manually as global AI-based data layers (e.g., forest coverage) and are not sufficient for the local context. PES systems can be significantly improved by developing a system that combines different data sources and any other available information for the most accurate and reliable forest monitoring results, likely a combination of global and local data layers.

5. Distributed ledger technologies

Distributed ledgers are digital systems for recording the transaction of assets in which the transactions and their details are recorded in multiple places simultaneously. Unlike traditional databases, distributed ledgers have no central data store or administration functionality. This technology is most famously exemplified by blockchain, which underpins cryptocurrencies like Bitcoin but can be applied to a wide range of other transactions and record-keeping systems, making them decentralized, immutable, and transparent. For example, blockchain can avoid tampering with verified data and ensure the traceability of contracts and payments.

6. Digital Identification (ID)

An ID system will help with contracting, land ownership verification, and cash distribution to communities or individuals. Countries with existing foundational Digital Public Infrastructure (DPI), such as a national digital ID system, are at an advantage when scaling the beneficiary enrolment. Especially when data such as bank information or land ownership are already integrated, with robust privacy and security measures. In the absence of DPI, the process of

beneficiary enrolment becomes significantly more cumbersome, less efficient, and prone to errors, underscoring the critical need for robust DPI to ensure seamless, secure, and transparent management of contracts, land ownership verification, and equitable cash distribution.

7. Digital payment systems

By enabling swift, secure, and transparent transactions, digital payment platforms significantly enhance the efficiency of PES initiatives. Existing DPI for Digital Payments makes it feasible to include a broader range of participants in PES schemes, as the ability to execute a payment transaction can often be a limiting factor in scaling the scheme. Payment through cash can pose security issues, exposing beneficiaries to potential fraud or theft. Traditional bank transfers represent similar security issues, as beneficiaries often need to 'cash out'. In contrast, countries that use existing DPI to combine mobile payments, traditional banking systems, and other contextually appropriate financial mechanisms offer more secure and accessible options for beneficiaries, ensuring that funds are transferred and utilized safely and efficiently.

Key concept 1: Digital Public Good (DPG)

As PES is a growing climate action mechanism with commonalities across countries, regions, and types of ecosystems, it is well suited for a **DPG approach**.

This entails collectively building a modular, replicable digital system for PES management with open-source technology, open data standards and open algorithms, accompanied by documentation, a supporting community, and a code governance mechanism. Some parts of the PES system (e.g., monitoring) may require a variety of tools depending on the ecosystem and context, while there are core components that any PES scheme will need. Therefore, rather than having a one-size-fits-all solution, a 'library' of interoperable DPG tools that follow an agreed data architecture and standards can provide flexibility and invite localized innovation.

We call on private, public, and academic institutions to work on solutions to **join us on this journey to collectively invest in developing modular DPGs**.

DPG is open-source software, open data, open AI models, open standards and open content that adhere to privacy and other applicable best practices, do no harm and are of high relevance for attainment of the SDGs.

https://digitalpublicgoods.net

Key concept 2: Digital Public Infrastructure (DPI)

DPI is a set of shared digital systems that are secure and interoperable, built on open standards and specifications to deliver and provide equitable access to public and/or private services at a societal scale.

https://www.undp.org/digital/digital-public-infrastructure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In recent times, DPI has emerged as a critical enabler of digital transformation in multiple sectors in several countries. Designed and implemented well, DPI can boost the capacity of countries to achieve their national development priorities, accelerate the Sustainable Development Goals (SDGs) and also scale the green transition.

DPIs are governed by rules and principles that drive and uphold sustainable development, inclusion, innovation, trust, human rights, and fundamental personal freedoms.

There are three DPIs that are deemed 'foundational' to carrying out essential public functions and which should be accessible at a low cost to citizens or the end beneficiary. The following three foundational DPIs allow the technology stack to facilitate cross-sectoral innovation and population-scale impact: Digital Identity; Digital Payments; and Consent-based Data Sharing.

1. Digital identity

The ability for people and businesses to securely and efficiently verify their identity, as well as complementary trust services such as electronic signatures and verifiable credentials.

2. Digital payments

Easy, safe, and instant transfer of money between people, businesses, and governments.

3. Consent-based data sharing

The seamless flow of personal data across the public and private sectors, with safeguards for personal data protection in line with robust data governance frameworks.

By building these core DPI using open protocols and standards, countries can enable network interoperability. This streamlines access to multiple services, making it easier for applications such as various PES management systems to be built on top. In the later chapters, the report applies the DPI thinking to identify key interlinkages with foundational DPIs.

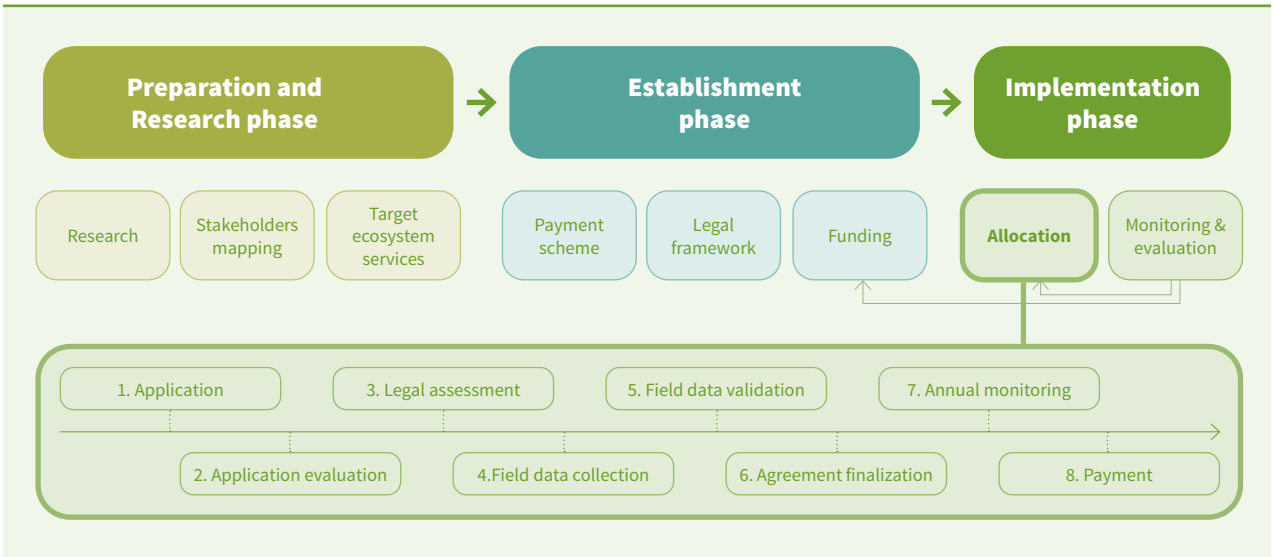
In addition to the three foundation DPIs, environmental management has several unique sets of digitalization needs that are shared across a broad variety of use cases. Therefore, in the following chapter we also propose a 'Green DPI' opportunity, which countries can consider not only for PES but also for wider application.

3 Digitalization of the PES implementation system

This section outlines how the PES implementation process works, and proposes a digital solution for each step of the process.

The incentive allocation, which is the granting of funds, is one of the most important phases of the PES process as it comprises all the central PES allocation steps from the beneficiary application to the final compensation/payment. In total, this phase consists of eight sub-steps (Figure 2). A contract is made with each individual (or community). The land is monitored against ecosystem indicators (e.g., forest coverage, forest quality, biodiversity, water quality, etc.), results are validated, and payment is made. Some schemes have also included social safeguard requirements to complement environmental indicators.[8]

Fig 2. **The PES life cycle with the eight Allocation sub-steps**



3.1. Application

In the first stage of the fund-granting process, applicants send their application for their country's PES system via the PES web app. After filling in all the application data and attaching all the relevant documents (e.g., farm maps), the potential beneficiaries can directly sign their application online (either via written, photo, or video signature), from which it is automatically forwarded to the corresponding PES Team. From here, it will be analyzed in the next system stage.[9]

The application process can be streamlined if the country has a Digital ID system (Foundational DPI) which can be integrated with the PES application process.

