GROVE: Forestry Smart Ledger (FSL)

LAB INSTRUMENT ANALYSIS
September 2020

DESCRIPTION & GOAL —
GROVE: FSL is the only platform to connect community mangrove projects with corporate and individual donors to scale up private finance for restoration and preservation.

SECTOR —
Forestry

FINANCE TARGET —
USD 38 million towards mangrove forestry projects within three years

GEOGRAPHY —
In the initial phase: India, Myanmar and Indonesia
In the future: India, Bangladesh, Myanmar, Indonesia and Nigeria

The Lab identifies, develops, and launches sustainable finance instruments that can drive billions to a low-carbon economy. The 2020 Global Lab cycle targets four specific sectors across mitigation and adaptation: nature-based solutions; sustainable agriculture for smallholders in sub-Saharan Africa; sustainable energy access; and sustainable cities, as well as three regions: India, Brazil and Southern Africa.

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SUMMARY

The GROVE: Forestry Smart Ledger (FSL) facilitates mass-scale, decentralized funding of regenerative forestry, thus reducing atmospheric carbon via planting and conservation of coastal mangroves and tracking the associated impacts. This technology is intended to be an open source public good and can be easily replicated to forestry projects beyond mangrove. GROVE:FSL shows promise and meets Lab criteria for endorsement:

- **Innovative:** GROVE:FSL connects small-scale mangrove projects with corporate/individual funders, improves transparency of funds through blockchain, reduces third-party cost leakages associated with carbon verification through remote sensing and ensures higher impact to local communities.
- **Financially Sustainable:** In the initial phase, the instrument needs ~$1 million dollars over a 12-month period to integrate and test remote sensing capability as a service, after which it would be self-sustainable. The FSL technology can also be patented to generate licensing fees, which would further bolster financial sustainability. In addition, the volume of listing on GROVE is expected to be large enough to generate admin fees to cover all running costs.
- **Catalytic:** Within three years, the platform could scale to restore and conserve 20,000 hectares of mangrove, which could mobilize capital worth $38 million dollars.
- **Actionable:** Global Mangrove Trust (GMT), the proponent, is a non-profit entity registered in Singapore, with strong linkages to the environmental, academic and entrepreneurial community. The team is highly capable and committed, and has chartered out a clear implementation pathway and growth plan for scaling up GROVE: FSL.

To summarize, the instrument is implementable and can generate economic, environmental, and social returns amidst COVID, making it a potential green recovery instrument in regions that are hard hit.

Next Steps: GMT will soon begin crowdfunding campaigns for a number of projects listed on its website, starting off with a 29-hectare project in Mumbai and a 200-hectare project in Myanmar.

In parallel, the proponent is involved in three major priority areas that will carry on in run up to and after the instrument launch. These include (i) refining the technology's remote sensing capabilities, (ii) structuring the benefit-sharing architecture to support investors, communities, and NDC stakeholders, and (iii) developing a roadmap for domiciling the technology as a public good within a global foundation or other philanthropic service structure.

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CONTEXT

GROVE: FSL is a platform that addresses persistent barriers that hinder financing of small-scale mangrove projects, have a limited impact on local communities and result in cost leakages for biomass estimation.

As part of the Nation Determined Contribution (NDC) targets, India has pledged to create an additional carbon sink of 2.5-3 billion tons of CO2 equivalent through 2030 (Forest Survey of India, 2015). In terms of policy implications, this would require India to increase its forest cover to rise to 33% from 22% currently – which would require an investment of $15 billion annually through 2030 (TERI, 2017).

Mangroves can typically store four times more carbon than rainforests and are one of the most efficient ways of sequestering carbon on Earth. In tandem, as rising sea levels pose a significant threat to coastal cities and communities, mangroves act as natural shields, and minimize damage from weather disasters such as flooding, tsunamis and cyclones.

Thus, in addition to contributing to India's mitigation targets, mangroves also help the country in adapting to a more volatile climate, protecting India's vulnerable coastal population and agricultural livelihoods.

The cost of restoring and conserving mangroves, along with improving the well-being of coastal communities, would require an estimated $10 billion through 2030 (Worldwidelife.org). However, given the scale of financing required relative to the needs, there is an urgent need to involve new sources of capital – which could be both return-seeking and non-return seeking (Althelia Capital, 2018). This need is exacerbated by the COVID crisis, which puts public budgets under pressure.

While the larger-scale regenerative forestry projects attract the attention and funding from the government and development finance (e.g. REDD), the small-scale community projects are left to look out for donors on an ad hoc basis. Currently, there are no platforms that connect potential financiers with community mangrove projects.

Voluntary carbon credits can also be a source of private financing for forestry projects, with the figure reaching $172 million in 2018 (Forest-Trends, 2019). However, access to voluntary carbon offsets remains limited for small-sized projects – since the costs associated with validation, verification and issuance of offsets can be steep (total costs over a year 20-year project life exceed $400k, with $100k required upfront) (Forest-Trends). Thus, small-scale community projects miss out on potential funding since only projects sized beyond a certain critical mass are able to justify the fixed costs outlays needed to access carbon markets.

Lastly, there is an urgent need to develop capacity and skillset to measure and monitor site-specific estimates of biomass and carbon sequestration potential of mangroves in order to strengthen conservation efforts to further instill financial and institutional funding towards forestry projects (United Nations).

GROVE: Forestry Smart Ledger (FSL) is a technology solution that aims to address barriers in the mangrove and the broader forestry sector. This instrument will bring in additional private finance for community mangrove projects through a P2P crowdfunding platform and improve upon the existing biomass assessment techniques to reduce third-party cost leakages and enhance positive and sustained impacts on local communities.

