Applicant Instructions: Prepurchase track

Thank you so much for your work on carbon dioxide removal (CDR), and thank you in advance for taking the time to apply for Frontier's purchase. Please read the following information carefully and in full before beginning your application, as well as take a look at Frontier's Fall 2022 Request for Proposals which includes information regarding our target purchase criteria, how we review applications, and what our team is looking for. For your reference, all previously submitted applications are available here (2020-2021) and here (2022 onwards).

We invite you to attend one of two application coaching sessions we will be hosting at 9 am PDT on Sept 20 and 10 am PDT on Oct 4 for general application guidance. If you have any further questions as you work through, please email us at suppliers@frontierclimate.com.

Timeline

- **October 7, 2022 9:00 pm PDT:** This application is due. You are welcome to submit early.
- **Mid October:** Frontier will review your application for completeness and basic scientific validity with respect to our criteria. Qualified applications will be sent to our expert reviewers for review against the criteria we outlined in the RFP. Each application will receive 2 scientific reviews and 1 governance review.
- **Early November:** Frontier will share anonymous reviewer comments and questions with you, and give you two days to submit a response to these comments, if you choose to.
- **Mid November:** Frontier will invite a subset of applicants to advance to a video interview to discuss your application.
- **Late November:** Frontier finalizes decisions and notifies applicants of prepurchase and small offtake (FYI, a separate template) awards. Together, Frontier and teams define renewal criteria, project milestones, and tonnage pricing within Frontier's standard purchase agreement templates. Larger offtake applicants will be notified if they are Finalists and invited for additional diligence that we will perform in early 2023.
- **Mid December:** Frontier will announce prepurchase and small offtake purchases and upload applications to Frontier's public GitHub.
- **First half of 2023:** Frontier's review team will conduct additional diligence with larger offtake Finalists, including a site visit to your facility.
- **Mid 2023:** Frontier signs larger offtake agreements.

How to apply

Step 1: Determine which category supplements apply to your project

- This document includes the General Application as well as all category supplements. All applicants should fill out the General Application, as well as whichever (typically 1 - 2) supplements apply to your approach.
- You should fill out applicable supplements IN ADDITION to the General Application.

- Using examples from Frontier's existing portfolio:
    - AspiraDAC would fill out the DAC supplement AND the Geologic Injection supplement.
    - Lithos Carbon would fill out the Surface Mineralization/Enhanced Weathering supplement
    - Running Tide would fill out the Biomass supplement AND the Ocean supplement.
    - CarbonBuilt would fill out the CO_2 Utilization to storage supplement.
- If it's not clear which supplements apply to your project, please ask at suppliers@frontierclimate.com.

Step 2: Delete the supplements that don't apply to you.

- This results in a document with the General Application and your applicable supplements only. Please delete these first four pages of instructions too!

Step 3: Fill out the application in this document.

- If you have any questions, attend one of two application coaching sessions we will be hosting at 9 am PDT on Sept 20 and 10 am PDT on Oct 4 for general application guidance or email us at suppliers@frontierclimate.com. Please reach out with questions as early in the application process as possible.

Step 4: Complete the techno-economic analysis (TEA) spreadsheet.

- We included a Google Sheet containing a TEA in the same Google Drive folder (specific to your application) as this template. Instructions on how to fill it out are included in the START HERE tab.
- We recorded a webinar with instructions for filling out the spreadsheet. The passcode is provided in your application invitation. We encourage you to review the spreadsheet early on and ask any questions you might have–either by email or attending an application coaching session.

Step 5: Prepare any materials you would like to submit confidentially [optional].

- We remain committed to a public RFP process because commercial-scale permanent CDR is a nascent field, and we are trying to advance transparency and knowledge-sharing across the ecosystem. However, companies applying for a prepurchase will be able to share select information confidentially.
- A confidential addendum, which can be up to six pages, may be submitted. It should be limited only to select data (e.g., specific site locations or supplier names, material formulations, revealing performance data, business plans, etc.) you wish to exclude from the main application. This confidential addendum and the TEA spreadsheet will not be made public.
- To submit a confidential addendum, create a Google Doc or upload a Word or PDF to the same Google Drive folder as this application and the TEA. All of your application materials must be in this folder.
- Frontier's expert reviewers have non-disclosure agreements (NDAs) in place with Frontier. If you have any concerns around confidentiality, please contact our team to discuss.

Step 5: Submit your application by October 7, 2022 9:00 pm PDT

- This application, the TEA spreadsheet, and confidential addendum (if applicable) must be in the Google Drive folder by this time.

- **Your submission constitutes your consent for Frontier to make your full application and all of its content - excluding the TEA spreadsheet and confidential addendum– available publicly under a CC-0 "Public Domain" License, regardless of whether or not Frontier selects you for purchase.** For more details, see "Why we make applications public" below.

What we're looking for

Please refer to Frontier's Fall 2022 Request for Proposals for a characterization of projects Frontier is excited to support and details on our selection process. There, we discuss the three lenses we use when making purchase decisions: approach, execution, and portfolio. Our approach criteria are:

Criteria	Description
Durability	Stores carbon permanently (>1,000 years)
Physical footprint	Takes advantage of carbon sinks less constrained by arable land
Cost	Has a path to being affordable at scale (<$100 per ton)
Capacity	Has a path to being a meaningful part of the carbon removal solution portfolio (>0.5 gigatons per year)
Net negativity	Results in a net reduction in atmospheric carbon dioxide
Additionality	Results in net new carbon removed, rather than taking credit for removal that was already going to occur
Verifiability	Has a path to using scientifically rigorous and transparent methods for monitoring and verification
Safety and legality	Is working towards the highest standards of safety, compliance, and local environmental outcomes; actively mitigates risks and negative environmental and other externalities on an ongoing basis

Why we make all applications public

All applications to our earlier purchase cycles were made public, and can be accessed here and here. We're grateful to all our applicants for providing this level of transparency; hopefully this will enable impact beyond the dollar amount of any particular purchase we may make, including visibility and the opportunity for potential collaborators and investors to connect with you. Making applications public enables subsequent academic works and independent analysis from nonprofits like CarbonPlan (examples here, here), and we've heard from a wide range of investors, engineers, and scientists that the shared applications are a valuable source of data on the current state of the field and opportunities for advancement. For these reasons, we're again making applications from this purchase cycle primarily public.

That said, in previous cycles, some companies have told us that this level of transparency can be challenging, particularly if the company is in stealth or in the process of patent filing. We understand the need to balance transparency with protecting business-sensitive information, and thus will accept a confidential addendum that will not be published. We still expect as much information as possible to be included in the public-facing portion of the application so that it is a comprehensive, standalone representation of the merits of what you're building.

Fine print

We intend to make the selection process as informal as possible. However, we do expect that (a) the content of your application is, to the best of your knowledge, complete and correct; (b) you do not include any content in your application that breaches any third party's rights, or discloses any third party's confidential information; (c) you understand that we will publicly publish your application, excluding the TEA spreadsheet and materials in the confidential addendum, at the conclusion of the selection process. You also understand that Frontier is not obliged to explain why or how it decided to purchase the CDR that it did, and that Frontier may decide to not purchase CDR from your application or make an offer to purchase less than what you proposed. Finally, if you are selected as a recipient for funding, Frontier will not be under any obligation to provide you with funding until such time as you and Frontier sign a formal written agreement containing the funding commitment.

Acknowledgements

Frontier gratefully acknowledges assistance and discussions from the following, who helped improve this application template and our purchasing process:

- AirMiners environmental justice working group for their many suggestions on the Public Engagement and Environmental Justice section
- CarbonPlan for their partnership on shaping measurement, verification and reporting requirements
- M. Van der Spek (Heriot-Watt University) for developing the TEA spreadsheet
- Microsoft and XPRIZE Foundation for perspective on life cycle analysis (LCA) and TEA tools

Mati
Carbon Dioxide Removal Purchase Application
Fall 2022

General Application - Prepurchase

(The General Application applies to everyone; all applicants should complete this)

Company or organization name

Swaniti Initiative's "Mati" Program

Company or organization location (we welcome applicants from anywhere in the world)

USA and India

Name(s) of primary point(s) of contact for this application

Rwitwika Bhattacharya, Shantanu Agarwal

Brief company or organization description

Carbon removal with basalt based enhanced weathering in Indian rice paddy farms enabled by robust MRV and tracking technology.

1. Project Overview[1]

a. Describe how the proposed technology removes CO_2 from the atmosphere, including as many details as possible. Discuss location(s) and scale. Please include figures and system schematics. Tell us why your system is best-in- class, and how you're differentiated from any other organization working on a similar technology. <1500 words

Introduction: Mati mineralizes CO_2 using enhanced rock weathering (ERW) of silicate rock. Our program uses ground basalt-based soil amendments marketed as "Mati" and distributed in rice paddy fields that catalyze conversion of CO_2 into dissolved inorganic carbon which flows through to rivers and eventually oceans and remains stable for >10,000 years. The presence of significant water from flooding in the rice fields and higher temperatures of the sub-tropical regions creates an

[1] We use "project" throughout this template, but note that term is not intended to denote a single facility. The "project" being proposed to Frontier could include multiple facilities/locations or potentially all the CDR activities of your company.

ideal environment for rapid and extensive weathering reactions. Mati provides beneficial effect in crop productivity and allows for sharing of carbon removal incentives with farmers creating a strong adoption driver. We have already tested and deployed this market hypothesis in the Indian agricultural sector this year.