Fig 3. **Colors legend**

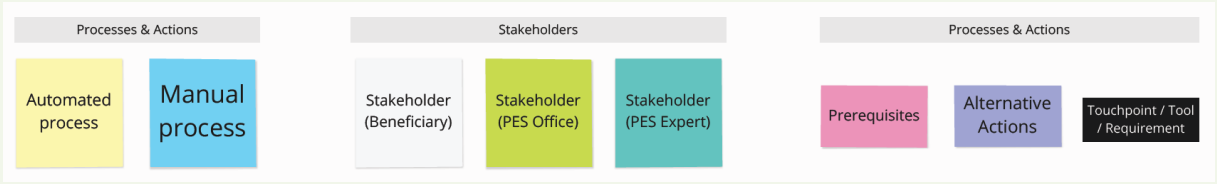
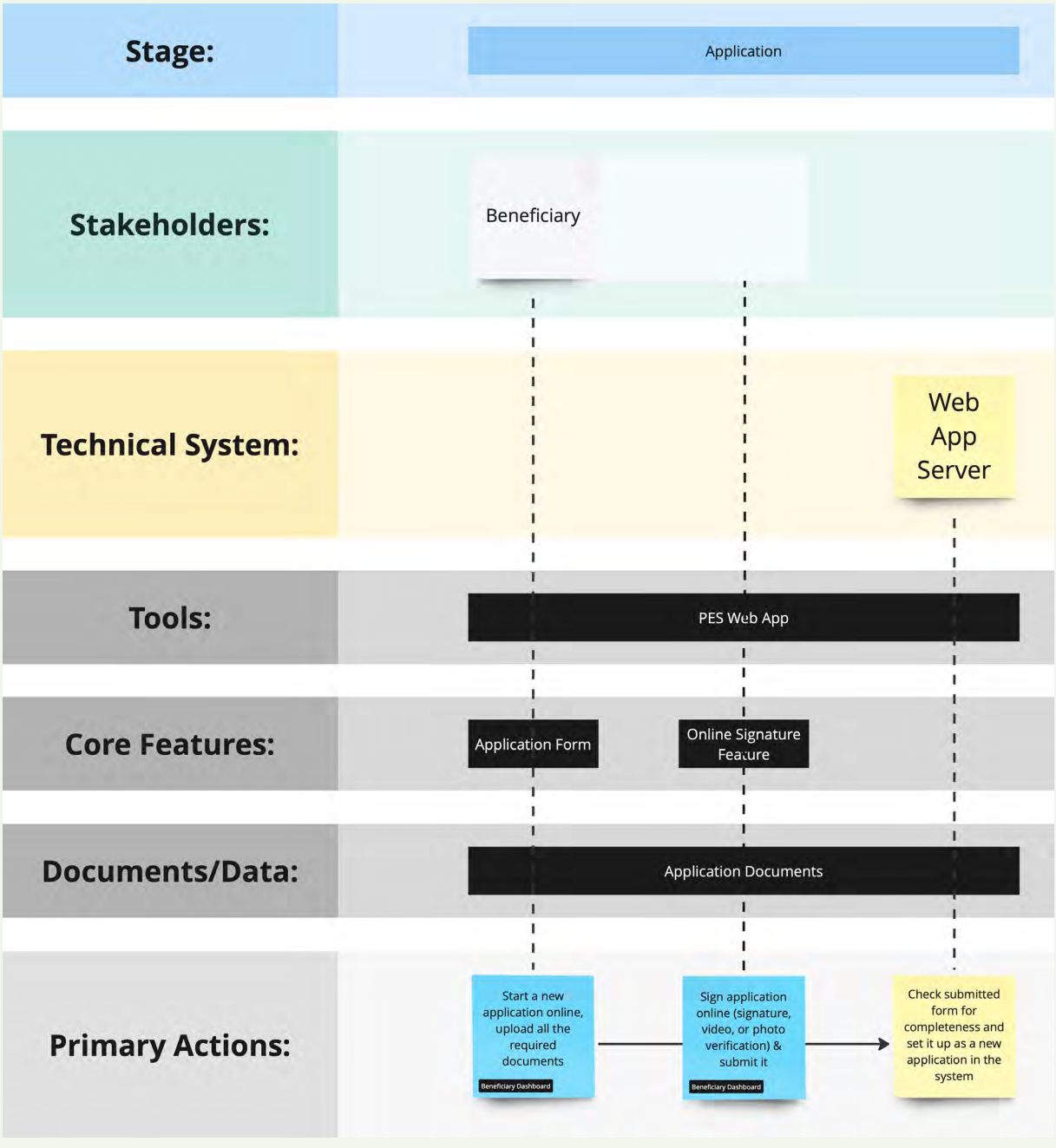


Fig 4. **Application details**

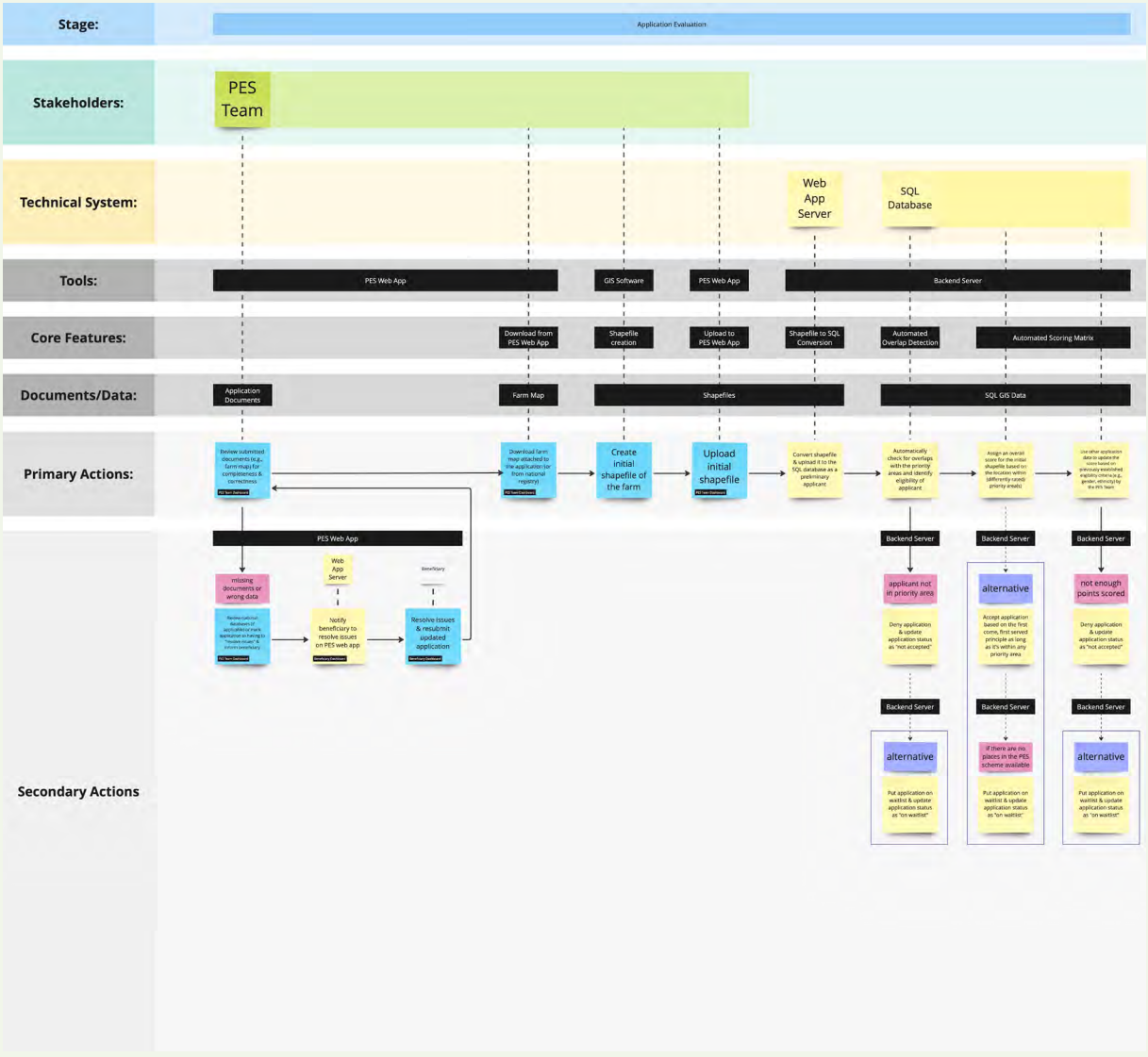


3.2. Application evaluation

Once submitted, every application goes through an evaluation process.[10] After a preliminary manual completeness review, the PES Team creates an initial geodata file (e.g., shapefile) of the beneficiary's farm area and uploads it to the PES web app. From there, it is converted into Structured Query Language (SQL) - readable Geographic Information System (GIS) data and uploaded to the backend SQL database.

After an additional automated analysis step (i.e., location within the priority areas), there are multiple pathways for how the application can be processed. For example, applications can be approved based on their submission date (first come, first served) or based on previously established evaluation criteria. Either way, should an application be approved, it proceeds to the next step; if not, it can be denied or placed on a waitlist.