CONCEPT

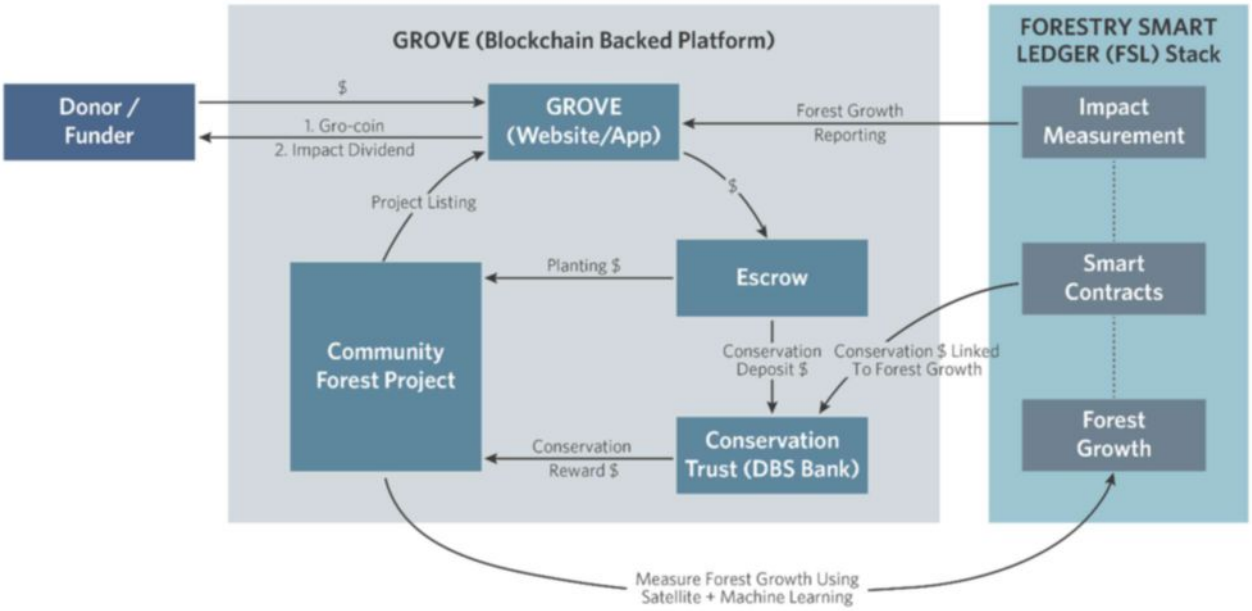
1. INSTRUMENT MECHANICS

GROVE: FSL combines blockchain, remote sensing and machine learning to drive new funding sources to mangrove projects through a peer-to-peer crowdfunding platform that would enable higher impact for local communities.

GROVE: Forestry Smart Ledger (FSL) is a two-in-one technology solution – GROVE and FSL- that aims to scale up private finance in mangrove forestry projects.

GROVE allows funders to directly sponsor forestry projects listed on its website/app. In exchange, funders receive a blockchain-backed digital currency token, called GRO-Coin, symbolizing their stake in the project. A blockchain's decentralized ledger facilitates flawless tracking and monitoring of funds and therefore GRO-Coins are more transparent than alternatives such as Voluntary Carbon Units (VCUs).

Figure 1: GROVE: FSL Instrument Mechanics



The FSL tech stack – which is linked to GROVE- utilizes satellite remote sensing in combination with Machine Learning (ML), as well as on the ground agents to confirm forest growth and improvements in natural capital. Depending on the assessment, funders receive impact dividends periodically. These dividends (akin to financial dividends for an equity share) represent impact directly generated as a result of their funding – in the form of tons of CO2 sequestered, jobs created, biodiversity enhancement, among others. FSL is intended to be an open source public good and can be easily replicated to forestry projects beyond mangrove.

GROVE and the FSL are also inter-connected through a digital smart contract that ensures that local community members are financially rewarded for their conservation efforts. A more impactful assessment would result in higher reward payments.

Key Stakeholders:

There are a number of stakeholders that play a key role in enabling finance for mangrove projects through the GROVE:FSL platform:

- **Funders:** These are individual and corporate entities that are keen to achieve carbon neutrality for personal ambitions or as an institutional mandate. As stated earlier, GRO-Coins offer a more efficient, transparent mechanism to achieve this vis-à-vis Voluntary Carbon Units (VCUs).

- **Conservation organizations and local communities:** The conservation organizations list their projects on the GROVE website/app for crowdfunding. They are responsible for execution and conservation of the projects, in conjunction with local communities, providing them employment and skills training where necessary.

- **Global Mangrove Trust (GMT):** GMT is a Singapore-based non-profit company on a mission to combat climate change by supporting forestry projects around the world, starting with mangroves. GMT is leading the development and execution of both GROVE and FSL.

- **Zilliqa:** A third-generation blockchain on which GROVE would operate. Zilliqa is designed on technology of sharding, which allows for low carrying and transaction costs.

- **DBS Bank:** Through an escrow account, DBS Bank acts as the custodian of the crowdfunded amount, releasing funds upfront for planting and periodically for conservation efforts and endowment for local community members.

- **Salo Labs:** Salo provides satellite imagery and environment mapping data that feeds into the FSL tech stack, which would assist in impact computation and iterative evolution of the solution's machine learning algorithm for biomass assessment and carbon impact estimation.

2. INNOVATION

Through a variegated set of technology tools, GROVE: FSL is able to address barriers in small-scale mangrove forestry projects in a manner no other technology solution is able to in entirety.

2.1 BARRIERS ADDRESSED: FUNDING AND EFFICIENCY OF SMALL-SCALE MANGROVE PROJECTS

There are a number of barriers in the forestry and voluntary carbon marketplace that prevent finance from flowing into community mangrove projects at a scale that is optimal. These are explained below:

- **Barrier 1: Funding for small-scale projects is limited:** Local mangrove communities and conservation organizations rarely have access to funders, financial institutions and carbon finance market.
  Solution: A peer-to-peer (P2P) platform such as GROVE that connects local communities with potential would help resolve the issue.

- **Barrier 2: Limited transparency of funding:** Understanding the direct impact of climate-related finance is challenging. Transparency levels may vary for different platforms, but in general it's not clear what proportion of funding goes towards conservation and what proportion towards project admin expenses, and how to evaluate the overall impact of funding is.
  Solution: GROVE: FSL's blockchain ledger ensures complete transparency and tracking of financial flow. Moreover, one can ensure pre-determined outcomes (such as distributing a fixed percentage of cash flows to local communities) through digital smart contracts facilitated by the platform.

- **Barrier 3: Cost leakages in the carbon credit accreditation process reduce impact:** In addition to the overall efforts required for carbon credits transaction, impact monitoring and verification of carbon credits involve significant ground-truthing and consultant expenses, resulting in substantial cost leakages. Total costs over a 25-year period can exceed $400k.
  Solution: A combination of satellite remote sensing and machine learning expeditiously measures impact and significantly reduces consultant costs related to third-party validation and verification.

2.2 INNOVATION: ENABLING DIRECT, DIS-INTERMEDIATED FINANCE AND IMPACT

There are a number of organizations involved in the carbon accreditation process as well as technology solutions that work with the objective of planting more trees, and reducing carbon footprint.