To measure CO_2 removal, Mati utilizes robust, state-of-art MRV from its partner third-party MRV provider Lithos Carbon. Lithos has agreed to provide Mati the following services: mass-balance empirical MRV, a field-to-ocean perspective of carbon fluxes for our deployments, and software support for optimizing the deployment of Mati feedstocks specific to small, marginal farmers. With of 3.746 million hectares of land under paddy farming in the state of Chhattisgarh alone, and its general proximity to deccan traps, we have a significant scale up opportunity. Nearby states of Maharashtra, Madhya Pradesh, Bihar, Uttar Pradesh, etc. have another 18.8 million hectares for potential further expansion. Abundant raw materials in proximity to these large agricultural regions provides a conducive opportunity to scale to >500,000 tonnes per annum of carbon removal within 5 years. We recognize that there are significant challenges in the logistics of transporting this feedstock and measurement at this scale. A purchase from Frontier would help us accelerate our existing efforts, provide market validation for the farmers we are working with, and help us make inroads to step one of deploying in a developing country market that is ripe for CDR.

Where: Mati is already being deployed, initially, in the rice paddy fields of Chhattisgarh state. The proximity to significant basalt deposits (range from a few km to 150km) and warm temperatures (Raipur temperature average of 82 deg F) make it an ideal region for ERW. The basalt quarries which we work with in the region already produce significant aggregates for construction; and in the process of crushing for aggregate production, significant fines are produced (8% to 15% by weight). These fines are a waste product that has limited commercial value.

Basalt feedstock for our deployment is sourced from the [redacted], which is an outflow of the deccan basalt traps. Currently transportation is largely by trucks that deliver the materials directly to our village distribution centers (we have already established 2 such VDCs). From these VDCs, farmers transport Mati to their individual farms with tractor trailers or bullock carts. We have already successfully deployed this process as described. We also account for the total CO_2 penalty required for transportation of Mati to the farms. In the long term we hope to create a distribution network that may leverage rail and low emission alternatives to optimize VDCs location with the lowest potential CO_2 penalty. Our current established sourcing relationships are with two mines in the [redacted]. We are contracted to source from these two mines for the Jan 2023 expansion. We are also in conversation with a large capacity mine in [redacted], [redacted] to provide for larger expansions into Maharasthra and Madhya Pradesh over time.

Our initial focus for this offer is the rice paddy farmers in Raipur area, within 150 Km of the source rocks. We have deep connections to this community, which is why we began here for the feasibility pilots. However, we have picked [redacted] districts for future expansions where distance from source rock is between 10km and 50km. Convincing and converting farmers to use Mati requires field support and direct contact with farmers, hence we are working village by village. Our pilot trials have been run across two villages – Amodi, and Nawagaon — in 5 different rice paddy farms.

Our next scale up for Jan 2023 is planned with expansions in the nearby villages of [redacted].We are also planning to do small pilot trials in the districts of [redacted] in Jan 2023, to enable expansion there. The next scale-up to 10,000 tonnes (potentially in June 2023 if logistics can be secured) could be done over 2,500 acres that will expand the program in the villages in [redacted] also expand in [redacted]

How: The process starts with getting farmers onboarded for the upcoming growing season. With Lithos' guidance, we then take soil samples selectively to generate soil chemistry baselines to feed into SCEPTER for recommending application rates. Before applying basalt, Mati takes a soil sample in the farmland and follows-up with additional geolocated soil samples at the end of the season. Samples are sent to Lithos for high-precision major and trace element composition analysis to Lithos, resulting in a transparent and cost-effective quantification of basalt feedstock dissolution and CO_2 capture. Sampling density for rice paddies is a recognized challenge; Mati is going to do **very** high sampling initially for our Jan 2023 scale-up. This, admittedly, will increase initial MRV costs — but is a necessary hurdle that must be cleared. Ideally, Mati would like the isotope technique to be adapted and localized for conducting tests in India as part of medium-term future program scale-up. However, our current mode of exporting sterilized soil samples to USA for testing, will be utilized as we move towards near-term validation of the rice paddy model.

Figure 1: Simplified depiction of the steps involved in ERW carbon removal by Mati

Why: The MATI program seeks to optimize application rates based on smallholder farms' soil conditions (which can vary significantly from village to village), and test with high-precision empirical MRV to validate ERW rates in this completely novel context. It is unique in its ability to manage local sourcing, supply chain, farmer relations and government approvals, due to a decade of previous work. MATI is developing a technology stack for logistics and tracking at scale that can capture location, sampling data — necessary for the number of farms needed in smallholder regions — and directly deliver cash incentives for good farming practices to farmers. We realize the field is biased towards larger farmers/landowners, but Mati believes there is a need for CDR to *begin* exploring smallholder markets despite the challenges. The economic incentives/impact potential for smallholder farmers from this roll-out are unparalleled. The very tangible impact to equity and livelihoods is one that the CDR field should take seriously.

MATI is being deployed in the state of Chhattisgarh, also due to its impact potential on food security and upliftment of marginal farmers. More than 80% farmers in Chhattisgarh are marginal sustenance farmers. With Mati's plan for scaling, this could uplift >20 million lives engaged in sustenance farming while delivering >5 million tonnes of CO_2 removal per annum in the future. We hope to scale the initial pilots very carefully and diligently; the scientific rigor and logistical infrastructure could then provide a template to scale in other states or developing countries. Over the next decade ERW provides one of the most viable means of permanent carbon removal for the world as reported below:

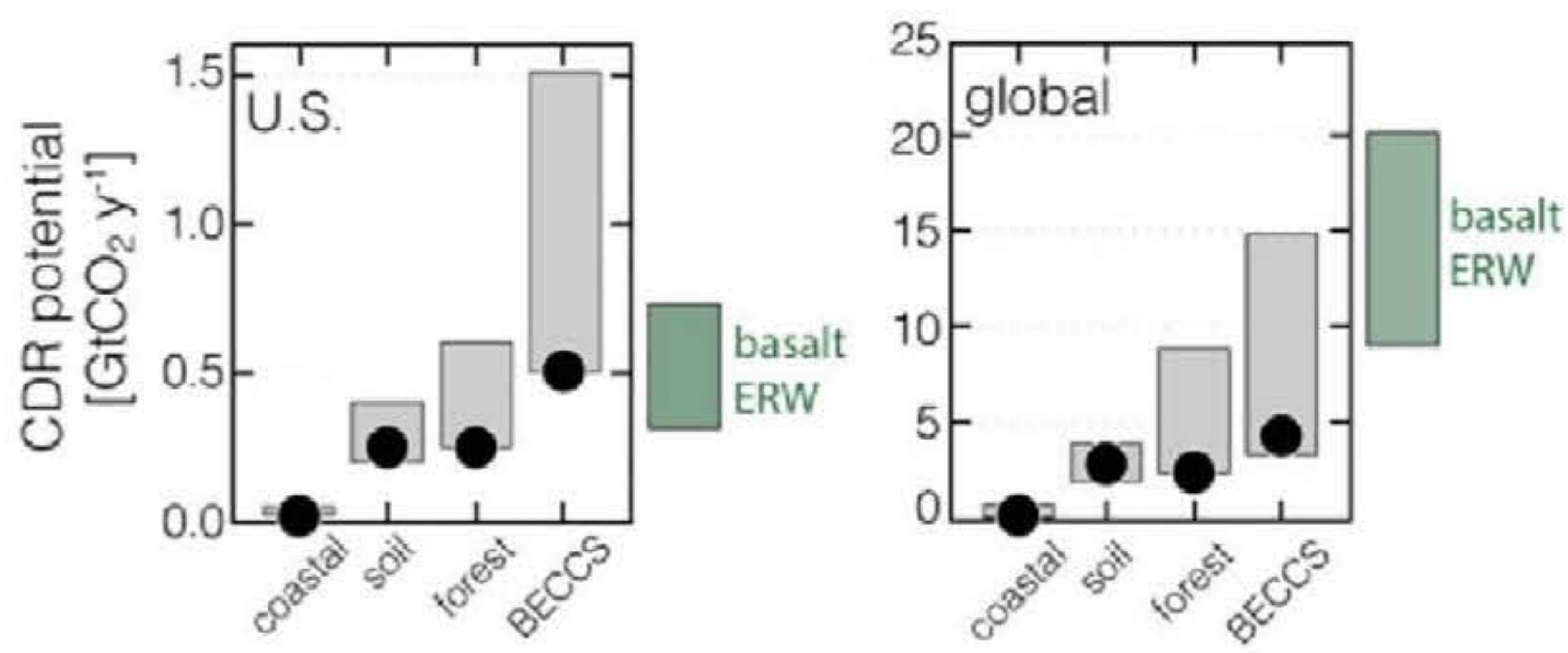


Figure 2. Regional (U.S.) and global estimates of CDR potential of enhanced rock weathering using basalt (green), compared to estim CDR for a range of other proposed approaches. Other approaches shown include sequestration in coastal "blue" carbon ("coastal"), soil ca sequestration in agricultural systems ("soil"), carbon sequestration associated with afforestation/reforestation and improved forest manager practices ("forest"), and bioenergy with carbon capture and sequestration ("BECCS"). Grey boxes show ranges for estimated CDR potential, v filled circles show values determined to be "safe" — e.g., levels of deployment that would, with high confidence, not be expected to cause adv societal, economic, and environmental impacts (Zhang et al., in press).

MATI will also provide a means to incentivize carbon emissions avoidance best practices amongst farmers such as reducing paddy-based methane emissions and negative impacts of chemical fertilizers. Deployment of ERW in the fields allows an opportunity for research on methane emissions in amended fields — which Mati is doing in collaboration with the Yale Center for Natural Carbon Capture.

Who: MATI's ongoing research is built in collaboration with Yale University's Center for Natural carbon Capture and University of Sheffield's Leverhulme Centre for Climate Change Mitigation. MATI partners with Lithos Carbon as its third-party provider for MRV. This will be the first smallholder trial where ERW will be verified through a third-party MRV provider. The team is led by Shantanu Agarwal and the project is being run by *Swaniti Initiative* which has been working with the local governments in India for more than a decade and already has ground presence in Chhattisgarh of 15 team members.