Fig 5. **Application evaluation details**

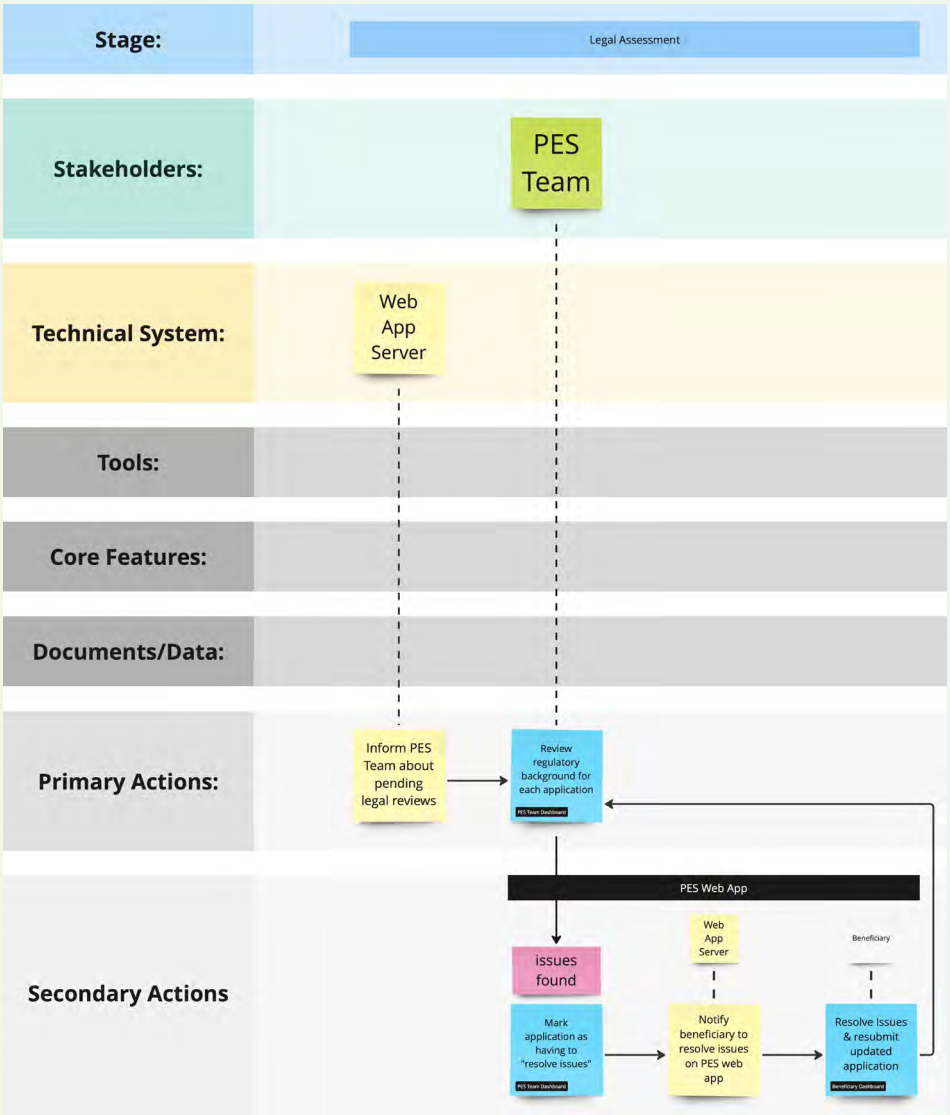


3.3. Legal assessment

The legal assessment occurs after the initial application evaluation to verify the potential beneficiary's land ownership. If there are any impending legal issues, the PES Team marks those as having to be resolved by the beneficiary via the PES web application. Only if all the documents have been positively reviewed can the application pass its initial verification and proceed to the field data collection phase. This process indicates an opportunity for a 'GeoID' DPI, whereby a plot of land is registered for ownership or use by an individual, household or legal entity. [11]

However, this step is highly dependent on the country context and fund source. Some countries might require more legal soundness of property data, while others could be more flexible. This is a key element to consider, given the high complexity of land tenure and land regularization systems in most countries in biodiversity-rich areas.

Fig 6. **Legal assessment details**

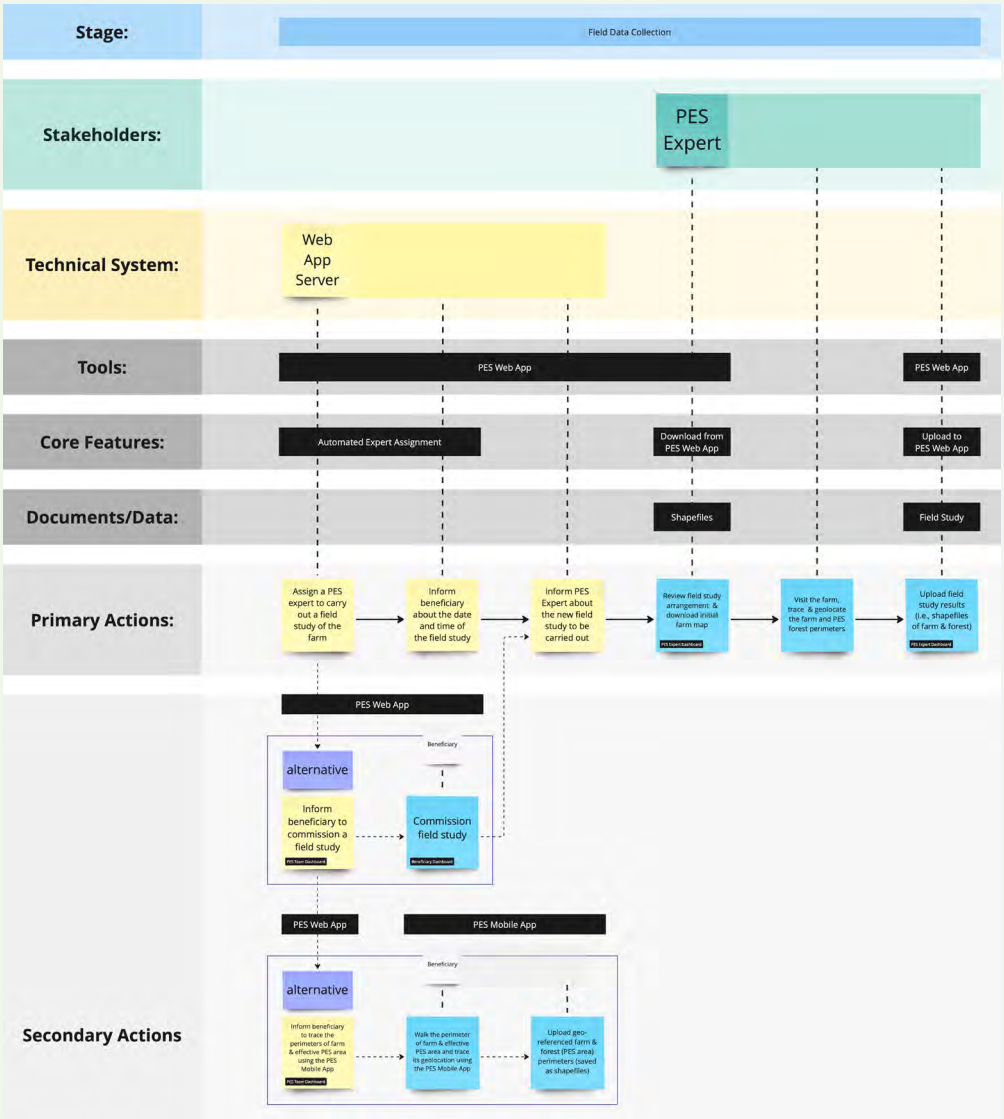


3.4. Field data collection

For the field data collection, an independent (or, in some countries, internal) PES Expert is assigned (or, in some countries, personally contracted by the beneficiary) to visit and geolocate the farm.[12] The PES Expert has to map out the ultimate and exact perimeters of the farm. The future PES area within (e.g., forest for protection, reforestation, agroforestry, etc.) as well as, in some cases, evaluate the condition and ecological value of the forest (there are other methods this value can be determined by, such as through GIS models that have been established for the PES scheme). Once done, the expert uploads the study results and the geographic data of the referenced farm and effective PES area (in shapefiles) to the PES web app.

Alternatively, some PES systems might also utilize an internal PES mobile application that allows beneficiaries to trace the perimeter of their farms directly from their phone.