GROVE: FSL is the only solution that focuses on growing forests, benefiting local communities and improving the efficiency and transparency of financial flows. We provide a comparison below on how GROVE: FSL differentiates itself from incumbent solutions in Table 1:

Table 1: GROVE: FSL Differentiation

Name	Description	GROVE:FSL Differentiation
Verified Carbon Offsets (e.g. Verified Carbon Standard (VCS), Gold Standard):	Globally recognized carbon emission reduction certifying entities	• The process of carbon credit accreditation involves registration, validation and verification – which require a significant amount of time, effort and costs. • Once credit offsets are issued, the process of price discovery isn't seamless and is facilitated through brokers that further add to costs. • GROVE: FSL overcomes these barriers through use of technology and minimizes human intervention for assessment of carbon sequestration.
Alipay Ant Forest	An app game for forest planting	• GROVE: FSL provides a verified carbon impact assessment to

		funders. This is not the case in Ant Forest. • Furthermore, unlike GROVE: FSL, there is no smart-contract in Ant Forest that ensures local communities are rewarded for their efforts in planting and conservation.
Poseidon	A combination of blockchain and Artificial Intelligence (AI) to reduce carbon footprint at a retail level (e.g. reducing supply chain carbon footprint for a consumer firm)	• Unlike GROVE: FSL, there is no direct stake in afforestation projects, and no direct assistance to local community members.
Lykke TreeCoin	A crowdfunding blockchain platform for reforestation/timber cultivation	• There is emphasis on sustainable forestry for financial returns in TreeCoin rather than on growing forests and enhancing biodiversity.

2.3 CHALLENGES TO INSTRUMENT SUCCESS

As with any emerging technology, GROVE will face challenges related to the financial sustenance of the company, adoption of the platform and ensuring organic growth of the company. These are explained in Table 2:

Table 2: GROVE: FSL challenges

Challenge	Description	Strategy
Financial Sustainability	• COVID-19 impact: i. Corporations/individuals less willing to invest in voluntary carbon markets. ii. Philanthropies will naturally reallocate their funding to combat COVID-19 related challenges.	• The critical mass of project churn required to sustain GROVE is fairly low. GROVE derives revenues in the form of project listing and admin fee. Annual GROVE revenues of $200k (equivalent to 10% admin fee of $2 million project churn) would be sufficient to financially sustain the platform. • The proponent is in advanced stages of a number of potential partnerships and proposals for tech development and deployment – that may

		partly resolve financing needs.
	• FSL's machine learning algorithm may take 2-3 years to perfect – during which it can be patented and generate licensing fee, if deemed critical to system growth.	• FSL can be deployed beyond GROVE: For instance, the platform's tech partners (e.g. DBS Bank) may test out FSL through pilot projects – that can generate additional revenues and partially offset funding needs. • Licensing fee: FSL technology can be patented and eventually generate licensing fees that can further contribute to the financial sustenance of the platform.
Platform adoption and user growth	• New user adoption of the P2P platform will be challenging and growth may not be linear/steady.	• The proponent has founded a start-up social enterprise called The Greeen Company to market tokenized sustainability impacts to eco-conscious consumer brands and customers using a SaaS mobile app (www.Handprint.technology). • The Lab, the proponent's professional networks in academia/industry, and the company's partner firms provide strong visibility to GROVE to gain initial traction.
Project Listing	• Given that GROVE is new to the market, populating a pipeline of quality mangrove projects on its platform will be an arduous task.	• The proponent is in advanced stages of a number of conservation organizations to list mangrove projects in India, Myanmar, Indonesia and Nigeria on GROVE platform.

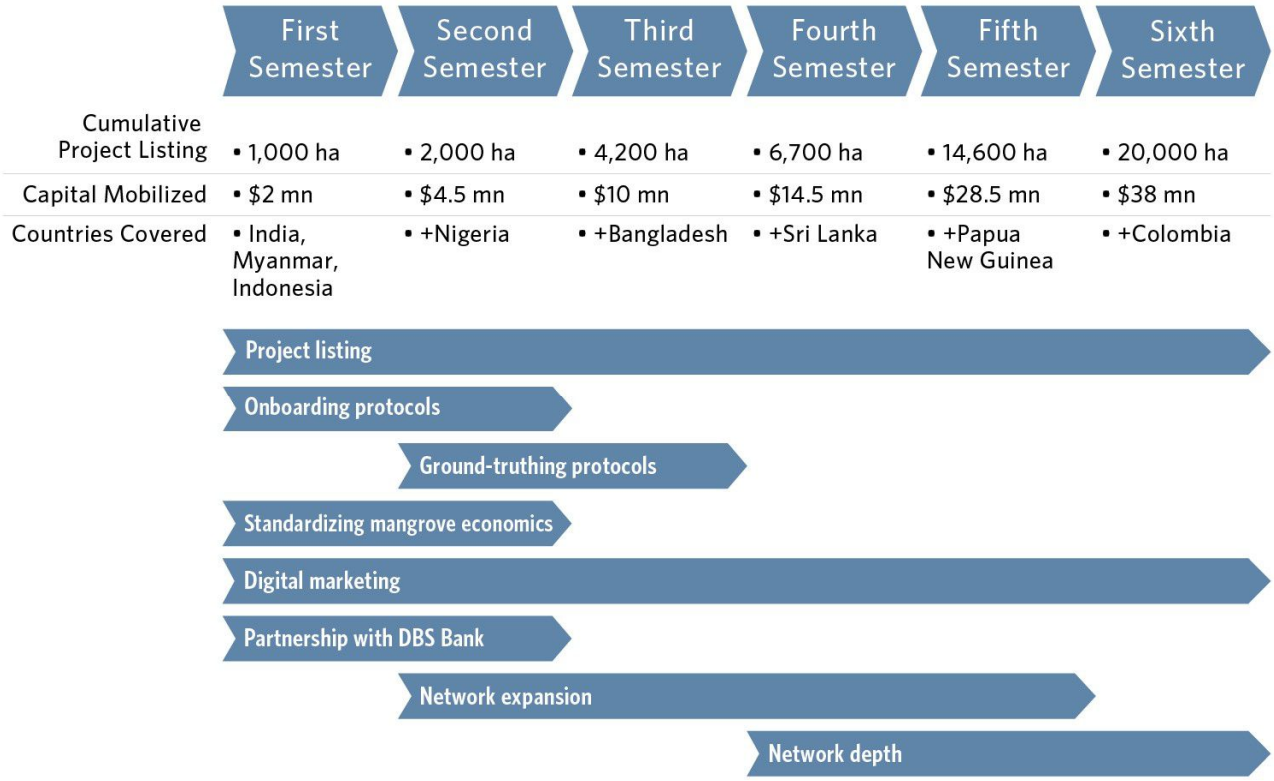
MARKET TEST AND BEYOND

3. IMPLEMENTATION PATHWAY AND REPLICATION

GROVE plans to close crowdfunding campaigns of projects equivalent to 2000 hectares in the first year, thus mobilizing $4.5 million in mangrove forestry. This figure could rise to $38 million within three years of launch.