Summary: Small and marginal farmers are particularly vulnerable to lower productivity due to lack of financial ability to fertilize and irrigate. Mati provides a unique opportunity to remove carbon at scale while creating unparalleled social impact for marginal and sustenance farmers. Powered by Lithos' empirical MRV, the program then leverages existing farming distribution infrastructure to allow for marginal farmers to access Mati nutrients while earning incentives from CDR. This incentive and crop productivity enhancement provides a driving force that supports the behavioral change required for adoption. The program brings together best-in-class technology (Lithos), domain experts (researchers and governance), and local implementation expertise under the leadership of a serial entrepreneur and in a region especially conducive for ERW.

b. What is the current technology readiness level (TRL)? Please include performance and stability data that you've already generated (including at what scale) to substantiate the status of your tech.

The Mati program is at TRL-6 stage. It has already conducted pilot scale demonstration of the technology with [redacted] in 5 different rice paddy fields, two clusters of 2 farms and 3 farms respectively spread ~50 Km apart. The tests are being conducted in the Kharif (winter) crop over the period Jun 2022 to Nov 2022. The initial results from testing of the basalt are included in Appendix 1. The farms were chosen to provide a wide variety of testing environments with different soil types and pH ranges around [redacted]. The results from our modeling predict a capture efficiency of [redacted] of feedstock deployment. Further, we will be doing direct empirical tests to confirm the modeled values against actual carbon removal rates at the end of season. Those results will be available post-harvest in late November, early December 2022.

We have also conducted drainage area flow study which shows an extensive river flow network in the area and the pilot sites are in proximity of Level 4 and Level 3 streams for the dissolved inorganic carbon to flow through to the river network and into the ocean. An Omega value range of [redacted] observed for the sites with very low DIC saturation in the river networks confirming that the bicarbonate will reach the ocean to enable permanent carbon removal for >10,000 years. The Simulation Charts can be seen in Appendix 2.

We have outsourced our MRV to Lithos carbon in a first of a kind partnership to separate the project developer from the MRV provider, creating a built-in independent/unbiased layer. This data can be provided to Frontier. As new ERW methodologies are released, Mati and Lithos can also provide the data to other 3rd parties for further checks and balances. On the back of smooth initial deployments from the trial, Mati is working to onboard a large number of farmers for expansion efforts in Jan 2023 (See list in Appendix 4). We have already agreed long-term sourcing deals with our mining partners to secure basalt compositions for deployment at scale. Mati's data collection toolkit is currently in development with the first alpha expected to be out by early December 2022

c. What are the key performance parameters that differentiate your technology (e.g. energy intensity, reaction kinetics, cycle time, volume per X, quality of Y output)? What is your current measured value and what value are you assuming in your nth-of-a-kind (NOAK) TEA?

Key performance parameter	**Current observed value (units)**	**Value assumed in NOAK TEA (units)**	**Why is it feasible to reach the NOAK value?**
Enhanced Rock Weathering Efficiency	[redacted] (lab based)	[redacted] mean	The higher temperatures and waterlogged conditions of Indian rice farmland are particularly conducive to higher reaction rate as compared to USA and Europe.
Lower CO_2 footprint	[redacted]	[redacted]	Proximity of source rock to the rice paddy fields lends itself to allow for very low CO_2 footprint for distribution in the long run
Application rate	[redacted] Tonnes/Hectare]	[redacted] Tonnes/Hectare (theoretical)	Higher application rate is possible due to the faster dissolution rate of MATI in the soil. Currently we are being conservative in our application rate, to prevent reverse silicate weathering. We will optimize to increase it as we scale.

d. Who are the key people at your company who will be working on this? What experience do they have with relevant technology and project development? What skills do you not yet have on the team today that you are most urgently looking to recruit?

Shantanu is a climate tech entrepreneur with more than 20 years of industry experience leads the program. He has founded three successful startups: Susteon, Sustaera, and Hicor Technologies. Shantanu has a MBA from Harvard Business School and B. Tech in Chemical Engineering from IIT, Roorkee. Shantanu is ably supported by Swaniti team members:

Pushkar Prasun who is a Chemical Engineer from BITS Pilani and has been working in field interventions in the state of Chhattisgarh for the last 4 years. Pushkar brings deep understanding of local eco-system and government relationships and has already helped secure Chhattisgarh state agricultural department support for the program.

Rahul who is a hydro geologist with Masters in Geology from Delhi University and has work

experience in managing operations and rural development project with Swaniti. He leads the sourcing function for managing logistics and relationships with mines. He has extensive knowledge of the source rock region and grew up in this area. Satvik Sahu is a rural development expert from School of Planning and Architecture Vijaywada and has been working in Chhattisgarh in the agricultural sector with local government. He is from a rural farming family and grew up in paddy fields. He is leading the farmer engagement function and has been instrumental in convincing farmers and enrolling them to the program. The program is also supported by research collaboration with leading technologists in enhanced weathering domain namely; Dr. Noah Planavsky at Yale University, Dr. David Beerling at University of Sheffield, Dr. Chris Reinhard at Georgia Tech and Dr. Shuang Zhang at Texas A&M. We are currently hiring two personnel in Mati team; one for finance and administration, and a second to support farmer engagement. The program will also need extensive field personnel hiring as we scale to support farmer adoption and use of Mati.

e. Are there other organizations you're partnering with on this project (or need to partner with in order to be successful)? If so, list who they are, what their role in the project is, and their level of commitment (e.g., confirmed project partner, discussing potential collaboration, yet to be approached, etc.).

Partner	Role in the Project	Level of Commitment
Yale Center for Natural Carbon Capture	Soil Testing & Research Support for India, methane flux measurements	Confirmed
Leverhulme Centre for Climate Change Mitigation	Research support	Confirmed
Lithos Carbon	Partnership in India for 3rd-party SCEPTER Modelling + MRV Framework	Confirmed
Indira Gandhi Krishi Vidyalaya Raipur	Research support	Confirmed
Texas A&M	Modelling Support	Confirmed (Through Yale partnership)

f. What is the total timeline of your proposal from start of development to end of CDR delivery? If you're building a facility that will be decommissioned, when will that happen?

Feedstock deployment: 1000 Tonnes in Jan-2023; 10,000 Tonnes in Jun-2023.

CDR Delivery period: Jan-2023 to Dec-2025.

We will rent existing warehouse and distribution facilities initially so no decommissioning is required.

g. When will CDR occur (start and end dates)? If CDR does not occur uniformly over that time period, describe the distribution of CDR over time. Please include the academic publications, field trial data, or other materials you use to substantiate this distribution.

Deployment of Mati in 2023 will capture carbon over the next 24 months after application. Removal begins immediately after application but accrues through multiple growing seasons (2 to 3 years for the majority of the capture based on reactive transport modeling). Based on our research partners' trials and experiences from other regions we expect that at least 70% of the removal to occur in the first 18 months and the remaining 20% to occur in the next 12 months, given our 'extreme' weathering environment.

h. Please estimate your gross CDR capacity over the coming years (your total capacity, not just for this proposal).

Year	Estimated gross CDR capacity (tonnes)
2023	3,300
2024	[redacted]
2025	[redacted]
2026	[redacted]
2027	
2028	
2029	
2030	

We are confident in our ability to deliver the 2023 scale-up with our current mine sources and logistics plan. However, we have set aggressive targets for the future growth. We believe these to be feasible, due to the opportunity to piggy-back on the [redacted] and development and deployment of a technology stack that will allow us collect data with geo-location tracking. To deliver this vision we will have to be rapidly build infrastructure, trucking, and deployment teams, much like a number of e-commerce and logistics companies have done in India in the last few years to deploy rapidly within 1-2 years (Delhivery, Wheelseye, Blinkit, Zepto, Swiggy etc.). The context

of our deployment will be different from these companies as we are in rural farm settings, but the logistics scale-up and skill pool for managing operations will be very similar to these successful precedents. Shantanu has the requisite experience necessary for developing this tech stack having built a remote survey app and a civic participation platform for Swaniti earlier.
We are cognizant about the nature of the challenge we are undertaking, and the significant hiring and infrastructure building involved. We will be careful to ensure that our MRV and quality assurance remain sacrosanct, and we will not sacrifice the quality of our results or safety of our deployments even if we have to delay the CDR capacity growth.

i. List and describe at least three key milestones for this project (including prior to when CDR starts), that are needed to achieve the amount of CDR over the proposed timeline.

Specific to current project:

	Milestone description	**Target completion date** (eg Q4 2024)
1	Mati's data collection platform for farmer logistics and crop analytics	Q1 2023
2	Sourcing arrangements with basalt mines for 10,000 tonnes	Q4 2022
3	Farmer agreements for the 1000 Tonnes deployment	Q4 2022

In the context of the FOAK and the longer-term program objectives of scale-up, the key long-term milestones are: to build a logistics organization and infrastructure to manage >100,000 tonnes of material movement – Q2 2024; to onboard >1000 farmers on the MATI technology platform for robust data collection, verification of deployment and incentive distribution – Q4 2024; to deliver >25,000 tonnes through [redacted] – Q3 2024. (We are happy to elaborate further on our work with the [redacted] in follow-up conversation.)

j. What is your IP strategy? Please link to relevant patents, pending or granted, that are available publicly (if applicable).

Mati's MRV related IP is led by Lithos Carbon, Mati's defensibility relies on the supply partnerships, logistics, farmer and government relationships, and local knowledge. Mati is creating a database of rock types, compositions of basalt and regional spread of rice growing regions and their accessibility to basalt sources. Mati is also developing its own proprietary suite of technology tools for tracking and recommending application rates and field data collection. These efficiency tools will specifically have features for marginal farmers, including the ability to directly transfer financial incentives to farmers through an app. These technology tools will give Mati logistics and deployment advantage as it scales.