Fig 7. **Field data collection details**

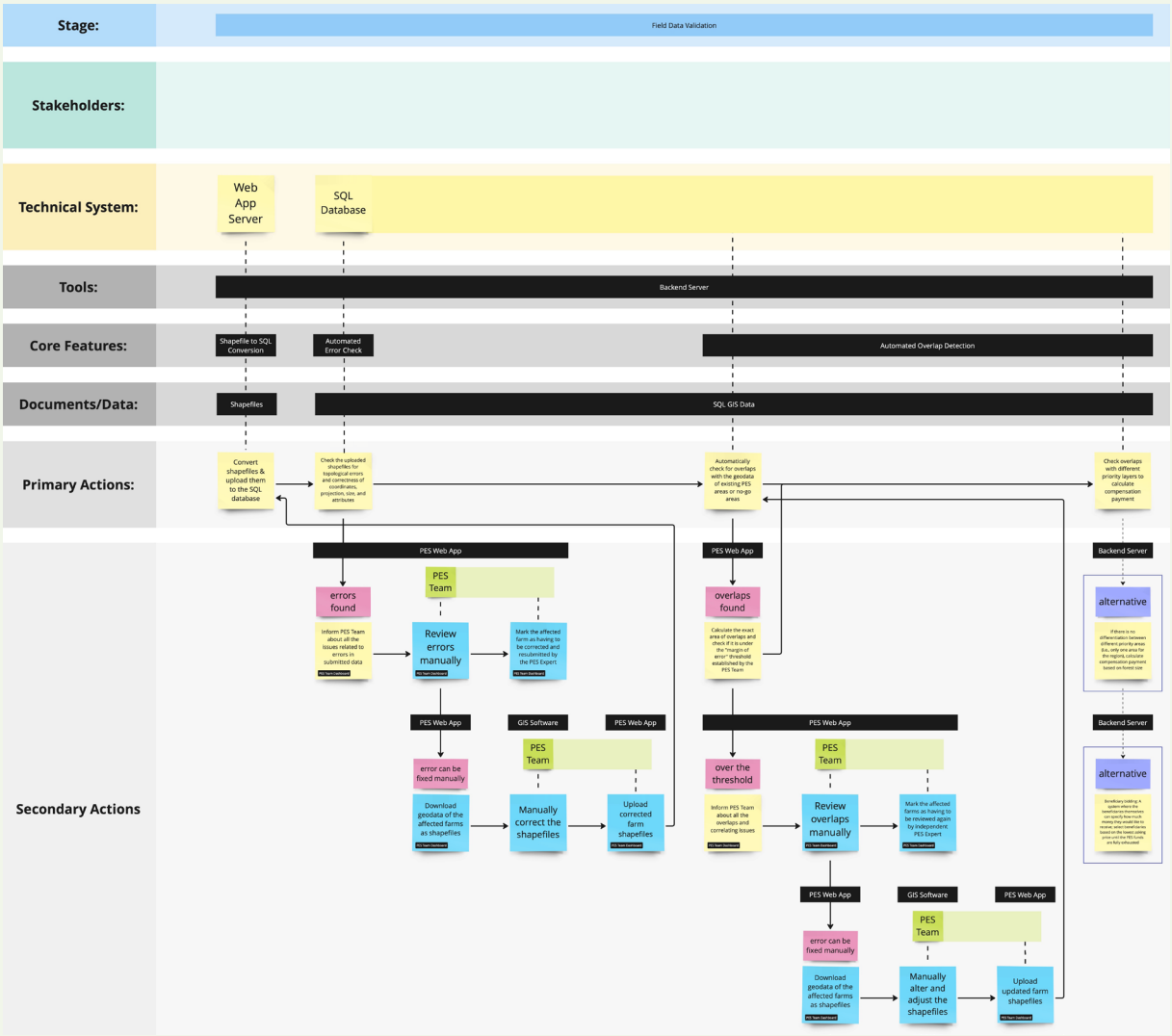


3.5. Field data validation

A fully automated validation process transforms the shapefiles from the previous step into SQL-readable geodata to verify that the field study documents comply with the approval requirements. On the SQL database, two separate checks are performed: first, to confirm the correctness of the uploaded geodata (e.g., identify topological errors), and second, to map out any overlaps with other areas (properties, government land, other PES areas, etc.). Should this automated process identify any errors, the PES Team must conduct manual verification steps to either directly correct the issues if possible and desired or ask the PES Expert to redo and correct their field study.

If the same land ownership / use right is commonly used for the individual or community to apply for multiple mechanisms such as PES schemes, commodities traceability systems, and/or tax incentives, this is another case for a 'Geo ID' or land registry, keeping in mind the regulatory context of the country.

Fig 8. **Field data validation details**

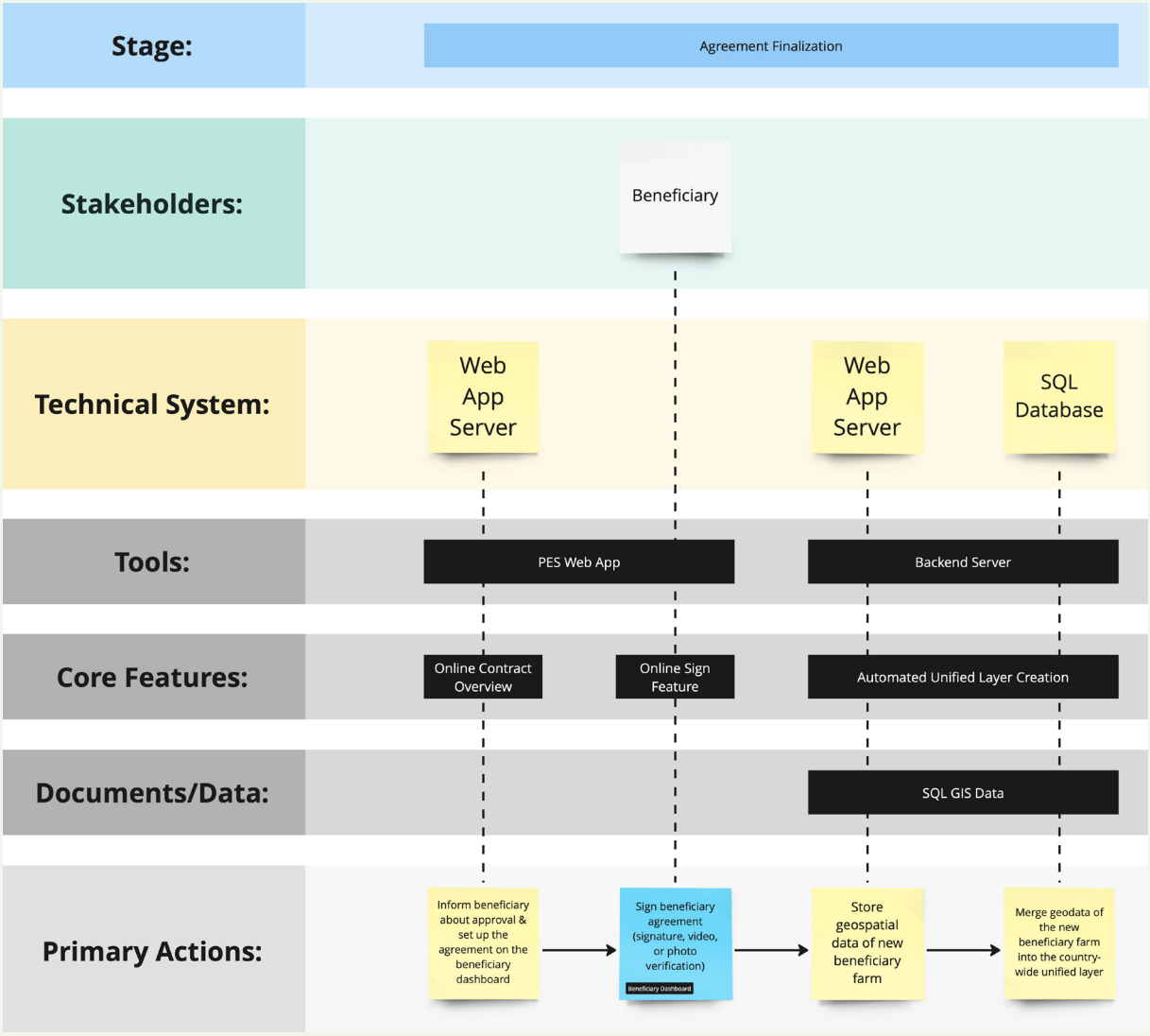


3.6. Agreement finalization

An agreement is sent to the beneficiary via the PES web app to finalize the application process.

Once signed, the agreement becomes official, and the SQL backend database takes the GIS location of the beneficiary's farm and merges the effective PES area with the geodata of all the other farm PES areas, thus creating a single file that complies in the entirety of the PES areas/sites. This geodata layer is crucial for monitoring and controlling the development of the PES program, as it documents all the forest/ecosystem areas that are part of the system.