GMT plans to formally initiate GROVE platform at the time of instrument launch. GROVE plans to close crowdfunding campaigns of projects equivalent to 2000 hectares in the first year and 20,000 hectares within three years of its launch. A tentative timeline on how the company plans to achieve its targets, along with the corresponding activities is provided in Figure 2. More details on activities are provided in the section following Figure 2.

Figure 2: GMT implementation pathway timeline



In line with the targets mentioned in Figure 2, the company is focused on the activities mentioned below, that have classified into three distinct categories – supply of projects, demand for projects and regulatory work. The proponent will continue to carry out these activities after the launch of the platform and into the growth phase of the company.

Supply of projects:

- **Project listing:** Building a database of potential project partners that can execute mangrove projects in different countries with Bay of Bengal (India, Bangladesh, Myanmar, and Sri Lanka), then the rest of South-East Asia, and eventually to the rest of the world.
- **Onboarding protocols:** Standardizing due diligence documents that are simple enough to be inclusive and rich enough to ensure we can trust the projects listed on the GROVE. The proponent is currently integrating biometric Know Your Customer (KYC) tools with Signzy (an Indian fintech security leader) to leapfrog industry leading on boarding protocols to fulfill anticipated increases in KYC regulations.
- **Ground-truthing protocols:** Developing a standardized way to collect, store, and share information about the ground planting to feed into Artificial

Intelligence/Machine Language part of the FSL. The proponent has developed a mobile Planter app to serve as a baseline tool for localized data collection and analysis.

- **Financial modeling of mangrove economics:** A financial model that helps GMT estimate the costs of mangrove projects all over the world by using public and private information about seedlings, land preparation, and planting (labor) costs – which would standardize and help predict mangrove project costs.

Demand for Projects:

- **Setting up a digital marketing company:** GMT founders have set up a for-profit start-up called The Greeen Company that is building an innovative value proposition, centered around "interactive impact as a service" to enhance the downstream value created for companies that support mangrove projects.

- **Partnering with DBS Bank:** GMT has partnered with DBS to set up a foundation that could in the future manage the technology developed by GMT and sell its verified mangrove projects via DBS Impact+. Impact+ will have reliable ecological, social, and financial impact verification.

Regulatory work:

- **Network expansion**: GROVE:FSL is a disruptive technology stack that is unlikely to be adopted early on by governments and incumbent organizations but the proponent has the goal for the technology to be recognized as a viable alternative to established forest certification bodies (e.g. Verra, Gold Standard, Corsia, among others). To accomplish this, GMT would connect with regulators whose countries can benefit from our disruptive approach and who could become LT advocates for GMT.
- **Network depth**: GMT's goal is to have GROVE:FSL recognized as a viable system to inform Nationally Determined Contributions (NDCs) at the country level. In this regard, GMT would connect with institutional entrepreneurs who can assist in navigating the complexities of local, regional, national, and transnational governance.

3.1 RATIONALE FOR GEOGRAPHY SELECTION OF PROJECT LISTING

To narrow down the locations for potential pilot projects, we considered following factors:

- **Existing mangrove cover and mangrove restoration potential** (reforestation and conservation): South and South-East Asia house approximately 40% of the global mangrove cover and thus provides a scalable market. Anthropogenic activity is considered as one of the biggest factors for loss of mangrove cover in these areas.[1]
- **Depth of partnership networks:** This is considered one of the most important factors for GROVE's on-ground success. GROVE values the presence of the Lab in India and Indonesia, while the proponents are based in Thailand and Singapore. The proponents have previous project experience in mangroves with Worldwide International Foundation (WIF) in Myanmar.
- **Maturity of fintech markets:** Financial literacy and digitization to understand the usage of crowdfunding platforms and blockchain technology are some of the factors that can facilitate the quick adoption of the technology in the implementation areas. Both primary markets considered. India and Indonesia are ranked 44th and 56th in the World Digital Competitiveness ranking, one of the highest among developing countries.

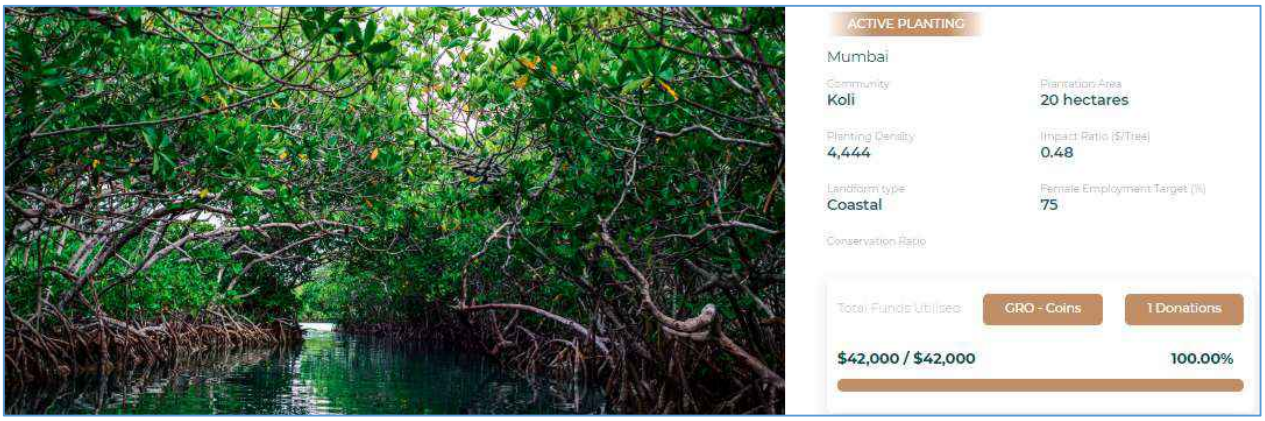
[1] https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0179302

After carefully considering these factors, the proponent has decided to channelize its efforts on India, Indonesia and Myanmar in the initial phase.