Mati has evaluated numerous basalt mines and structured two supply deals with the most favorable mines. Swaniti has a significant execution advantage, being a non-profit entity with > 10 years of rural India experience and being specially appointed as convener of Green Council by the Chhattisgarh government. The Mati program delivery through a **non-profit social development entity** helps with farmers trust and onboarding as well.

Lastly, Mati will use Lithos' independent third-party MRV and application recommendation software, SCEPTER. With Lithos' support, Mati can develop a start-to-end, science-driven approach to ERW in a unique climatology and agricultural context.

k. How are you going to finance this project?

We are currently raising grant funding for scaling up the program.

- We have basic infrastructure support from Swaniti Initiative corpus of [redacted]
- We have further received investment commitment from [redacted]
- We have a commitment for support of [redacted] from the Yale Center for Natural Carbon Capture for sponsoring early feedstock costs and in kind support while the pilot is in early pilot stage.

We are in late-stage discussions with a large foundation for a multi-year multi-million dollar grant to scale this program into multiple states in India.

A pre-purchase by Frontier fund will be catalytic in accelerating our program and its ability to deliver on the deployment schedule. It will not only provide the early capital to execute our plan for 2023 but will also provide the market signal for our foundation partners.

l. Do you have other CDR buyers for this project? If so, please describe the anticipated purchase volume and level of commitment (e.g., contract signed, in active discussions, to be approached, etc.).

We are in conversation with one large industrial player for purchase of credits. We are also in active discussions with a number of carbon market intermediaries who have expressed interest in ERW carbon removals credits purchase.

We have firm interest from a number of buyers for purchase of ERW CDR tonnes post facto (after removal has been achieved). However, we are trying to structure pre-purchase deals so that we can scale faster.

m. What other revenue streams are you expecting from this project (if applicable)? Include the source of revenue and anticipated amount. Examples could include tax credits and co-products.

During the initial scale-up period, the only revenue stream expected is from credits. However, long term, once the beneficial effect of MATI for crop productivity is established amongst the farming community, we hope to be able to get part of the cost recovery from the farmer's purchase of MATI as a fertilizer replacement.

We are also working on quantifying the avoided emissions [redacted] due to MATI under collaborative research with Yale University, University of Sheffield and Indira Gandhi Krishi Vidyalaya. Initial results in previous lab experiments at Yale show promise for significant GHG emission reductions. We expect to be able to monetize some of these emissions reductions as well in the long run to support farmers to convert to sustainable farming practices and using MATI.

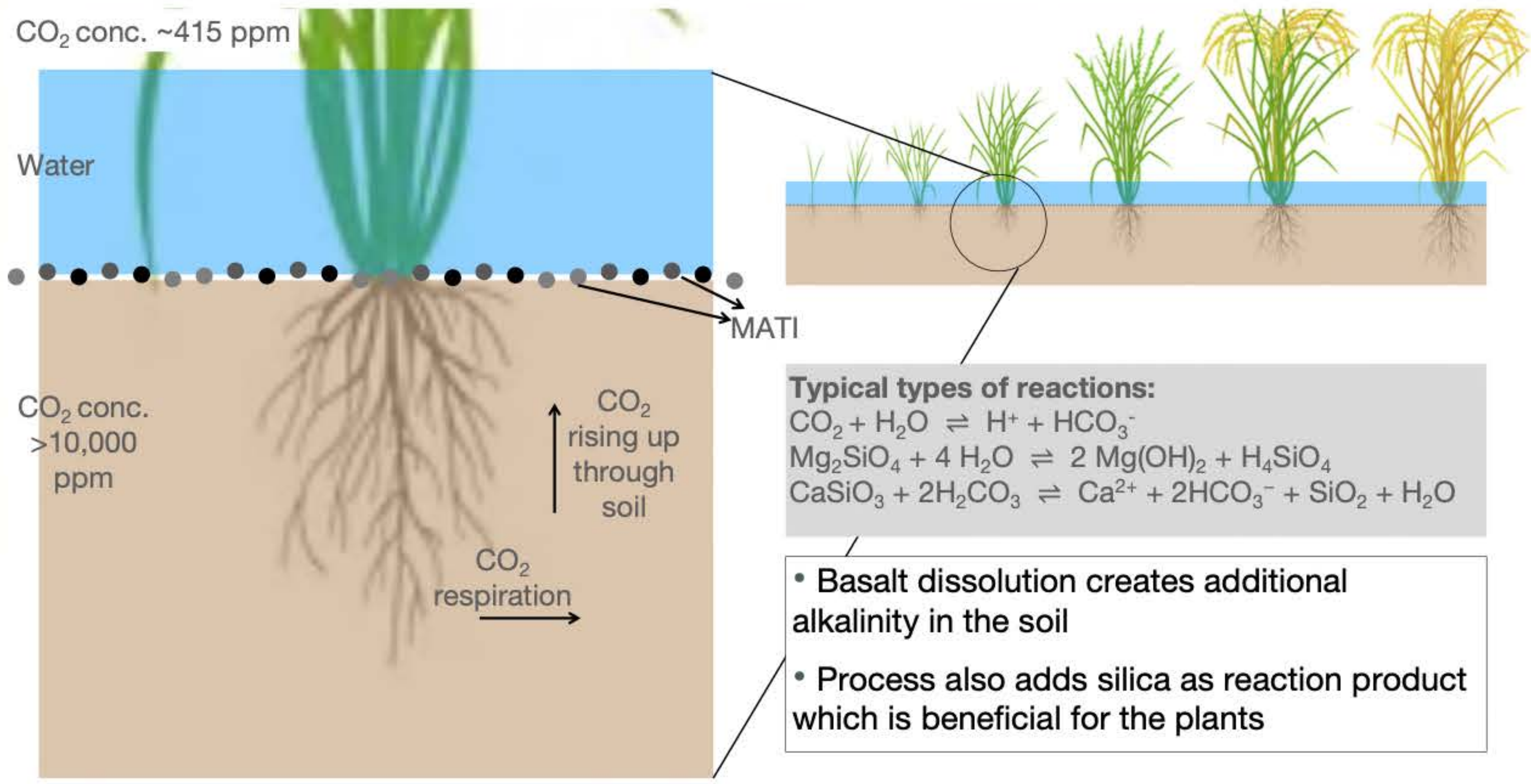
n. Identify risks for this project and how you will mitigate them. Include technical, project execution, ecosystem, financial, and any other risks.

Risk	Mitigation Strategy
Actual capture potential of basalt in rice fields in South Asian conditions	We have done laboratory tests to quantify theoretical capture efficiency, however, actual field capture efficiency per year is only going to be verified in November 2022, after we have results from the current trial. Current capture efficiency is assumed to be [redacted] of CO_2 per Ton of Basalt, based on the average chemical composition of Deccan Trap basalts. However, the final number could range between 0.25 to 0.4. Cost impact: a. higher @[redacted] of CO_2 per Ton of Basalt would reduce long term costs to [redacted] b. lower @[redacted] of CO_2 per Ton of Basalt would reduce long term costs to [redacted]
Distribution Costs uncertainty for moving the materials from the mine to the field	We have done detailed analysis of the transportation costs and accounted for the carbon emissions for fuel used in moving materials. As transportation remains one of the major cost components, its cost variability can have a large impact. We estimate an impact potential of \$10 to \$30 /ton of CO_2 removal based on fuel price movement. Long term goal would be to eliminate dependence on fossil fuel-based transportation altogether
Farmer perception of Mati as a beneficial fertilizer like substitute rather than something harmful	Mati specifically focuses on basalt as compared to olivine to avoid any harmful elements such as Chromium and Nickel entering the food chain even by mistake. Even with basalt, the marketing and messaging to the farmers as this is distributed and scaled is to be managed very carefully, so that it results in a positive reinforcing story rather than any negative stories.

2. Durability

a. Describe how your approach results in permanent CDR (> 1,000 years). Include citations to scientific/technical literature supporting your argument. What are the upper and lower bounds on your durability estimate?

Mati's approach adds basalt feedstock to rice fields in a flooded field environment. This provides for a beneficial environment for silicates to react with CO_2 to create bicarbonates. These bicarbonates flow down into riverine networks and on to oceans to create permanent removal of carbon from atmosphere. See figure below:



The permanence of carbon removal in various natural environments are as below:

Oceans (45%): 10,000+ years

Sediments (45%): 1,000,000+ years

Rivers/estuaries (10%): 5-10 years

Drainage modeling and river flow modeling shows that, almost all the carbon should end up in the oceans from our current pilot sites. As we scale the solution to different locations, Lithos can help quantify the potential leakage by running their model to determine the percentage of carbon removed ending up in the ocean. Based on regional modelling of generalized river flow networks Mati expects >90% transfer to oceans in the region. The recommendation engine may optimize regions with highest flow transfer potential and where long-term carbon removal is favored.

The upper and lower bounds of the durability are 5 years to >1,000,000 years with >90% removal being in the higher category. Refer to Paper by Kanzaki etal for more details.

b. What durability risks does your project face? Are there physical risks (e.g. leakage, decomposition and decay, damage, etc.)? Are there socioeconomic risks (e.g. mismanagement of storage, decision to consume or combust derived products, etc.)? What fundamental uncertainties exist about the underlying technological or biological process?

Physical Risks: Decomposition of DIC back to CO_2 or forward conversion to carbonate both create a removal accounting challenges. With Lithos' scientific support, our mitigation of this "geochemical" durability risk, involves using a data-constrained model to explicitly calculate downstream carbon leakage based on Lithos' MRV framework. However, the timescale over which this carbon leakage occurs is longer than the period of Frontier offer and as such has not been accounted for in Mati's quoted carbon removal figures.

Socioeconomic Risks: Not Applicable. Once Mati is spread in the field, it cannot be reversed, and

removing it is cost prohibitive. Data Collection Risks: We are designing our deployment system specifically to take into account the tracking challenges in villages and small marginal farmer settings to ensure the reporting remains accurate each time. At future scale Mati envisions an app-based data collection system, which uses geolocation of Mati deployment and soil sampling to recommend safe application rates and estimated tracking of carbon removed. However, in recognition of the user challenges for rural communities to use such an app, we plan to create an incentive system to allow for the MRV to be done correctly.