Fig 9. **Agreement finalization details**

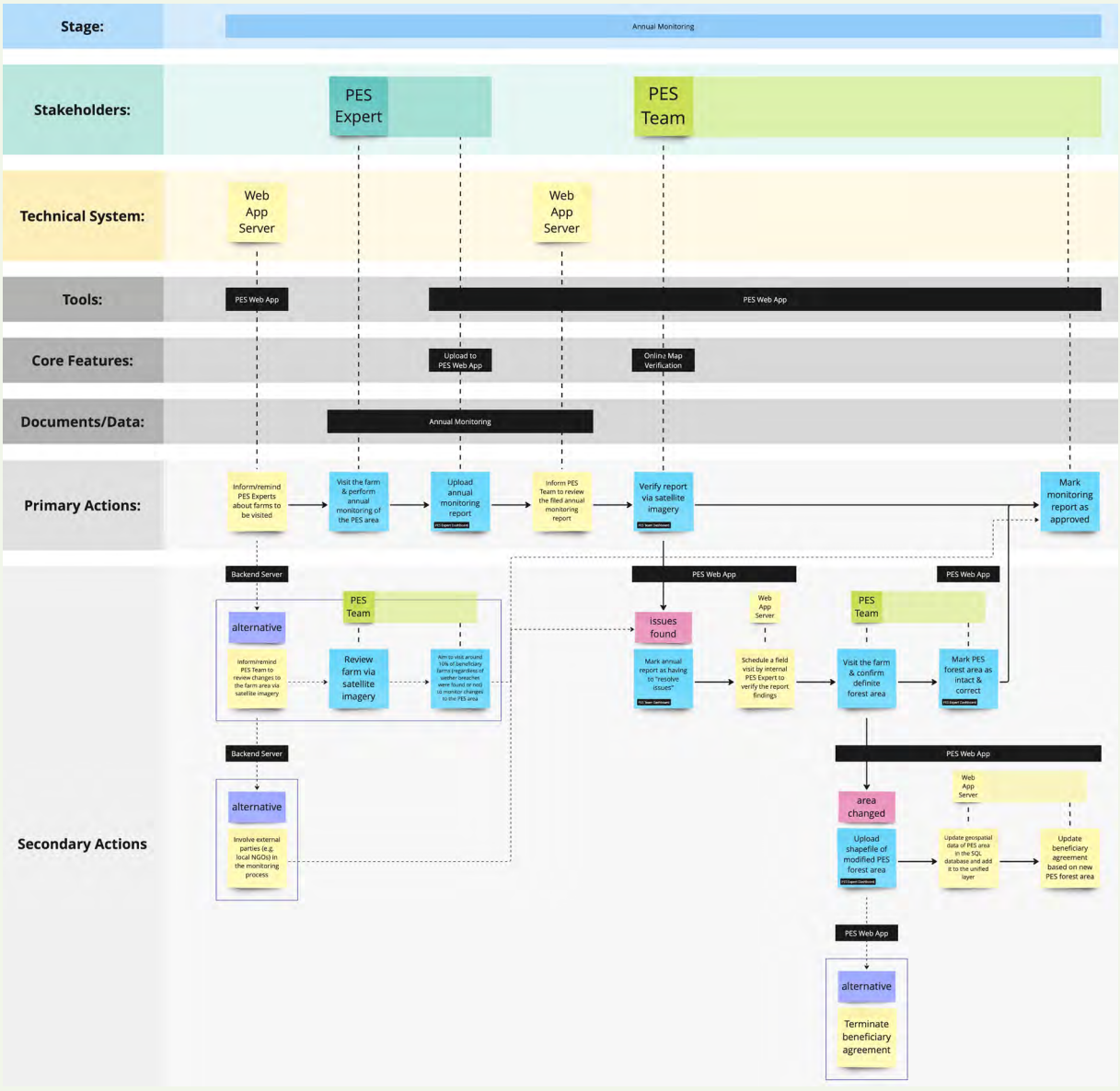


3.7. Annual monitoring

Every year, all the agreed-upon PES farm/community areas need to be monitored to verify their compliance with the initially drafted beneficiary agreements. This can be done either entirely remotely or with the help of a PES Expert who conducts a field visit to verify the beneficiary's farm area directly on the ground. Any potential changes to the agreed-upon PES area are tracked and uploaded to the PES web app.

Should the PES Team encounter any issues with the data collected, they need to conduct another field visit before potentially marking the PES area as intact and ready to receive its payment. Alternatively, they might need to modify the agreement to reflect any changes to the PES area. No matter how many farms are visited as part of the regular monitoring process, it is recommended that PES Teams do additional spot

Fig 10. **Annual monitoring details**



field visits at least 10 percent of the farms that are part of their system, in addition to 100 percent monitoring based on remote sensing technologies.
Note that some PES schemes are keen to monitor the socio-economic benefits of the incentives/payments provided through the PES Programme. This could be considered in some instances, depending on whether the system's final objectives include socio-economic benefits (like poverty alleviation). Also note that in some cases, compliance with social safeguards, e.g., by presenting specific evidence, is used as a condition before disbursing the payment. Systems can vary depending on the different objectives it is trying to achieve.

Currently, monitoring is largely depending on human-collected ground data, combined with very high resolution satellite imagery, which can be costly and does not easily monitor socio-economic benefits. A data sharing protocol for individuals to share automated information, with privacy and security measures, can be explored.

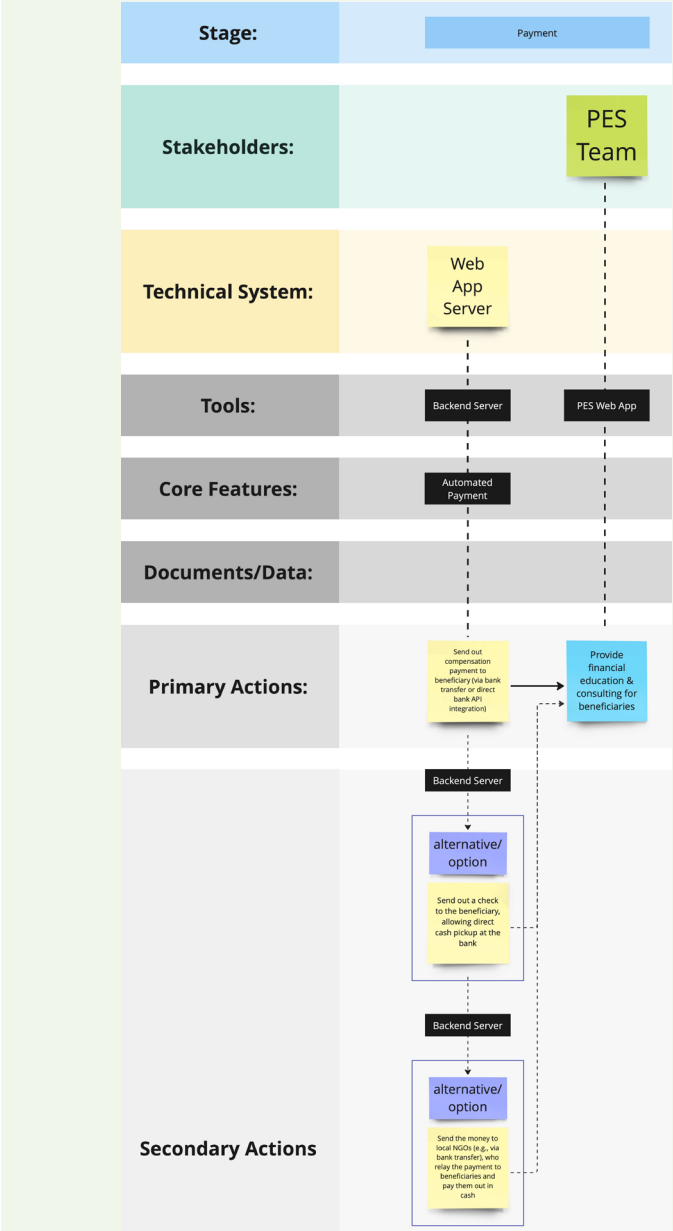
3.8. Payment

After the annual monitoring results are finalized, the last step of the fund-granting process is the payment stage. Here, the backend PES system automatically relays the compensation payment to each beneficiary to reimburse them for their efforts. This can be done as a bank transfer, via check, or with the help of local NGOs, which might pay out any payment directly to the corresponding beneficiaries in cash (depending on the payment-related locally available).

This is an apparent case where a foundational DPI Digital Payment system can be useful.

After the payment, the PES fund-granting process repeats itself the following year, either at the annual monitoring step or at the application stage (if the agreement expires and needs to be renewed).

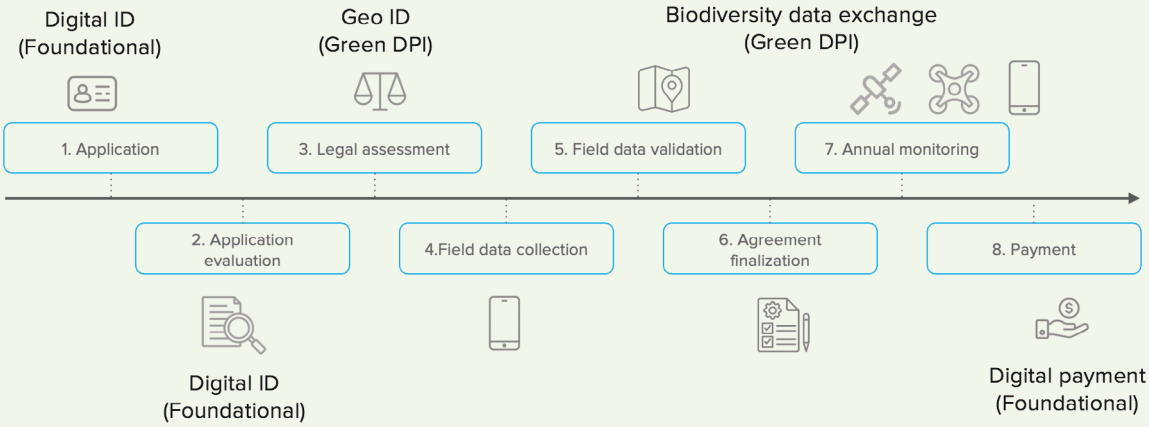
Fig 11. **Payment details**



3.9. DPI opportunities

As identified in each process section, a digital PES system will greatly benefit from leveraging on foundational DPIs if they already exist in a country. In addition, a 'geospatial ID' or land registry is a potential 'Green DPI' to help streamline the contracting and monitoring processes, along with a data exchange protocol for biodiversity and ecosystem data to incentivize data sharing from beneficiaries, private sector and citizens to revolutionize results verification.