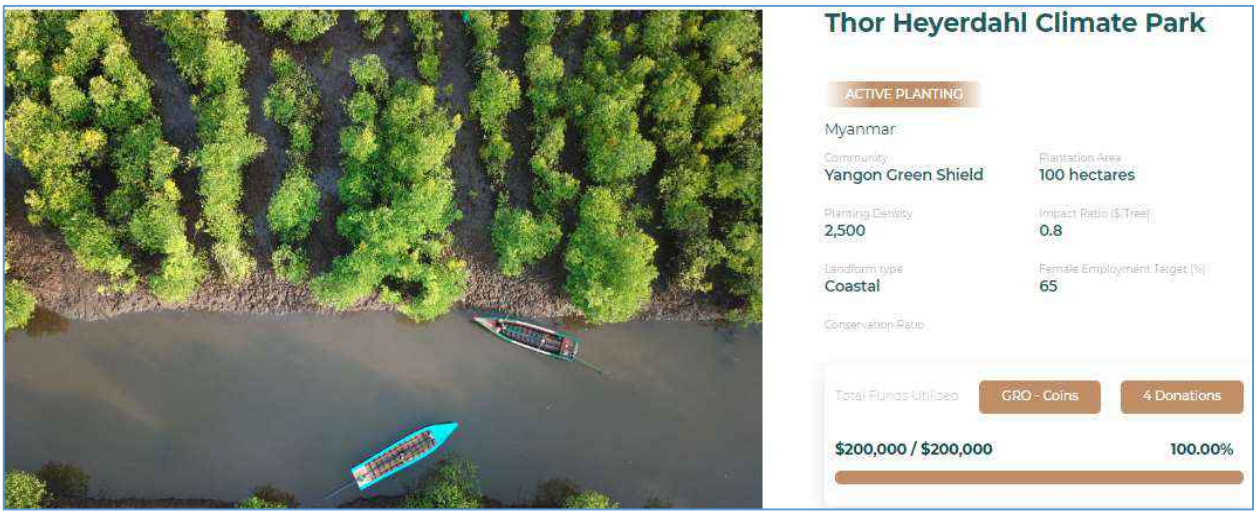
3.2 UPCOMING MANGROVE PROJECT LISTINGS

GMT plans to list several projects after the soft launch of its GROVE platform, of which the following are likely to be the first couple:

- **Vanashakti Mangrove Restoration project (Thane/Mumbai, Maharashtra, India):**



- **Thor Heyerdahl Climate Park (Myanmar):**



4. FINANCIAL IMPACT AND SUSTAINABILITY

4.1 QUANTITATIVE MODELING – HYPOTHESES VERIFICATION

The Lab analysis included developing a project cash flow model for a small-scale mangrove project in order to validate the claims that (i) GROVE:FSL can generate higher impact for local communities vis-à-vis conventional mangrove planting projects and (ii) enable small-scale projects to access carbon finance markets.

To ensure a controlled experiment (ceteris paribus), we built two scenarios – one with and the other without GROVE: FSL, and performed the analysis over different inputs. We found out that GROVE: FSL scenario validates both the hypotheses in each case.

Project assumptions and description:

We assumed a 100-hectare project of 25 years duration as the default project and used the same mangrove costing assumptions for GROVE vs non-GROVE projects. This project would generate carbon offsets, which can be sold in carbon markets, the proceeds of which can be partially paid out to local communities involved in the planting and conservation process.

Table 3: Financial model assumptions and general information

Project assumptions and information		Notes/Comments (if applicable)
Area (Ha)	100	Project size in hectares
Year 1 planting cost/tree (USD)	0.9	-
Year 2 Cost/Tree (upkeep)	0.1	-
Long-term cost/tree/year (monitoring) (USD)	0.02	-
Conservation endowment (%)	50% of planting and upkeep costs	Endowment funds are paid on a continual basis to local communities to incentivize them to conserve forests
Average annual inflation (%)	3%	-
Discount rate	10%	The discount rate used for computing present value of expected cash flows
Carbon offset unit market price (USD)	6	Average voluntary carbon unit market price assumed in 2020
GRO-Coin carbonized token discount	50%	GRO-Coin carbonized tokens are likely to have a lower market price initially but should converge to market price eventually
GRO-Coin convergence rate with market price	13%	Rate at which GRO-Coin carbonized tokens would converge to market prices over a period of 25 years
Average annual price escalation	5%	We built in a reasonable level of price increase given that carbon credit prices are expected to rise in the long-term
Carbonized token proceeds payout ratio to local community (GROVE)	50%	50% of the net proceeds from sale of proceeds of GRO-Coin carbonized tokens would be distributed to local community using smart contract tech.
Carbonized token proceeds payout ratio to local community (Non-GROVE)	30%	Since non-GROVE carbon credits do not have digital smart contracts, they are unlikely to be able to payout at the same level as that of GRO-Coin.

(i) Funding of the project: The project raises funds for planting trees as well as for an endowment fund (equal to 50% of planting/maintenance costs in this case). The endowment fund would make periodic payments to local communities as an incentive to conserve forests. In absence of such a fund, local communities may not have any stake in conservation of forests.

(ii) Costs with and without GROVE: FSL: While the costs associated with planting and conservation of the forests remain the same with and without GROVE: FSL, the cashflows associated with carbon credit accreditation process and the carbon offset unit price realization vary in the two cases.

(iii) Sources of income for local communities: The total financial impact to the local community is computed by aggregating the present value of the expected cash flows from the two streams – endowment fund payouts and proceeds from sale of carbon offsets. A portion of the net proceeds from the sale of carbon offset units would be distributed to local communities – which again would vary for the two scenarios.

For complete details on the assumptions used, please refer to Annex 1.

4.1.1 HYPOTHESIS I: PROJECTS LISTED ON GROVE: FSL CAN GENERATE HIGHER FINANCIAL IMPACT FOR LOCAL COMMUNITIES COMPARED TO CONVENTIONAL PROJECTS

Result: Validated
This hypothesis is validated by the financial model. We estimated financial impact by computing the present value of expected cashflows that the local communities would receive.

Table 4: GROVE vs non-GROVE expected financial impact

GROVE	Non-GROVE	Ratio
$222k	$123k	1.8

Further, we decided to conduct a sensitivity analysis for different scenarios by varying parameters such as project size, carbon credit market price and average price escalation rate. We found that the GROVE:FSL listed projects typically generate 1.5-2x times more impact than that for conventional projects.

The primary reasons why projects listed on GROVE:FSL are able to generate higher impact for local communities are:

- **Reduced third-party costs associated with carbon accreditation process:**

  A forestry project in order to be eligible for carbon credits within the incumbent frameworks needs to follow established processes that incur significant amount of costs. These include one-time upfront costs such as registration and submission of project design documents that can collectively cost over $100,000. The verification process typically costs between $30,000 to $50,000 each time and is typically conducted once every 4-5 years over a 25-year project. Once verified, there are costs associated with issuance of carbon offset units as well as brokerage involved in selling off these units in a marketplace, since the process of price discovery is not yet efficient. These costs are reduced significantly for GROVE projects.

- **GROVE: FSL's blockchain-backed smart contract technology**: This enables a pre-determined portion of the net proceeds from the sale of GRO carbonized tokens to be paid out to local communities in order to make them a key stakeholder and incentivize forest conservation.