3. Gross Removal & Life Cycle Analysis (LCA)

a. How much GROSS CDR will occur over this project's timeline? All tonnage should be described in **metric tonnes** of CO_2 here and throughout the application. Tell us how you calculated this value (i.e., show your work). If you have uncertainties in the amount of gross CDR, tell us where they come from.

Gross tonnes of CDR over project lifetime	3300
Describe how you calculated that value	(From Lithos team) We calculate the value based on the tonnes of basalt spread. We can use a modified Steinour formula to estimate the CDR potential of our basalt feedstocks (CDRpot, in $kgCO_2$ per ton of feedstock) based on major oxide composition: $$CDR_{pot} = \frac{M_{CO_2}}{100} \cdot \alpha \frac{CaO}{M_{CaO}} + \beta \frac{MgO}{M_{MgO}} + \varepsilon \frac{Na_2O}{M_{Na_2O}} + \theta \frac{K_2O}{M_{K_2O}} \cdot 10^3 \cdot \eta$$ Mi terms refer to molar masses, while CaO, MgO, Na2O, and K2O refer to abundances of major oxides in the feedstock. Scaling parameters (α, , ε, θ) are pH-dependent and will have a value of 1.0 across the conditions implemented in our process. Our current feedstocks yield values of ~330 $kgCO_2$ per ton of feedstock, which is typical for basalt. We assume a CDR of 300 $kgCO_2$ per ton of feedstock. For our deployment of 11,000 tonnes of basalt feedstock yields a total gross CDR of 3300 tonnes CO_2. The carbon removal potential for a particular deployment is further validated based on the SCEPTER model using soil properties, climatic properties and basalt compositions. The model takes into account other side reactions that may inhibit or enhance the total CDR potential of the basalt applied and also takes into account the reactions rates based on the climatic conditions.

b. How many tonnes of CO_2 have you captured and stored to date? If relevant to your technology (e.g., DAC), please list captured and stored tonnes separately.

Five hundred Kilograms based on a conservative estimate. We will have removed >2 tonnes by year end. (Based on spreading of 20 Tonnes basalt)

c. If applicable, list any avoided emissions that result from your project. For carbon mineralization in concrete production, for example, removal would be the CO_2 utilized in concrete production and avoided emissions would be the emissions reductions associated with traditional concrete production. Do not include this number in your gross or net CDR calculations; it's just to help us understand potential co-benefits of your approach.

Addition of basalt results in a reduction in the emission of CH_4 and N_2O from rice farming. Quantification of this potential emission reduction is still being studied and tested in our laboratory and field experiments. On average [redacted] GHG emissions are emitted from each hectare of rice farmland annually.

Furthermore, addition of Mati enables farmer to reduce use of conventional NPK fertilizers. Global synthetic N fertilizer supply chain was responsible for ~1.13 $GtCO_2e$ in 2018. Use of Mati with vermicompost can reduce use of synthetic N-fertilizers.

Reduction in use of chemical fertilizers also reduces the nutrient run-off problem which is causing large scale ecosystem destruction due to algal blooms and water body destruction in farming areas.

Other co-benefits include increased crop productivity and yield potential for the farmer due to improved resistance to pests, drought and salinity due to release of plant available silica and re-building of top-soil.

d. How many GROSS EMISSIONS will occur over the project lifetime? Divide that value by the gross CDR to get the emissions / removal ratio. Subtract it from the gross CDR to get the net CDR for this project.

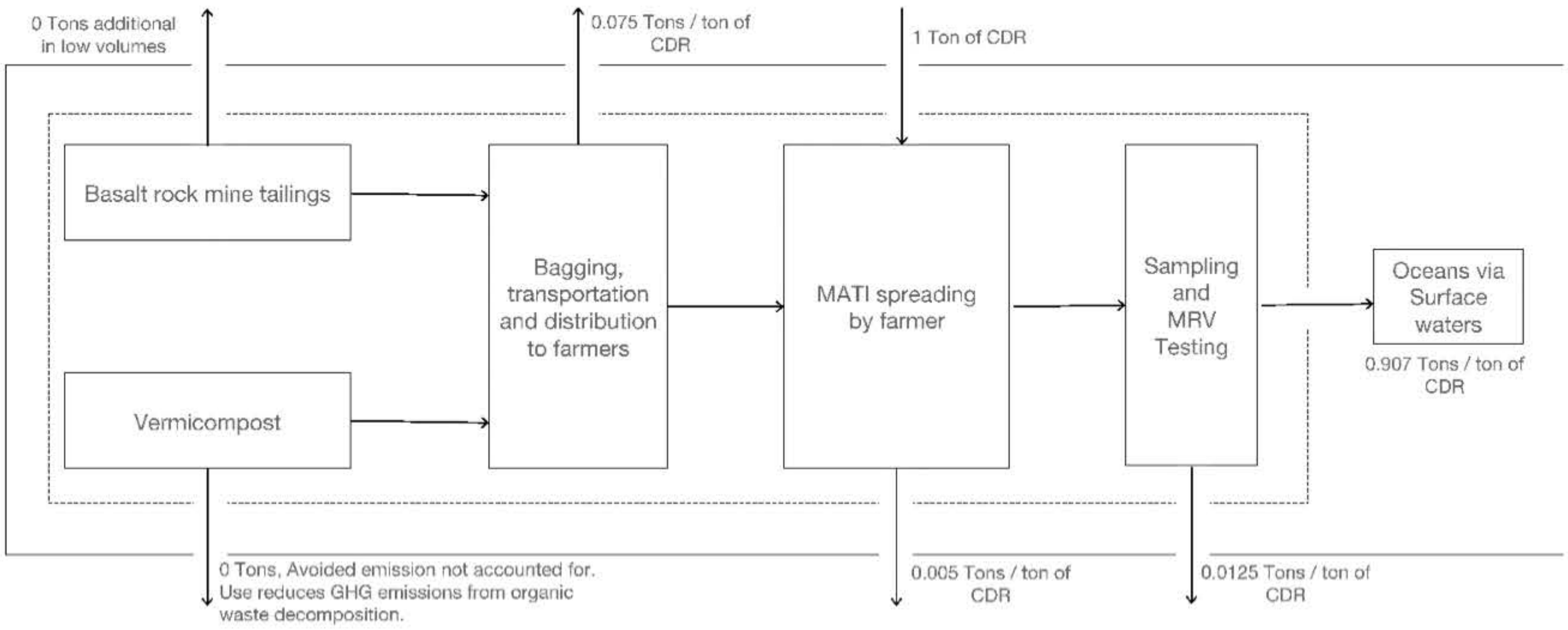
Gross project emissions over the project timeline *(should correspond to the boundary conditions described below this table)*	305.3 Tonnes
Emissions / removal ratio *(gross project emissions / gross CDR–must be less than one for net-negative CDR systems)*	0.0907
Net CDR over the project timeline *(gross CDR - gross project emissions)*	2994.69 Tonnes

e. Provide a process flow diagram (PFD) for your CDR solution, visualizing the project emissions numbers above. This diagram provides the basis for your life cycle analysis (LCA). Some notes:

- The LCA scope should be cradle-to-grave
- For each step in the PFD, include all Scope 1-3 greenhouse gas emissions on a CO_2 equivalent basis
- Do not include CDR claimed by another entity (no double counting)
- For assistance, please:

- ○ Review the diagram below from the CDR Primer, Charm's application from 2020 for a simple example, or CarbonCure's for a more complex example
- ○ See University of Michigan's Global CO_2 Initiative resource guide
- If you've had a third-party LCA performed, please link to it.

Please see below the cradle to grave LCA for the 2023 deployments:



We have also done the work for long-term LCA estimate, for the full scale-up scenarios. This can be seen in Appendix 3

f. Please articulate and justify the boundary conditions you assumed above: why do your calculations and diagram include or exclude different components of your system?

> Initial boundary conditions include transport emissions from mines to the fields and spreading in the fields. As we are utilizing waste mine tailings we do not have additional processing or grinding, so emissions for feedstock sourcing are negligible at this scale (See appendix 3 for NOAK).
>
> Our MRV related emissions are high due to mailing of samples to Yale for testing, which is necessary to prove scientific efficacy. In the future these emissions will be lowered by adding local lab facilities with Lithos' support.
>
> We do not account for avoided emissions [redacted] or vermicompost use at this time.

g. Please justify all numbers used to assign emissions to each process step depicted in your diagram above. Are they solely modeled or have you measured them directly? Have they been independently measured? Your answers can include references to peer-reviewed publications, e.g. Climeworks' LCA paper.

Process Step	**CO_2(eq) emissions over the project**	**Describe how you calculated that number. Include references where appropriate.**

	lifetime (metric tonnes)	
Feedstock sourcing	0	The feedstock is currently produced as a waste product from the aggregate mining industry. Hence we do not add any new energy or emissions for making them.
Bagging, transportation and distribution to farmers	247.5 Tonnes	We have assumed a travel [redacted] for delivery of the feedstock by truck. This is a conservative distance for the current demonstration based on our experience during the pilot trial. In the long term we expect this to be reduced significantly by at least a two-thirds. (Ref: ICCT, Fuel Consumption standards, for light commercial vehicles in India)
Mati spreading by farmer	16.5 Tonnes	This emission is calculated based on a [redacted] driving with tractor trailer to spread Mati based on our experience in the field. (Ref: ICCT, Fuel Consumption standards for Heavy duty vehicles in India)
MRV and Lab testing	41.3 Tonnes	This assumes the air transportation related emissions for samples that have to be sent to USA in an initial pilot stage to confidently prove scientific efficacy. (Ref.: https://www.icao.int/environmental-protection/Carbonoffset/Pages/default.aspx)

4. Measurement, Reporting, and Verification (MRV)

Section 3 above captures a project's lifecycle emissions, which is one of a number of MRV considerations. In this section, we are looking for additional details on your MRV approach, with a particular focus on the ongoing quantification of carbon removal outcomes and associated uncertainties.

a. Describe your ongoing approach to quantifying the CDR of your project, including methodology, what data is measured vs modeled, monitoring frequency, and key assumptions. If you plan to use an existing protocol, please link to it. Please see Charm's bio-oil sequestration protocol for reference, though note we do not expect proposals to have a protocol at this depth at the prepurchase stage.