Fig 12. **DPI opportunities for each step of PES implementation**



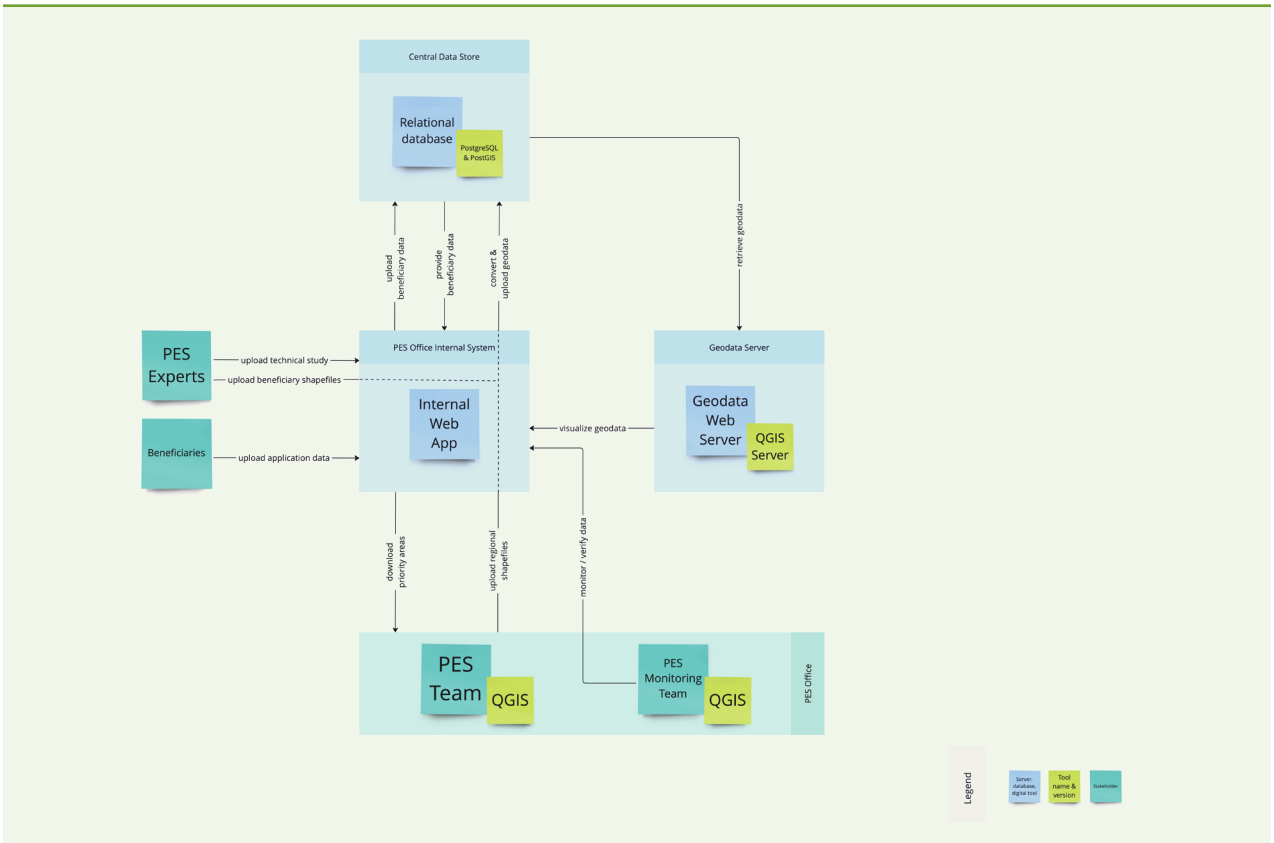
4 Technical requirements and architecture

The final section outlines the technical requirements, system architecture, information architecture, and core feature lists for a digital solution to support PES schemes implementation.

Technical requirements: data flow

The underlying structure of the universal PES process follows a heavily streamlined system approach with a high degree of automatization. The data flow on the right indicates how information is sent from one tool to another, thus creating an intricate system in which all data exchange paths are greatly optimized. This is further enhanced by the minimal use of software touchpoints that are part of the system, as described in more detail on the following pages.

Fig 13. **PES system data flow**



Technical requirements: Tools & software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RDBMS Server (PostgreSQL & PostGIS)

- The 'central point of truth' over which all PES geospatial information and beneficiary application data is stored
- Highly efficient SQL database that stores data in the form of easily addressable tables, making it perfectly suitable for GIS data

QGIS Server

- Geodata web server for visualizing geographic information from an SQL database
- The primary link between the SQL database and the PES web application

Web Backend Server

- Web server for hosting the PES web application, running on an environment like Node.js

Internal PES Web App

- The main portal between the front- and back-end of the system (described in more detail on the following pages)

GIS Software (QGIS)

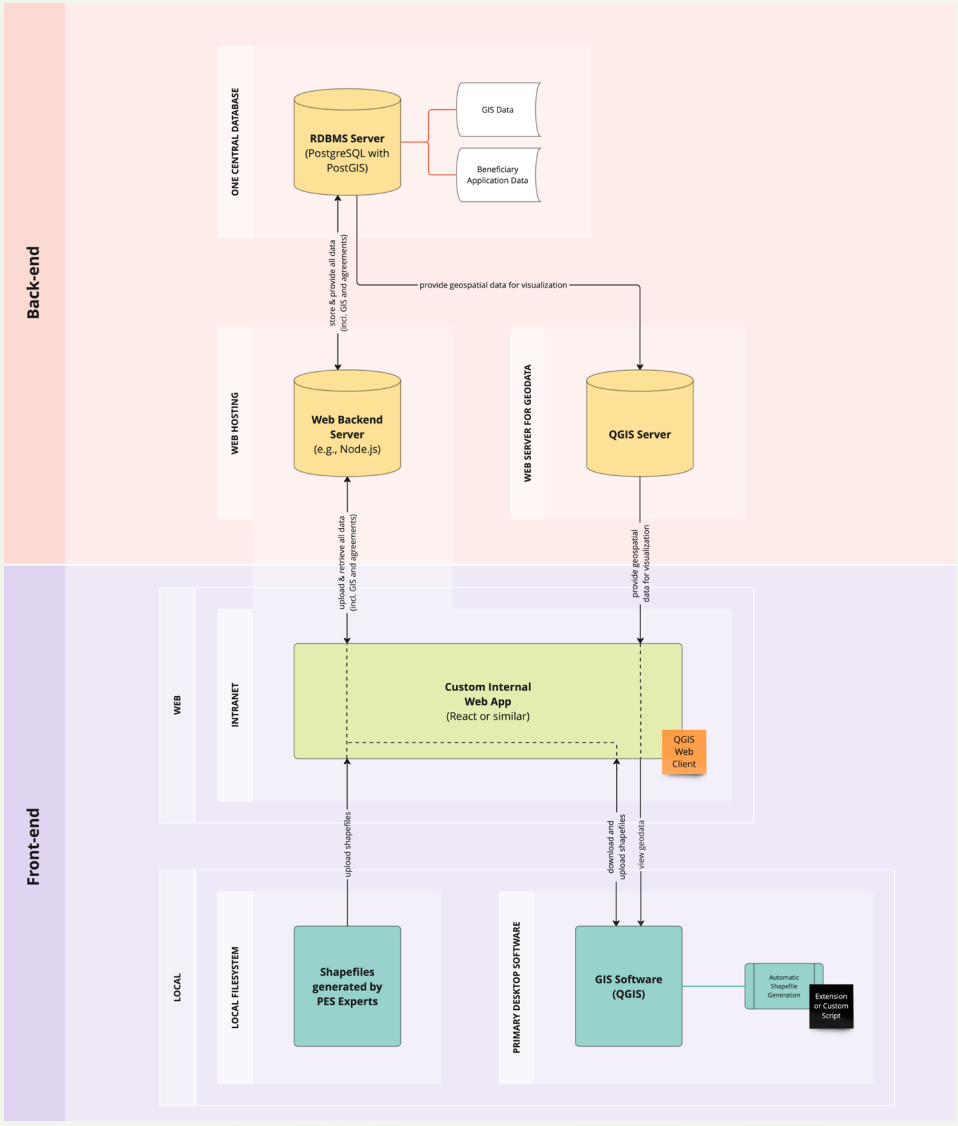
- Open-source desktop software for generating and analyzing GIS data
- Highly visual representation of geospatial data that makes relations between different geolocations easily recognizable

System architecture: PES process

As part of its overarching system framework, the universal PES process features a variety of tools and software elements that all work together in the streamlined processing of geospatial data and beneficiary application documents. Hereby, all the tools that are part of the system fall into one of two overarching categories: frontend or backend.

While the frontend tools are responsible for all the manual activities that must be executed as part of the PES process, the backend handles all the automated geodata analysis procedures and storing relevant beneficiary application data. Because of this, it is of utmost importance that a seamless conversion between frontend and backend data is achieved throughout the system, as highlighted by the system architecture see Figure 13.