  In our model, we estimate 50% of the net proceeds can be distributed back in the GROVE listed projects. The corresponding figure for a non-GROVE project has been assumed to be 30% - although this number can vary significantly depending on the requirements of the funder. Absence of a default payback technology would naturally reduce the likelihood of proceeds getting distributed back to local communities.

4.1.2 HYPOTHESIS II: GROVE: FSL FACILITATES SMALL-SCALE PROJECTS TO ACCESS CARBON FINANCE MARKETS THAT OTHERWISE WOULD NOT HAVE THE FINANCIAL WHEREWITHAL TO DO SO

Result: Validated
This hypothesis is implicitly validated in the financial model. As highlighted in Hypothesis I, the carbon accreditation process within existing frameworks incurs fairly high upfront costs. Most small-scale forestry projects do not have buffer funding to absorb upfront costs and are thus

unable to access carbon market financiers. This keeps the sources of funding of such projects to a very limited pool of network donors.

These barriers are resolved by GROVE: FSL to a large extent, since they do not require massive upfront costs in order to be able to access carbon finance markets. The FSL technology utilizes remote sensing and machine learning, and minimizes bureaucratic processes and human intervention required to assess carbon sequestration and verify carbon offset units. GROVE: FSL's technology substantially reduces these costs while transforming the fixed costs into variable costs (as a percentage of project size).

4.2 GROVE: FSL FINANCIAL SUSTAINABILITY

While section 4.1 describes the project cashflows and expected impact of projects listed on GROVE: FSL platform, we estimate the financial sustainability prospects and timelines for both GROVE and FSL in this section.

For GROVE, the primary revenue source is admin fee (equal to 10% of the crowdfunded amount). The costs would primarily include expenses on marketing and sales (through the Greeen company), cloud computing, employee salaries and others. Based on projections for revenues and costs, GROVE is likely to be self-sustainable from the very first year.

Table 5: GROVE financial sustainability timeline

GROVE	Year 1	Year 2	Year 3
Revenue ('000 $)	**448**	**992**	**2360**
Costs ('000 $)			
Marketing and sales	72	192	636
Cloud computing	22	26	32
Employee salaries	80	160	240
Others	18	39	85
Total Costs ('000 $)	**192**	**417**	**992**
Profit ('000 $)	**256**	**575**	**1370**

For FSL, revenue would be derived from verification services and project services (that includes project registration, reports on baseline estimation and biomass growth estimation, benefit sharing contract setup and legal fee). Both of these would generate revenue on a per hectare basis.

The costs would primarily include cloud computing and salaries. In addition, developing and fine-tuning of the FSL technology stack would also incur a one-time cost of USD 1 million, expensed primarily in year 1 – which would be financed using debt. Based on forecasts for project listing in Figure 2, we estimate the expected revenues and costs in Table 6, which illustrates that FSL is likely to be self-sustainable in the third year. Moreover, once FSL technology has been tested rigorously, it can be patented and licensed to third-parties to generate a licensing fee. Thus, prospects of financial sustainability would be further bolstered after FSL is patented.

Table 6: FSL financial sustainability timelines

FSL	Year 1	Year 2	Year 3
Revenue ('000 $)	**49**	**118**	**333**
Verification fee	10	24	67
Project services	39	94	266
Costs ('000 $)			
Cloud computing	22	26	32
Employee salaries	76	124	172
Debt services	28	28	28

Others	3	10	34
Total Costs ('000 $)	**129**	**188**	**266**
Profit ('000)	**-80**	**-70**	**67**

4.3 PRIVATE FINANCE MOBILIZATION AND REPLICATION POTENTIAL

GROVE: FSL plans to close crowdfunding campaigns of projects equivalent to 2500 hectares in the first year, thus mobilizing close to $5 million of private finance in mangrove forestry, assuming these projects are equally distributed across reforestation and conservation. This figure could rise to **$38 million within three years** of launch. Given that crowdfunding platforms for small-scale projects currently don't exist, almost all of this capital is likely to be additional.

If successful, GROVE: FSL will have a demonstration effect and set precedent for other market players to move in and develop similar technologies. This will bring in additionality of funders as well as improve biomass estimation through a combination of remote sensing and machine learning, thereby reducing cost leakages and ensuring that a greater proportion of funding impacts local communities.

Table 7: Private Finance Mobilization Potential

	Year 1 (Pilot)	Year 3 (Scale)	Year 2030 (Market Replication)
Forest cover (Hectares)	2000	20,000	625,000
Finance Mobilized ($ Million)	4.5	38	2500

According to Global Mangrove Alliance, a leading organization for mangrove conservation, the restoration of mangrove forests, along with improving the well-being of coastal communities, would require an estimated $10 billion through 2030 (Worldwidelife.org). GROVE: FSL can be instrumental in helping achieve these ambitious targets. Given that blockchain, tokenization and satellite remote sensing are expected to play an important role in forest finance in the coming years, we assume 25% of all global mangrove forestry projects by 2030 to utilize technology solutions that have been directly or indirectly inspired from GROVE: FSL (Mozaic Markets, 2020) This would translate to an additional capital mobilization of $2.5 billion.

The potential for replication is possibly much higher since the FSL technology is developed as an open source public good – which means it can be eventually adopted at an institutional level by conservation organizations and replicated across forestry projects beyond mangroves. Capital mobilized for non-mangrove forestry projects is not included in our computations for replication.

Please note that we assume longer tenure for replication (year 2030) than the usual 5 or 7 years given the inherent nature of projects. Mangrove trees take 2-3 years to grow after planting before they can be observed and monitored via remote sensing technologies. Thus, market replication will naturally entail a lag and may take longer than usual.

5. ENVIRONMENTAL AND SOCIO-ECONOMIC IMPACT

GROVE: FSL has potential to mobilize funding for 20,000 hectares of mangrove plantings – restoration and conservation combined- in the next three years and sequester 8.2 million tCO2e – equivalent of taking off 180,000 cars from roads annually.

Mangroves are natural carbon sinks. They are shown to store four times more carbon per hectare than most other tropical forests around the world (Science Daily). The aerial roots of mangroves prevent erosion while the canopy protects from the destructive forces of storm surges. Therefore, they play an important role in climate change and flood risk management. Apart from their biophysical significance, mangroves are a reliable source of sustainable livelihood and provide intangible benefits such as enhanced biodiversity and cultural value to local communities.