Mati is partnering with Lithos Carbon to use empirical MRV for initial pilots at this prepurchase stage. (Discussion can begin for how MRV can be done (without high sample mailing emissions) for long-term offtake stages.) Today's measured approach takes physical soil samples to quantify the level of basalt dissolution. This approach builds from extensive work tracking the extent of weathering in modern soils. The Lithos team has previously done MRV for their academic partners' rice studies in academic settings. Testing this in real-world settings is a hurdle that must be cleared in order to provide ERW access to ricegrowers.

The Lithos approach starts with a measurement of the extent of basalt weathering from soil samples. This is achieved by measuring the abundance of trace and major elements in each bulk soil sample. Lithos uses an immobile trace element to establish the amount of basalt relative to soil, and calculate the difference between measured and predicted major element composition to establish the fraction of applied basalt that has been removed through weathering (and thus the extent of CDR). Lithos utilize an isotope dilution method wherein an isotope spike 'cocktail' is added to the soil sample. Elemental analysis is conducted using an inductively coupled plasma mass spectrometer method to reduce measurement error. For each unique field deployment, soil samples are collected and the process is repeated.

Lithos' approach eliminates the need for continuous rate monitoring because it is a time-integrated look at weathering rates. The measurement will be done every year to directly quantify annual integrated carbon removal. Lithos' empirical method of tracking CDR rates — which relies only on mass balance — works for any row crop system that is not directly formed on basalt. (We are happy to elaborate further on this including consultation with our partner Lithos team -Mary Yap, Dr. Reinhard, and Dr. Planavsky).

b. How will you quantify the durability of the carbon sequestered by your project discussed in 2(b)? If direct measurement is difficult or impossible, how will you rely on models or assumptions, and how will you validate those assumptions? *(E.g. monitoring of injection sites, tracking biomass state and location, estimating decay rates, etc.)*

Mati will measure the durability of CDR occurring in rice paddies using the Lithos Carbon MRV approach. With some additional India-focused research investment from Lithos, output on the extents of weathering in the Mati field deployments could be fed into Lithos' dynamic river network that is coupled to an ocean carbon cycle model. Today, these stages track the products of enhanced weathering in surface waters and in the oceans on a decadal to thousand-year time scale: it tracks the export of water from the weathering zone into surface waters after passing through a soil column, as a river enters the surface ocean, and as weathering products are transported and stored in the oceans over out to 1,000-year timescales.

The frameworks already works in America, and successful deployments by Mati will provide a template for research, adaptation and deployment for other regions. The *Lithos* model pipeline allows for a comprehensive, robust "cradle-to-grave" assessment of carbon capture permanence out to thousand-year timescale

c. This tool diagrams components that we anticipate should be measured or modeled to quantify CDR and durability outcomes, along with high-level characterizations of the uncertainty type and magnitude for each element. We are asking the net CDR volume to be discounted in order to account for uncertainty and reflect the actual net CDR as accurately as possible. Please complete the table below. Some notes:

- In the first column, list the quantification components from the Quantification Tool relevant to your project (e.g., risk of secondary mineral formation for enhanced weathering, uncertainty in the mass of kelp grown, variability in air-sea gas exchange efficiency for ocean alkalinity enhancement, etc.).
- In the second column, please discuss the magnitude of this uncertainty related to your project and what percentage of the net CDR should be discounted to appropriately reflect these uncertainties. Your estimates should be based on field measurements, modeling, or scientific literature. The magnitude for some of these factors relies on your operational choices (i.e., methodology, deployment site), while others stem from broader field questions, and in some

cases, may not be well constrained. We are not looking for precise figures at this stage, but rather to understand how your project is thinking about these questions.

- See this post for details on Frontier's MRV approach and a sample uncertainty discount calculation and this Supplier Measurement & Verification Q&A document for additional guidance.

Quantification component Include each component from the Quantification Tool relevant to your project	**Discuss the uncertainty impact related to your project** Estimate the impact of this component as a percentage of net CDR. Include assumptions and scientific references if possible.
Mati deployment amounts	The amount of feedstock deployed is one of the easier things to track. However, the location and amount deployed in a marginal-distributed-farm scenario makes MRV validation difficult. Recognizing this, we hope to [redacted] to verify carbon removal calculations based on deployment locations. [Percentage impact: 100%]
Soil and water conditions measurement	Soil and water conditions measurement will be important to validate SCEPTER model results for understanding the risk of secondary reactions. This will be done on a sampling basis by our field team in the regions where we deploy to verify assumptions of our calculations. [Percentage impact: 100%]
Downstream leakage of bicarbonate	Some downstream leakage of of bicarbonate to CO_2 will happen for this pathway. However, based on our calculations the risk of significant back conversion is very low. Catchment alkalinity fluxes and biogeochemistry models suggest that in the India context this leakage will be [redacted]

d. Based on your responses to 4(c), what percentage of the net CDR do you think should be discounted for each of these factors above and in aggregate to appropriately reflect these uncertainties?

Risk 1 & 2: For this project ZERO due to high-touch, high-sampling density and field presence. Risk 3: This remains at [redacted] Based on simulation of alkalinity in riverine networks we believe that very limited off-gassing will occur downstream and most of carbon should reach the ocean where it will be sequestered for >10,000 years.

e. Will this project help advance quantification approaches or reduce uncertainty for this CDR pathway? If yes, describe what new tools, models or approaches you are developing, what new data will be generated, etc.?

Yes, the project will advance the field of ERW CDR significantly. The field of ERW is nascent in the field of application for small landholder farmers or rice paddies as only limited small scale studies have been conducted to date. This will be the first time rice paddies will use ERW at scale and deliver

carbon removal using a scientific robust MRV process. Furthermore, the application of basalt feedstock in India context is entirely new, and has not been tried before. The project will allow for scale-up of the methodology in a developing country context and begin to demonstrate/unpack feasibility and challenges for other countries/markets to follow suit.

Mati will also for the first time apply a third party MRV in the context of ERW. With its MRV partner Lithos Carbon, and with initial research funding to support higher-density confidence building, Mati will begin to report how such a MRV framework may be adapted to be conducive for application in small farmland context and with rice paddies.

Mati will also develop a logistics, and data collection model that will allow for scaling of MRV (geolocation and accountability) with small landholder farmers. The system will create incentives to report quantity and quality deployment metrics and allow for distributed verification.

Lastly, Mati will also collect data for feedstock compositions from across the region to create a characterization map for optimizing source and deployment efficiencies to maximize carbon removal. This dataset over long-run would be an indispensable part of a technology tool-kit developed by Mati and provided to the farmers for deployment.

f. Describe your intended plan and partners for verifying delivery and registering credits, if known. If a protocol doesn't yet exist for your technology, who will develop it? Will there be a third party auditor to verify delivery against that protocol or the protocol discussed in 4(a)?

The protocol for ERW is still being developed by multiple organizations at this time. We are in touch with Ithaka Institut and South Pole who are independently developing methodologies for ERW. We expect in the long-run to follow these methodologies and adapt them into the existing Lithos MRV framework (who are also independently collaborating with other methodology organizations).

The model used by Mati, where a third party MRV provider Lithos will independently verify the carbon removal, lends itself well to add a check and balance, in this stage. This is a first trial of this model.

5. Cost

We are open to purchasing high-cost CDR today with the expectation the cost per tonne will rapidly decline over time. The questions below are meant to capture some of the key numbers and assumptions that you are entering into the separate techno-economic analysis (TEA) spreadsheet (see step 4 in Applicant Instructions). There are no right or wrong answers, but we would prefer high and conservative estimates to low and optimistic. If we select you for purchase, we'll work with you to understand your milestones and their verification in more depth.

a. What is the levelized price per net metric tonne of CO_2 removed for the project you're proposing Frontier purchase from? This does not need to exactly match the cost calculated for "This Project" in the TEA spreadsheet (e.g., it's expected to include a margin), but we will be using the data in that spreadsheet to consider your offer. Please specify whether the price per tonne below includes the uncertainty discount in the net removal volume proposed in response to question 4(d).

[redacted]

b. Please break out the components of this levelized price per metric tonne.

Component	Levelized price of net CDR for this project ($/tonne)
Capex	[redacted]
Opex (excluding measurement)	[redacted]
Quantification of net removal (field measurements, modeling, etc.)[2]	[redacted]
Third party verification and registry fees (if applicable)	[redacted]
Total	[redacted](should match 5(a))

c. Describe the parameters that have the greatest sensitivity to cost (e.g., manufacturing efficiencies, material cost, material lifetime, etc.). For each parameter you identify, tell us what the current value is, and what value you are assuming for your NOAK commercial-scale TEA. If this includes parameters you already identified in 1(c), please repeat them here (if applicable). Broadly, what would need to be true for your approach to achieve a cost of $100/tonne?