Fig 14. **PES system architecture**

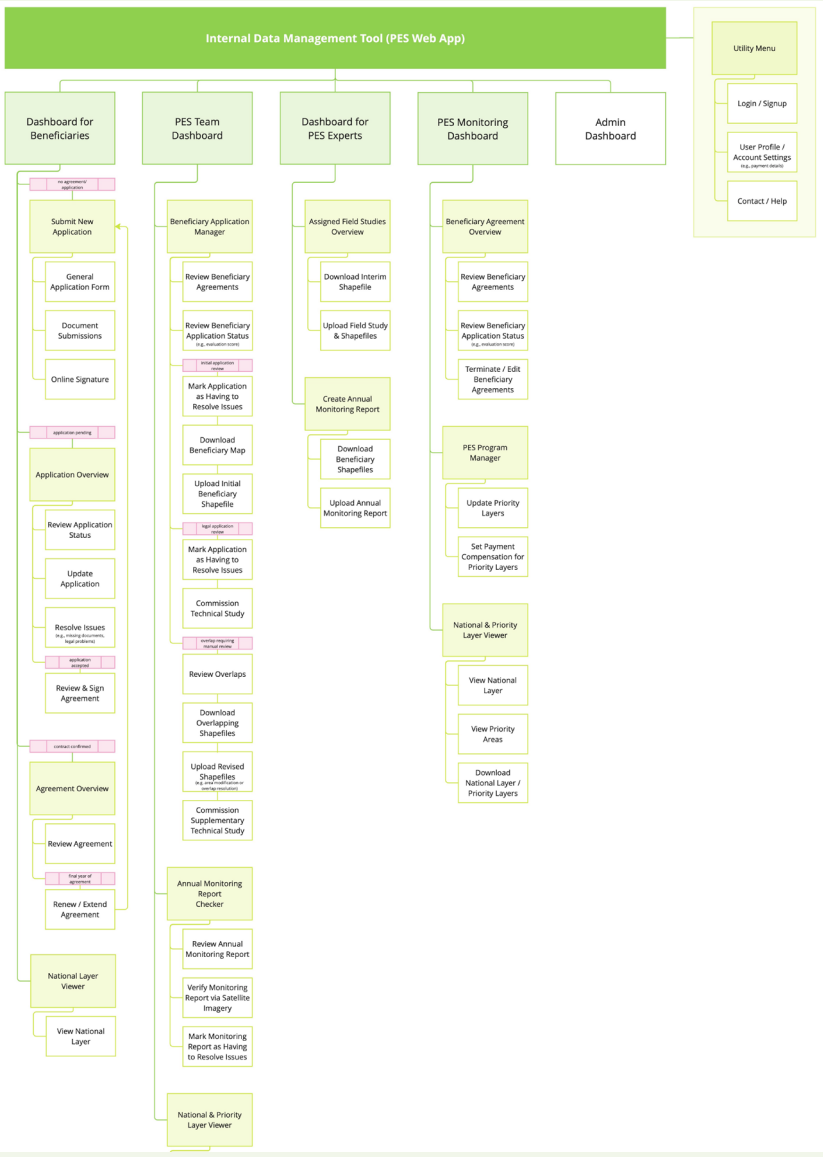


Information architecture: PES web application

A crucial component of the universal PES Process is the so-called PES web application (web app for short), which acts as the central interaction point between the front- and back-end of the system. The PES web app is the online portal through which all local geographic data generated by PES Experts and Teams is converted into SQL GIS data and then uploaded to the corresponding SQL database. Moreover, the web app also processes all the relevant application documents submitted by beneficiaries, who can hand in their application directly through the system.

As shown in the information architecture see Figure 14, the PES web app features four core first-level navigation elements (plus the Admin Dashboard and Utility Menu), all of which offer unique functionalities for different stakeholders of the PES system.

Fig 15. **PES web app architecture**



Technical requirements: PES web application

Beneficiary Dashboard

- Dashboard for beneficiaries to submit/review their PES application
- Upload all required documents, resolve any potential issues, and digitally sign the application
- View the national layer of the PES system

PES Team Dashboard

- Dashboard for the organization that oversees the PES development of their respective region
- Review all the application data submitted by beneficiaries, verify the submitted documents, and check for issues in the application.
- Review the annual monitoring reports written by PES Experts and verify them using remote sensing.
- View the geodata layer that compiles all PES sites/areas and the priority layer of the PES system.

PES Expert Dashboard

- Dashboard for PES Experts to arrange field studies and annual monitoring reports
- Download farm maps and upload verified geodata of beneficiary farms (i.e., as shapefiles)

PES Monitoring Dashboard

- Dashboard for the control & monitoring department of the PES Team to manage beneficiary agreements and priority areas
- Update priority layers and set the compensation payment rates for each of those
- View the national and priority layers of the PES system

Admin Dashboard

- Administrative functionalities of the PES web app

Core feature list: PES web application

#1 Application form

Online application form for beneficiaries to join the PES program

#2 Online signature feature

Online signatures for the application form and PES agreement

#3 Online agreement overview

Beneficiaries can review their application and agreement status on the PES web app

#4 Automated scoring matrix

Applications by beneficiaries are automatically scored based on predefined PES evaluation criteria

#5 Automated expert assignment

PES Experts are automatically assigned to conduct field studies

#6 Upload to/download from PES web app

The PES web app allows users to upload/download documents such as shapefiles or farm maps

#7 Shapefile to SQL conversion

Shapefiles uploaded by PES Teams & Experts are automatically converted into SQL-readable data

#8 Automated overlap detection

Overlaps between different farms are automatically logged on the SQL database

#9 Automated error check

Geodata uploaded by PES Experts is automatically reviewed for errors in the SQL database

#10 Automated national layer creation

Once approved, all beneficiary farms are automatically combined into a unified national layer

#11 Online map verification

PES Teams can verify the annual monitoring reports submitted by PES Experts via online satellite imagery

#12 Automated payment

Beneficiaries get paid their annual compensation payment automatically by the PES system

Endnotes

1. Wunder, S. (2008). Necessary Conditions for Ecosystem Service Payments. *Economics and Conservation in the Tropics*. Note that a widely accepted and basic definition of PES contains five elements (a) voluntary transaction, (b) a well-defined environmental service or a land use likely to secure its provision, (c) at least one buyer, (d) at least one provider effectively controlling service provision, (e) Conditionality that if and only if the environmental service provider secures service provision. This serves as a theoretical framework even if some PES schemes may not fulfill all.
2. Salzman, James & Bennett, Genevieve & Carroll, Nathaniel & Goldstein, Allie & Jenkins, Michael. (2018). The global status and trends of Payments for Ecosystem Services. *Nature Sustainability*, vol. 1(3), pages 136-144, March.
3. UN DESA. (2023). DESA Voice: 5 things you should know about how forests benefit people and planet.
4. In most cases, the government will pay on behalf of the users. Still, there are also schemes where private stakeholders contribute with finance to typically a fund that will finance the PES scheme (often for water-related ecosystem services).
5. Molina G, Montoya-Aguirre M, Ortiz-Juarez E. (2022). *Addressing the Cost-of-living Crisis in Developing Countries: Poverty and vulnerability projections and policy responses*. New York: UNDP.
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10. Engel, S., Pagiola, S., & Wunder, S. (2008). Designing payments for environmental services in theory and practice: An overview of the issues. *Ecological Economics*, 65(4):663-674.
11. Greiber, Thomas (Ed) (2009). Payments for Ecosystem Services. Legal and Institutional Frameworks. IUCN, Gland, Switzerland. xvi + 296 pp.
12. Wunder, S. (2005). *Payment for Environmental Services: Some nuts and bolts*. CIFOR Occasional Paper No. 42.

Annex: Overview of a PES life cycle

The Annex outlines the common processes for scoping, establishing and implementing a PES programme. Digital experts and IT service providers are encouraged to understand the entire life cycle of the PES scheme to better understand the users, following a design thinking approach.

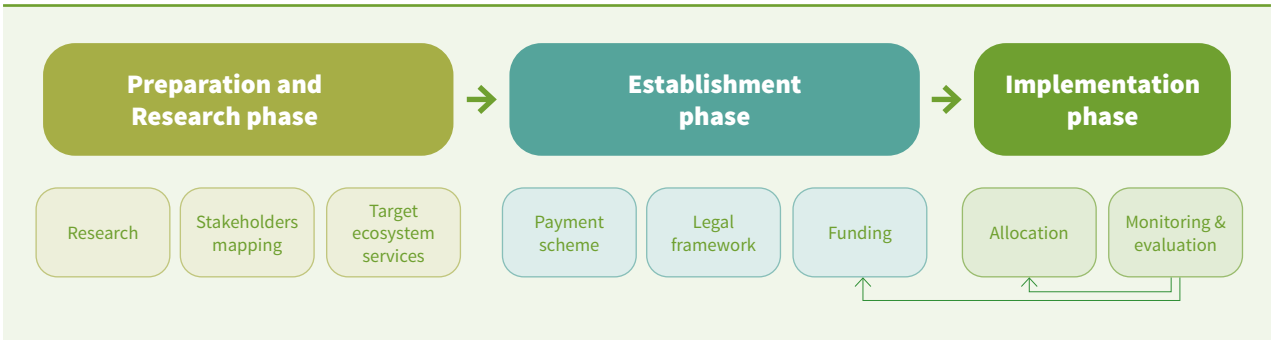
Overview of the PES lifecycle

Although not an exhaustive list, these crucial benchmarks serve as important indicators throughout the process and contribute to the overall success of the PES scheme.