The nature of community mangrove projects facilitated through GROVE: FSL fulfill seven sustainable Development Goals (SDGs) through its socio-economic and environmental impact:

- 1 (no poverty): Ensuring social and economic protection is critical to improving health, education and sanitation to all vulnerable communities.
- 5 (gender equality): Access to sustainable livelihoods enhances women's rights and opportunities and helps to end discrimination.
- 8 (decent work and economic growth): Inclusive and sustainable economic growth, productive employment and decent work environments foster innovation and efficiency.
- 11 (sustainable cities and communities): In the event of extreme events and anomalies, safe and resilient communities avoid large scale destruction to life and property.
- 13 (climate action): Urgent action to strengthen resilience and adaptive capacity through building sustainable communities is crucial to plan for the adverse impacts of climate change.
- 14 (life below water): Worldwide, over 3 billion people depend on coastal ecosystems for livelihoods. To conserve the world's oceans, seas and sustainably manage the resources will help mitigate the overexploitation of marine resources and ensure sustainable livelihoods.
- 15 (life on land): Mangroves serve as buffers between coastal and terrestrial ecosystems and protect life and property on the shorelines from extreme winds, waves, floods and storms.

5.1 ENVIRONMENTAL IMPACT

GROVE has significant potential for mitigation through reforestation and avoided deforestation of mangroves and for adaptation through reduced hazard risk and protection of people and property. In the next three years, GROVE plans to cover 20,000 hectares to sequester 6 million tCO2 eq. through reforestation and 2.25 million tCO2 eq. through conservation efforts taking a total of more than 8 million. This is equivalent to 180,000 cars taken off road annually, assuming that a typical passenger car emits 4.6 tCO2 eq per year (EPA.Gov) and has an average life of 10 years.

Table 8: GROVE:FSL environmental impact

Activity	Planting area (Ha)	Planting Density	Carbon sequestration	Additionality	Carbon Sequestered

		(Trees / Ha)	rate (tCO2e / tree)		/ Activity (tCO2e)
Reforestation	5000	3000	0.5	80%	6,000,000
Conservation	15000	3000	0.5	10%	2,250,000
Total	**20000**				**8,250,000**

In our computations, we include only the additional carbon sequestration numbers brought about through project intervention. For instance, for conservation projects, we assume that only a small fraction of the land (10%) is prone to degradation and project intervention (through GROVE: FSL) would prevent this degradation. For reforestation projects, we assume that the planting was done on lands that had been largely degraded (80% in this case) and the intervention resulted in successful restoration of forest lands.

5.2 ECONOMIC AND SOCIAL IMPACT

In addition to generating environmental impact, the projects listed on GROVE: FSL can:

1. **Protect human lives and property** worth billions of dollars: Coastal areas, in particular, are at enhanced risk given climate change and increased frequency and intensity of extreme events. Mangroves are known to reduce the height of the waves by almost 66% for a stretch of 100m and by about 50% for a stretch of 500m (Losada et al.,2018). For coastal areas, this can translate to not just avoided losses of residential and industrial property worth billions of dollars, but also of precious human lives.

2. Facilitate a significant increase in income (typically 50%) of **local communities** benefiting from mangrove planting[2]: Studies show that since women in coastal communities tend to spend more time in mangrove conservation than men because of traditional gender roles, mangrove habitats can provide "protective, stable and sure" incomes for women (Thakur &Yeragi 2012). However, they often lack the social, economic and political power for decision making in conservation initiatives. Mainstreaming gender equality in mangrove conservation can be powerful avenue for coastal communities to overcome women's marginalization and incorporate their perspectives in decision making for climate action. (Bosold, 2012)

NEXT STEPS

Overall, GROVE: FSL has a clear implementation pathway and can mobilize private finance into forestry at a time when state budgets are likely to be constrained due to COVID-19 impact. As for immediate next steps for GROVE: FSL, the proponent is involved in a number of activities that will carry on in run up to and after the instrument launch. These are:

1. **Project Listing** activities that include:

    - **Advanced scoping** a shovel ready reforestation and restoration project on 29 hectares of degraded mangrove forest land in Thane Creek, Mumbai with Vanashkati conservation organization.
    - **Advanced scoping** a series of shovel ready projects with Worldview International Foundation on 1,500+ hectares of degraded mangrove forest land in Ayeyarwaddy, Myanmar.

[2] Yagasu Report (Primary Research)

- **Early-stage scoping** of several mangrove reforestation and restoration projects with conservation organizations such as Yagasu and Blue Forest in Indonesia.

2. **Technology Development:**
    - Complete end to end bug-fix and stress-testing of the GROVE website. The proponent is updating offline listing content for all projects to prepare for a global soft launch.
3. **Digital Marketing:**
    - Founded a start-up social enterprise called the Greeen Company to market tokenized sustainability impacts to eco-conscious consumer brands and customers using a new mobile app called Handprint. The proponent has initiated funding seed-round in Q3 and will use the SaaS and mobile Handprint solutions to embed mangrove sponsorships into retail goods and services.
4. **Legal Structuring of FSL:**
    - **Mid-stage scoping** a large, multi-stakeholder R&D collaboration with Temasek Foundation, Zilliqa, National University of Singapore (NUS), DBS Bank, Conservation International, and several other major local players to create an independent foundation in Singapore to house the Forest Smart Ledger (FSL) solution within a novel, high-scaling carbon certification regime. This includes several grant applications that are both under review and in the process of submission.

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6. ANNEX I – MANGROVE RESTORATION POTENTIAL

According to Ocean Wealth, there is potential to restore more than 800,000 hectares of mangroves globally (Oceanwealth). This would translate to about $3.2 billion, assuming $4000 per hectare as the cost for planting and conservation. The cost per hectare can vary widely depending on the size of the project, location, local cost of living, level of restoration required and other site specification requirements. Thus, these computations have a representative utility and actual figures may vary.

For the geographies GROVE:FSL plans to focus on in the initial few years, we highlight the restoration potential and investment required corresponding to each geography:

Country	Mangrove Cover (Ha)	Area Restorable (Ha)	Percent Restorable (%)	Investment Required ($ Million)
India	346713	15241	4.4%	61
Bangladesh	411120	13799	3.4%	55
Indonesia	2703410	186611	6.9%	746
Myanmar	491957	43571	8.9%	174
Sri Lanka	19944	2866	`14.4%	11
Thailand	232683	17471	7.5%	70
Philippines	270822	15647	5.8%	63
Cambodia	58937	5510	9.3%	22
Total	**4535586**	**300716**	**-**	**1203**

7. ANNEX II – QUANTITATIVE MODELING ASSUMPTIONS

7.1 HECTARAGE AND COSTING ASSUMPTIONS

Table 1 outlines the hectarage and costing assumptions made for the financial model developed for community mangrove projects, comparing prospective cash flows and local community impact for projects facilitated through GROVE: FSL vs projects enabled through established carbon credit mechanisms.