Parameter with high impact on cost	Current value (units)	Value assumed in NOAK TEA (units)	Why is it feasible to reach the NOAK value?
Sourcing & Logistics Costs	[redacted]	[redacted]	We are currently deploying near the capital city for ease of monitoring and deployment. Hence our trucks have to travel [redacted] At scale we will have a distributions network of rail and low cost transportation and will also focus on areas which are within 50km range of the source to significantly reduce the costs.
MRV	[redacted]	[redacted]	We are currently shipping the samples to USA for testing which adds to cost. Furthermore, we are also doing

[2] This and the following line item is not included in the TEA spreadsheet because we want to consider MRV and registry costs separately from traditional capex and opex.

			significantly higher density testing, almost sampling every field. We will be able to reduce costs by localizing the testing lab in India over the long run and also reduce sampling density with improved sampling models.
Operations Cost	[redacted]	[redacted]	Currently we are a top-heavy organization with mostly management costs and fewer field personnel. As field personnel start dominating the head-count for Mati, the costs will significantly reduce. Furthermore, the use of technology tools to collect and verify data will allow us to reduce the high-touch nature of our engagement that we are planning at the beginning and be able to reduce density of our field operatives.
Capex	[redacted]	[redacted]	Currently our capex cost per tonne is high as we are sub-scale and are using a capex cost factor of 15% per annum. At full scale we can use a 7% capex cost factor and also benefit from scaling. The capex costs are mostly related to establishment of trucking and distribution infrastructure.

d. What aspects of your cost analysis are you least confident in?

Operational Costs: We are confident that the operational costs per tonne will be significantly reduced as the field head-count increases. However, we have assumed that the high-touch model (where we deploy one field associate for 40 farmers) is lowered to low-touch technology enabled model (where we deploy one field associate for every 200 farmers) as the technology stack gets implemented. This will need to be tested in live trials to ensure that the quality of data collection does not deteriorate. We may end up having to retain a higher density of 1:100 say, in case the technology requires more intervention. In the worst case if we have to retain the field associate density of 1:40, the costs for Operations increases to $39.84/tonne at full scale and adds ~$19/tonne to the costs.

Sourcing and Logistics cost: We have assumed a trucking cost based on fuel costs of moving [redacted] for each tonne. As we scale we have assumed the distribution logistics and rail support will allow for our average trucking distance to be [redacted]. The distribution center logistics could cause variations in this number based on our final implementation. Similarly the trucking costs (which are based on current trucking vendor quotes) will also move if fuel prices move significantly. In long-run we hope to implement a hydrogen/electric truck fleet to move materials, which has potential to significantly reduce costs of trucking and also reduce the carbon footprint of the operation.

e. How do the CDR costs calculated in the TEA spreadsheet compare with your own models? If there are large differences, please describe why that might be (e.g., you're assuming different learning rates, different multipliers to get from Bare Erected Cost to Total Overnight Cost, favorable contract terms, etc.).

Our own models give us a number which is not too far from the TEA spreadsheet for the current project and FOAK. [redacted] including MRV cost as compared to [redacted]

However, our NOAK cost are significantly lower than calculated by the spreadsheet. This may be due to the following reasons:

- This is not a typical EPC project and the capex costs are mostly attributed towards logistics infrastructure creation. The TEA model treats it like an industrial plant building EPC project.
- The reduction in cost of operational personnel due to implementation of technology does not figure in the FOAK and only is accounted for in NOAK
- The Sourcing and trucking cost at NOAK scale will allow for reduction in average distances traveled which are not accounted for in FOAK.

Our NOAK cost per ton is [redacted]/tonne as compared to [redacted] from the TEA spreadsheet.

f. What is one thing that doesn't exist today that would make it easier for you to commercialize your technology? (e.g., improved sensing technologies, increased access to X, etc.)

Large-scale availability and adoption of hydrogen/electric trucks charged on renewable electricity could reduce our costs of trucking significantly and also reduce the carbon footprint from trucking which is ~80% of our emission footprint.

6. Public Engagement

In alignment with Frontier's Safety & Legality criteria, Frontier requires projects to consider and address potential social, political, and ecosystem risks associated with their deployments. Projects with effective public engagement tend to:

- Identify key stakeholders in the area they'll be deploying
- Have mechanisms in place to engage and gather opinions from those stakeholders, take those opinions seriously, and develop active partnerships, iterating the project as necessary

The following questions help us gain an understanding of your public engagement strategy and how your project is working to follow best practices for responsible CDR project development. We recognize that, for early projects, this work may be quite nascent, but we are looking to understand your early approach.

a. Who have you identified as relevant external stakeholders, where are they located, and what process did you use to identify them? Please include discussion of the communities potentially engaging in or impacted by your project's deployment.

Swaniti Initiative has been working in Chhattisgarh for over four years, and in the process, we have had the opportunity to develop deep connections within the community, with a key focus on farmers. Mati has been developed after detailed conversations with farmers through formal interviews, and focus group discussions. Additionally, our team members who are embedded in the community have also mindfully sought feedback from farmer partners for village selection and development of strong program design.

Our prime stakeholders are these farmers, and their respective cooperatives, village governance bodies ("Panchayats") and regional agricultural departments of the state government. We have carefully and thoughtfully engaged with all these stakeholders, including the state government to create buy-in and understanding at all levels. As this program is being deployed, we are continuing to have regular conversations to address concerns, educating the farmers on the science and benefits of ERW and gathering feedback, identifying potential misunderstandings, and allaying fears early. This approach has enabled our current partner farmers to bring in other farmers through word of mouth and given us insights into different farming practices that we can adapt our model to and optimize. For example, Swaniti has been holding regular meetings through the Gram Panchayat (village assembly) to assess the ongoing interest level of farmers.

Our stakeholder for feedstock sourcing are mining suppliers who have the lowest carbon footprint to transport to target farmlands. We have surveyed the potential mining partners and their location and operations to carefully select two partners for our current deployment. We are creating a database of such suppliers with feedstock composition to allow for future optimization of sources and deployment locations for carbon footprint minimization.

As we scale, we will continue to increase our engagement with government and farming communities to build brand recognition and trust for ERW. We also plan to leverage existing community distribution systems for deployment of the feedstock.

b. If applicable, how have you engaged with these stakeholders and communities? Has this work been performed in-house, with external consultants, or with independent advisors? If you do have any reports on public engagement that your team has prepared, please provide. *See Project Vesta's community engagement and governance approach as an example and Arnestein's Ladder of Citizen Participation for a framework on community input.*

Mati is being initially deployed with small farmers with <2 to 5 hectares of land in rural Chhattisgarh. We choose villages based on farmer conversations, input from the regional agricultural department of the state government, and Panchayat officials and accounting for the distance from feedstock source. Our engagement starts with group meetings with rural farmers in each of these villages to educate the farmers of the program and seek volunteers who would like to try the program, we also take soil samples from the farms to ensure applicability at this time. In our initial trials we have also created risk profiles of farmers to understand their relative ability to take risk and experiment with new ideas. As we prove the efficacy and performance with the early adopters in a season, we make it available to all farmers in the subsequent season.

In the initial 2 years we plan to offer Mati as a fully subsidized soil amendment that is free to the farmer and at their option to add. This largely subsumes the risk of a negative outcome as the farmer is not paying anything extra for the feedstock and may in fact benefit from increased productivity and pest resilience.

Throughout this process we have not used any external consultants for engaging with stakeholders. All this work is performed in-house by Swaniti – Mati staff. Our farmer partners have become our biggest advocates and we hope to leverage that as we scale our public engagement. We plan to create a formal community engagement strategy as we scale and will utilize external consultants as needed.

c. If applicable, what have you learned from these engagements? What modifications have you already made to your project based on this feedback, if any?

Through the experience of the last four years, we know that small land holding farmers are living on basic sustenance and are generally risk averse. They have limited exposure or awareness about carbon markets and the prospects of improving their farming practices. Introducing these new CDR concepts will require a significant amount of social trust building and education of these farmers for them to accept this new method and get comfortable about the perceived risk to their crops. However, through our discussions we have learned that these sustenance farmers have had experience of NGOs and government bodies bringing in new varieties of seeds and fertilizers in the past. Because the interventions have yielded them success, Swaniti is leveraging this learning for Mati program, as we work through regional agricultural officers, government departments and village gram panchayats to provide the assurances and trust needed for adoption. We have already seen this modus operandi work for enrollments for our next scale-up in January-2023.

d. Going forward, do you have changes to your processes for (a) and (b) planned that you have not yet implemented? How do you envision your public engagement strategy at the megaton or gigaton scale?

As we scale to megaton scale, we plan to partner with other NGOs working to uplift farmers. We would also like to bring the emissions reduction benefits of the feedstock amendments to the farmers for [redacted] reduction. We would engage with the government at a deeper level by partnering with the government supported village self-help groups to become the education and information dissemination partner and reach the last marginal farmer in the state. We also plan to expand into other states into India and adapt our engagement strategy based on the local needs. All through these expansion efforts, we will disseminate the results of crop productivity improvement, continued sampling of plant tissue and soil to showcase benefits and bring trust and transparency to all stakeholders.

7. Environmental Justice[3]

As a part of Frontier's Safety & Legality criteria, Frontier seeks projects that proactively integrate environmental and social justice considerations into their deployment strategy and decision-making on an ongoing basis.

a. What are the potential environmental justice considerations, if any, that you have identified associated with your project? Who are the key stakeholders? Consider supply chain impacts, worker compensation and safety, plant siting, distribution of impacts, restorative justice/activities, job creation in marginalized communities, etc.

[3] For helpful content regarding environmental justice and CDR, please see these resources: C180 and XPRIZE's Environmental Justice Reading Materials, AirMiners Environmental and Social Justice Resource Repository, and the Foundation for Climate Restoration's Resource Database

Climate change is having devastating effects on small land holding farmers. They are one of the most marginalized and vulnerable segments of the population in India. However, the climate discourse rarely speaks about the plight of these farmers. Majority of the conversation focuses on urban areas and leaves out the concerns of rural farmers. Even government policies relating to agriculture incentives have structurally benefited the rich farmers rather than the marginal farmer.