Generally, PES schemes start from a preparation phase (Research, stakeholder mapping, target ecosystem services); establishment phase (payment scheme, funding, legal framework) and finally the implementation (allocation, monitoring and evaluation (M&E) over years.

The following pages explain each step and user needs in more detail.

Fig 1. **PES life cycle**



Research

When conducting research for a new PES scheme, the following topics are relevant starting points:

Ecosystem

What are the desired environmental outcomes? In which areas could the PES scheme help achieve these outcomes? Understanding the targeted environmental outcomes and services helps define **stakeholders** in later steps and is necessary for defining **priority layers** (or spatial targeting) later in the process.

Legal and institutional framework

Which legal and political frameworks could help or hinder the PES scheme? Which regulations and laws related to land use, environmental protection, and natural resource management are existing? Is there any instrument that links PES outcomes with the country's NDC?

Land tenure system

How are people associated with a piece of land? Is the land tenure system clean and clear? Uncontested land ownership is the most challenging bottleneck for PES systems.

Socio-economic context

Understanding the socio-economic context helps identify the potential stakeholders and the types of incentives that might be most effective in motivating them to participate.

Market analysis

Explore partnerships with local stakeholders like NGOs, government agencies, and private sector players. Understand the market for PES in the country, including potential buyers and sellers and already existing PES schemes.

Stakeholders

Identify potential stakeholders and engage with them to understand their needs, concerns, and willingness to participate (e.g., beneficiaries, governments, funders, providers of the PES scheme).

M&E

To later assess the effectiveness of the PES scheme, and identify appropriate indicators to measure environmental and socio-economic outcomes. Find the best ways to establish mechanisms to collect and analyze data.

Reliable institutions

There need to be institutions in place that are trusted by the beneficiaries, as they need to be confident they will be paid for what they have agreed to do.

Existing PES schemes

The first PES scheme in a country is the hardest to set up - if possible, countries should try to build on existing schemes.

Stakeholders

Decisive for the success of a PES scheme are its stakeholders and their (political) willingness to engage permanently in the process. Relevant stakeholders to identify when working on a new PES scheme are:

Ecosystem service providers

Individuals or communities who could provide the ecosystem services (e.g., farmers, landowners, foresters). These stakeholders maintain the ecosystem by providing the respective services (e.g., forest conservation, reforestation, and improving grassland health).

Buyers of ecosystem services

individuals, organizations, or governments who pay for the ecosystem services (e.g., companies that want to offset their carbon emissions, municipalities that want to protect watersheds and water catchment areas)

Facilitators

organizations that facilitate the transactions between providers and buyers (e.g., NGOs, brokers, or government agencies that provide technical assistance, monitoring, and verification)

Communities

groups and individuals who are affected by or interested in the PES scheme but who may not directly participate as providers or buyers (e.g., environmental groups, local communities)

A participatory design process can help gain stakeholders' trust, thus reducing long-term monitoring and enforcement costs and promoting equity outcomes.

Target ecosystem services

When assessing the ecosystem for the new PES scheme, the following steps are relevant. Generally, a feasibility study will be conducted:

Identify benefits

Evaluate the services that the ecosystem provides to all relevant stakeholders

Identify threats

Investigate which current threats the ecosystem is facing and how to address them best

Collect data

Analyze the current state of the ecosystem and all its related stakeholders (e.g., farmers, landowners, local communities, investors, users of ecosystem services, relevant government agencies, etc.)

Utilize GIS tools

Use GIS software to map the ecosystem and where ecosystem services are most needed

Identify priority areas

Pin down which parts of the ecosystem are most essential to be preserved and classify those as higher priority areas. Several methods exist to prioritize areas, from complex GIS algorithms to simple proxies (i.e., proximity to risks). A relevant factor to assess the method to be used for prioritization is the available data.

Payment scheme

Besides pure financial support for beneficiaries, it could be advisable to consider complementing with financial management support for individuals and communities. This could be done in partnership with local NGOs to work on social topics. Besides this, when developing a payment scheme, the following factors should be considered:

Type of services offered or provided

Identify the ecosystem services that landowners will participate in and determine how these services will be measured/monitored

Definition of payment amount

Define the compensation payment without complicating this task too much. Some elements that could be considered include a proxy value of provided services, the opportunity cost of not using the land for other purposes, and possibly the respective priority area. Note that in practice, other factors, like budget availability, land tenure structure, and others, will heavily impact the definition of the payment amount. Even though the opportunity cost can provide some direction in terms of the payment amount, it should not be seen as a determining factor under the wrong assumption that the PES payment will equal the opportunity cost. The PES scheme should be seen as a complementary measure based on incentive policies to other measures based, for example, on command and control policies.

Definition of beneficiary

Define who will be the beneficiaries receiving payments (individuals or communities)

Definition of eligibility

Define requirements or criteria for eligibility to participate in the PES scheme

Definition of funding sources

Define financial sources for the incentive or payment system (NGOs, private funding, taxes, etc.)
Definition of priority areas: Establish which areas are most important for ecosystem conservation or restoration and rank them based on their ecological impact (also referred to as spatial targeting). Since there will be limited funds, priority areas should receive PES compensation first. It could be considered paying a higher amount there.

Payment options

Identify the preferred and potential payment options. Digital payment might seem the most optimal. However, some beneficiaries may find it difficult to cash out. Some countries may already have well-established cash payment systems through traditional banks or even have other means such as crypto-currency or local currency.

Funding

Acknowledging that a sustainable source of funding is a common challenge of PES programs, securing a constant stream of funds for the support of the PES scheme is critical. As is the transparency of the PES system for attracting investors and funding. The following resources can be helpful in this context:

Potential funding sources

Identify potential sources of funds for the PES Program, such as taxes/government grants or tradable permits or development rights (e.g., International climate funds)

Portfolio

Create financial structures that facilitate a diversified portfolio of finance

Long-term planning

Develop a business plan that outlines the long-term financial, social, and environmental benefits of the PES scheme; working simultaneously on water, carbon, and biodiversity could help to gain a broader set of funding sources

Financial architecture

the financial structure needs to be able to implement different sources of funding. It is imperative that such financial architecture is transparent and keen to disclose information

Communication strategies

Develop a communication strategy to raise awareness in the general public about the scheme and its benefits

Legal framework

Establishing a suitable legal framework that is bespoke to the region interested in implementing a successful PES system will, by definition, differ from country to country. Nonetheless, while every country has its own underlying legislative structure they ought to follow, the following considerations might still be universally applicable:

Legal environment

Comply with the regulatory and legal restrictions of the country regarding property rights, contractual agreements, environmental and social regulations, and standards as well as financial regulations; consult with legal experts and relevant authorities in the country or region

Long-term solutions

Ensure the long-term stability of the PES system by building on regulatory requirements that will remain even after an eventual change of government

Allocation

The granting of funds is one of the most important phases of the PES process as it comprises all the central PES allocation steps from the beneficiary application to the final compensation/payment. In total, this phase consists of eight sub-steps (see below). The main body of this report explains each step in detail (see Chapter 3).

M&E

Monitoring and evaluating a PES is expensive and difficult. Not only do environmental outcomes need to be monitored, but some PES programs also aim to monitor social effects (e.g., How do beneficiaries use the financial support they receive? How is this monitored?) The following factors might be considered when establishing an M&E system:

Definition of indicators

Define universal metrics that can be used to assess the environmental and social outcomes of the PES program. The objective is not to overcomplicate the measurement of the desired outcomes but to find metrics that are accepted by all stakeholders involved, including the use of proxies. There is no value in overcomplicating the definition of indicators and the monitoring framework.

Definition of relevant data

Define a system for collecting and managing data that can best portray the PES program delivery (including the use of proxies, as opposed to hard data), keeping a balance between what is already available and what can be added without overcomplicating the system.

Definition of success

Examine the state of the ecosystem in order to establish a benchmark against which to measure the success of the PES program. It is recommended that this be kept as simple as possible.

Impact assessment

Examine the impact of the PES system on the ecosystem and all its stakeholders.
External monitoring: An external organization (e.g., an environmental audit firm) could be consulted to evaluate the successes and drawbacks of the system without bias.

Re-adjustment

Flexibly adjust the PES scheme based on all the collected monitoring results.

Engage the local communities and individuals:

Collaborating with the local communities and individuals can significantly streamline the monitoring process, based on simple but clear monitoring protocols.

Annex endnotes

1. Jack, B. K., Kousky, C., & Sims, K. R. E. (2008). Designing payments for ecosystem services: Lessons from previous experience with incentive-based mechanisms. *Proceedings of the National Academy of Sciences*, 105(28), 9465-9469.
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