Table 1: Hectarage and costing assumptions

Hectarage and costing assumptions	
Area (Ha)	100
Density (Tree/Ha)	3000
Year 1 planting cost/tree (USD)	0.9
Year 2 Cost/Tree (upkeep)	0.1
Long-term cost/tree/year (monitoring)	0.02
Conservation endowment	50%
GROVE admin (%)	10%
GROVE transaction (%)	5%
Average annual inflation (%)	3%
Discount rate	10%

7.2 CARBON STOCK ASSUMPTIONS

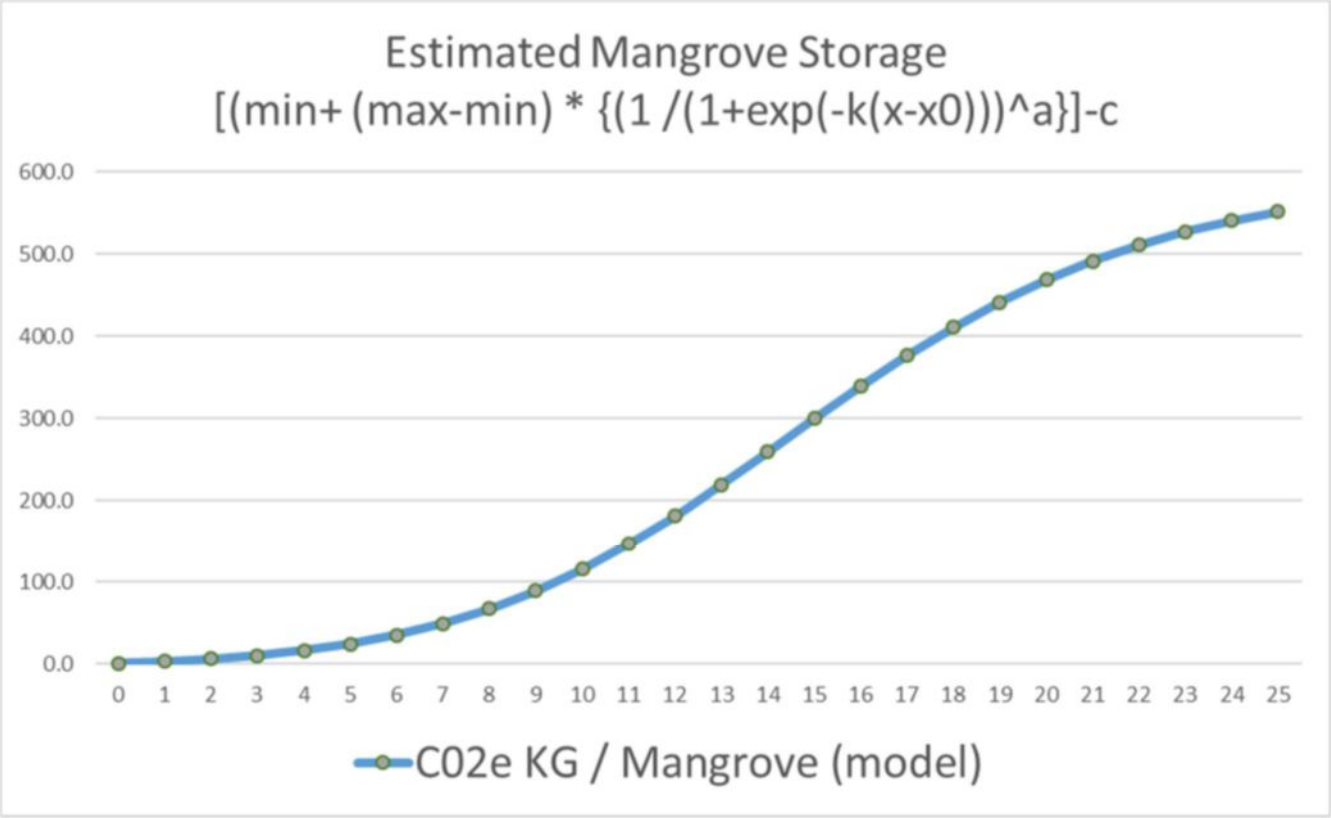
In this section, we list the assumptions for the accumulation of carbon stock in a mangrove tree during the project life of 25 years.

Table 2: Carbon stock assumptions

Carbon Stock Assumptions		
Max	Max lifetime (25yrs) storage: KG CO2e/tree	600
Min	Initial storage: KG CO2e/tree	0.5
x0	Period mean	12.5
K	Slow-start curve parameter	0.24
A	Fast-start curve parameter	1.55
C	Correction	5
	Storage Density/Ha (Degraded)	10.00%
	Baseline Carbon Stock (Degraded)	165
	Storage Density/Ha (Mature)	1655

The accumulation of carbon stock in a mangrove tree is not linear and usually follows a logarithmic function, the trajectory of which is depicted in Figure 2.

Figure 2:Mangrove tree carbon storage function



7.3 CARBON CREDIT MARKET PRICE ASSUMPTIONS

The voluntary carbon credit market price assumptions and the average annual growth rate assumptions are listed in Table 3. In addition, we assume that carbonized tokens backed by GRO-Coin would eventually trade at a discount to the more established carbon credit units in the market, but would eventually converge to a common price. These details are also provided in Table 3.

Table 3: Carbon credit market price assumptions

Carbon Credit Market Price	
World Blue carbon price ($/TCO2e)	$6
Average annual carbon price appreciation rate	4.00%
GRO-Coin carbonized token price Discount factor	50.00%
GRO-Coin price convergence rate	13.00%

7.4 CARBON VERIFICATION AND OTHER RELATED COSTS

As highlighted in Section 4.1, the costs associated with validation, verification and issuance of offsets can be steep (total costs over a year 20-year project life exceed $400k (with $100k required upfront). Given that these costs are significant, most small-scale forestry projects are not able to access the carbon finance market.

These challenges are resolved by GROVE: FSL to a large extent, since they do not require massive upfront costs in order to be able to access carbon finance markets.

Table 4: Carbon verification costs

Carbon Verification Cost	
Non-GROVE:FSL project design documentation and registration (one-time) ($)	$85,000
Non-GROVE:FSL verification (recurring per 5 yrs)($)	$40,000
Non-GROVE:FSL brokerage fees ($) for carbon credit issuance	10%
GROVE brokerage fees	5%
GROVE-FSL verification cost/ha *($)	$2
GROVE one-time registration fees ($)	$2000
Avg GROVE leakage and non-permance (%)	10%
Avg leakage and non-permanence for non-GROVE (%)	15%