Mati program aims to address this injustice by focusing on these marginalized communities. Our program is being implemented in a state with >80% marginal farmers. These farmers are placed in the mining belt in Eastern India. If these farmers are not provided with economic opportunities, then in the face of climate impact, it is likely that they will turn to the mining industries for livelihood. Mati program maintains undertones of a Just Transition movement, by improving economic value and viability within the agricultural sector for these marginal farmers. We recognize that environmental injustices are not just focused on economically weaker sections but also that there are little to no efforts being made to raise them out of the poverty cycle through innovative technologies.

b. How do you intend to address any identified environmental justice concerns and / or take advantage of opportunities for positive impact?

The Mati program can have transformative impact to help uplift and improve earnings of vulnerable communities being affected most by climate. Specifically, small land holding farmers (who primarily come from tribal and minority community) very rarely have the opportunity to have economic gains while addressing key environmental issues.

Over the last two years, Swaniti has reached out to farmers working in the [redacted] to understand their perspective in depth. Pressing concerns have included the [redacted] to address effects of changing climate on crops, reducing yield and dropping income levels. Through our conversations, we have recognized that the climate solution must go hand-in-hand with an economic solution. Environmental justice can only take place for farmers when they are able to deliver higher yield and increase income levels.

Therefore, the Mati program has been designed to provide means of crop productivity increment without additional costs to these farmers. This will boost income levels for these farmers, creating a transfer of value enabled by carbon removal and avoided emissions for the farmer and improve food security. Our estimates indicate a potential of 25% to 33% increased annual income for these vulnerable farmers from the adoption of Mati program through incentives, cost reduction and improved productivity.

Mati also reduces chemical fertilizer use and potential nutrient run-offs that have been extremely difficult to manage and have been polluting water bodies and entering food systems. This co-benefit provides for better health outcomes for these communities who depend on the water bodies currently being polluted by the nitrogen run-offs.

8. Legal and Regulatory Compliance

a. What legal opinions, if any, have you received regarding deployment of your solution?

We have not taken any legal opinion in the matter at this stage. We do not believe there to be any aspect at this stage which needs a legal opinion.

b. What permits or other forms of formal permission do you require, if any, to engage in the research or deployment of your project? What else might be required in the future as you scale? Please clearly differentiate between what you have already obtained, what you are currently in the process of obtaining, and what you know you'll need to obtain in the future but have not yet begun the process to do so.

The movement of feedstock requires issuance of a certificate for transportation, which can be issued by the supplier and provided to the transport company. We do not need any other specific permit for the deployment of Mati, which we have already done in our pilot trials in 5 farms earlier this year. Ground basalt is already an approved soil amendment by Organic Materials Review Institute (OMRI), which regulates products for use in certified organic growing operations under the USDA National Organic Program. We are working with the local Agricultural University to conduct trials and release an official application feasibility memo for use of basalt in agriculture for the state. This will further boost confidence in the methodology and allow for adoption.

However, in order to sell at scale we expect to become compliant to one of the forthcoming VCS methodologies for ERW. We will leverage an intermediary to audit and certify us according to the methodology. In the long-run we also hope to leverage emissions reduction credits for methane and nitrous oxide reductions from the addition of Mati, which will need its own certification for the voluntary carbon markets

c. Is your solution potentially subject to regulation under any international legal regimes? If yes, please specify. Have you engaged with these regimes to date?

India is party to the Convention on Biological Diversity (CBD), an international protocol associated with the United Nations Environment Programme (UNEP). There is some consideration for larger scale geoengineering in the convention, however no mention of ERW. We do not see that to be relevant at this stage and have not engaged with any regimes.

d. In what areas are you uncertain about the legal or regulatory frameworks you'll need to comply with? This could include anything from local governance to international treaties. For some types of projects, we recognize that clear regulatory guidance may not yet exist.

Currently there is no legal or regulatory framework specific to ERW in India. Existing environmental guidelines for air, water, material handling, pollution in the country provide a framework for maintaining minimal negative environmental impact of ERW deployment

e. Do you intend to receive any tax credits during the proposed delivery window for Frontier's purchase? If so, please explain how you will avoid double counting.

We do not plan to receive any tax credits for the proposed window.

9. Offer to Frontier

This table constitutes your **offer to Frontier**, and will form the basis of contract discussions if you are selected for purchase.

Proposed CDR over the project lifetime (tonnes) *(should be net volume after taking into account the uncertainty discount proposed in 4(c))*	[redacted]
Delivery window *(at what point should Frontier consider your contract complete? Should match 1(f))*	Jan 2023 to Dec 2025
Levelized Price (\$/metric tonne CO_2) *(This is the price per tonne of your offer to us for the tonnage described above)*	[redacted] This offered price is higher than the results from the TEA as it contains contingencies for a number of uncertainties in the cost of transportation and application, and also accounts for farmer incentives)

Application Supplement: Surface Mineralization and/or Enhanced Weathering

(Only fill out this supplement if it applies to you)

Source Material and Physical Footprint

1. What source material are you using, and how do you procure it?

> Our source feedstock is composed of natural basalt rock dust. Current feedstock sources include mines in the [redacted]. We have collaboration with [redacted] which produce our feedstock as waste material in their aggregate production business. We have tested and sourced feedstock materials from these suppliers for our pilot and have agreed long term sourcing from them. We are also in conversation with several other mines in the area to source feedstock as we scale.

2. Describe the ecological impacts of obtaining your source material. Is there an existing industry that co-produces the minerals required?

> Our feedstock has minimal ecological impact as it is a waste material produced during the aggregate production used in the construction industry. The basalt is mined from the significant deccan traps and aggregate is produced in various sizes to satisfy the road and building construction industry. The Mati feedstock is a waste material produced during this manufacturing process

3. Do you process that source mineral in any way (e.g., grinding to increase surface area)? What inputs does this processing require (e.g. water, energy)? You should have already included their associated carbon intensities in your LCA in Section 3.

> We do not process our source material currently. This minimizes the carbon footprint and also eliminates any need for water/energy for the process (see LCA). However, as we continue our experimental work, we may eventually change the particle size of our distributed materials or add additional materials to our mixture to improve effectiveness as a crop productivity enhancer and net carbon removal. If such a change is made, the total energy required for reducing particle size by grinding should increase the carbon removal by at least the additional carbon footprint created by such activity for such an activity to be pursued.

4. Please fill out the table below regarding your project's physical footprint. If you don't know (e.g. you procure your source material from a mining company who doesn't communicate their physical footprint), indicate that in the table below.

	Land area (km^2) in 2021	Competing/existing project area use (if applicable)
Source material mining	N/A (Material is a waste product from existing mines that produce aggregates. Current contracted mines and aggregate facilities have areas of ~2km^2)	N/A
Source material processing	There is no additional processing area required. It occurs as part of the aggregate production process.	N/A
Deployment	[redacted]	Non-competitive – land use will remain agricultural with same crops.

5. How much CDR is feasible globally per year using this approach? Please include a reference to support this potential capacity.

Globally there is 4.62 Billion acres of land under active farming according to USGS. India has 9.6%, U.S. follows at 8.9%, then China at 8.8%. In areas which has basalt within accessible distance of farmlands, this approach can be easily applied. This analysis has been done in details by Beerling etal in the 2020 paper in Nature. The paper concludes that a global potential of between 0.5 gigatonnes to 2 gigatonnes per annum is possible using this approach. The specific potential in India is between 0.25 gigatonnes and 1.0 gigatonnes per annum according to the same paper.

6. If you weren't proceeding with this project, what's the alternative use(s) of your source material? What factors would determine this outcome?

There are limited alternative uses for our feedstock today. It is currently either left on site as waste product or is utilized and sold for low value as a filler material to be used instead of soil, sand or mud. Our project provides a utilization path for this waste material that can be highly valuable to local agriculture and climate impact.

Human and Ecosystem Impacts, Toxicity Risk

7. What are the estimated environmental release rates of heavy metals (e.g. Cr, Ni, Pb, Hg)? Dust aerosol hazards? P loading to streams? How will this be monitored?

Release rates of heavy metals can be a significant problem for rocks with abundance of those elements. Basalt compositions in the Deccan trap have very low concentration of such heavy metals. We test all our basalt source mines for compositions before sourcing from them to verify for this very problem. We are also collaborating with local agricultural university IGKV and Yale CNCC to actively test soil samples to further verify these assumptions on actual field applications.

P concentration of feedstock material is very low, hence ERW cannot cause any P loading of streams.

The basalt dust hazard was non-existent in our pilot applications in the region, as the feedstock is typically lightly water wet and kept that way through its transportation to final application. We typically have [redacted] in the feedstock as it makes basalt easy to handle and for transportation. On the application site, the feedstock goes into rice paddy fields which are typically also very wet or fully flooded. The scenario of feedstock dust becoming a hazard is very low. Lastly our particle size is [redacted], which can cause limited harm if it were to form a dust hazard

8. If minerals are deployed on croplands, what are the estimated effects on crop yields? Include citations to support this claim. How will actual effects be monitored?

We have reviewed literature on the effect on crop yields with application of silicates, which provide a range of significantly positive results and insignificant results. Our partner Lithos Carbon has also shared their experience with a positive impact on yields between 4 and 47%. Our pilot results will be available at the end of November 2022 to give us a real field observation of yield improvements. We monitor yield improvement by comparing the actual production from an equivalent area between the field with Mati application and the control and analyzing the plant, leaf, stem, and seed physical characteristics from each. We will continue to capture yield observations as we scale up.

9. How will you monitor potential impacts on organisms in your deployment environment? (e.g. health of humans working in agricultural contexts, health of intertidal species, etc.)

We have bi-weekly visits to the farms by Mati representatives to take samples, observe plant growth and converse with the farmers. As we scale we plan to depute a Mati representative in each village (typically >1000 acres of land). This representative will actively manage and monitor the deployments and be able to report any impacts positive or negative for our scale up effort. The bi-weekly soil samples are routinely tested for any detrimental constituents including heavy metals.