Center for Sustainable Economy

An Analysis of Carbon Market Opportunities for Adventure Scientists

Memorandum 2: Field Data Requirements for Carbon Credit Projects

By

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I: Overview

This second memorandum in the series provides a deeper dive into field data requirements for offset credit markets. For six credit categories included in Ecosystem Market's typology, this memo identifies specific field data requirements, what market participants are currently involved with gathering that data, and what technologies are employed. The categories include (1) REDD+; (2) Afforestation, reforestation, and revegetation (ARR); (3) Landfill gas; (4) Households and communities; (5) Agriculture, and (6) Fugitive emissions. Not every particular type of offset project within the categories is addressed. Instead, the memo focusses on the most prevalent offset types. Primary sources for this information are the protocols and methods used by the various registries and verification bodies that certify the integrity of credit generation projects, periodic evaluation reports on those methods, project descriptions, and project verification reports.

II: Forestry and land use (REDD+ and ARR)

REDD+ methodologies and project profiles

As noted in Memorandum 1, offset credits generated by REDD+ projects are by far the leading source of forestry and land use credits, and these credits adhere to one of six accepted standards, including UNFCCC REDD+ framework, FCPF Carbon Fund Program, Climate, Community and Biodiversity Standards (CCB Standards), Green Climate Fund's REDD+ Result-based Payments Requests for Proposals Program, The REDD+ Environmental Excellence Standard (TREES), Tropical Forest Standard, Verra's Jurisdictional Nested REDD+, and Verra's Verified Carbon Standard (VCS). VCS and CCB are described below, followed by two project examples.

Verra VCS methods applicable to REDD+ projects

Verra's VCS is the most ubiquitous and includes seven approved project methodologies relevant to REDD+ projects: (1) VM0004 – avoidance of planned land use conversion in peat swamp forests; (2) VM0006 – carbon accounting for mosaic and landscape-scale REDD projects; (3) VM0007 – REDD+ methodology framework; (4) VM0009 – methodology for avoided ecosystem conversion; (5) VM00011 – GHG benefits from preventing planned degradation; (6) VM0015 – avoided unplanned deforestation; (7) VM0037 – implementation of REDD+ activities in landscapes affected by mosaic deforestation and degradation. There are overlaps between several of these because older methods are often republished in a different form.

Field data requirements are identified by most of these methodologies and are specified under sections that describe the specific variables needed to establish credits and implement monitoring and quality assurance protocols. They also include methods for establishing a network of plots on which these data are gathered. VM0037 provides an example.[1] Seven specific variables require the use of field data from plot samples, including stem volume of trees of a given species, root

[1] VM0037 – Methodology for Implementation of REDD+ Activities in Landscapes Affected by Mosaic Deforestation and Degradation, v1.0. Available online at: https://verra.org/methodologies/vm0037-methodology-implementation-redd-activities-landscapes-affected-mosaic-deforestation-degradation-v1-0/.

shoot ratio, biomass, number of baseline trees for the ARR (afforestation or reforestation) component, DBH and tree height. In addition, VM0037 includes the following quality assurance/quality control requirement for all monitoring methods:

- People involved in field measurement must be fully trained in field data collection and data analysis.
- List the names of all the field teams and the project leader and the dates of the training sessions.
- Record which teams have measured the sampling plots, record who was responsible for which task.
- Develop Standard Operating Procedures (SOPs) for each step of the field measurements and adhere to these at all times, both ex-ante and ex-post.
- Put a mechanism in place to correct potential errors or inadequacies in the SOPs by a qualified person.
- Verify that plots have been installed and measured correctly. Appropriate internal auditing mechanism must be established.

Climate, Community and Biodiversity (CCB Standards)

Many REDD+ projects also use the CCB standards, which were developed by the Climate, Community and Biodiversity Alliance. The CCBA is a partnership of international NGOs with a mission to a mission to stimulate and promote land management activities that credibly mitigate global climate change, improve the well-being and reduce the poverty of local communities, and conserve biodiversity. Members include the Wildlife Conservation Society, Rainforest Alliance, The Nature Conservancy, Conservation International, and CARE. Verra provides management services in support of the standard.

Under the CCB methodology, field data is collected to establish baseline carbon (biomass) using a well distributed system of inventory plots and is also collected as part of the monitoring and verification process for a number of environmental variables such as changes in the volume of agro-chemical applications, water quality, and presence/absence of key species.

One important dimension of REDD+ projects under the CCB methodology is the requirement to monitor community impacts, which is almost exclusively done via interviews and field data.[2] In particular, the CCB standards require that project proponents "[d]evelop and implement a monitoring plan that identifies community variablesto be monitored, communities, community groups and other stakeholders to be monitored, the types of measurements, the sampling methods and the frequency of monitoring and reporting."[3]

[2] The following manual is recommended for guidance on appropriate monitoring methodologies: Richards, M. and Panfil, S.N. 2011, Social and Biodiversity Impact Assessment (SBIA) Manual for REDD+ Projects: Part 1 – Core Guidance for Project Proponents. Climate, Community & Biodiversity Alliance, Forest Trends, Fauna & Flora International and Rainforest Alliance. Washington, DC (available at: http://www.v-c-s.org/project/ccb-program/guidance/).

[3] The CCB standards, managed by Verra, are available online at: https://verra.org/wp-content/uploads/CCB-Standards-v3.1_ENG.pdf. See pages 38-40 for a description of the community impact monitoring requirements.

Project samples

(1) Colombian Andes - Project for Reducing Emissions from Deforestation and Forest Degradation: Regional Natural Park: Biological Corridor PNN Puracé – PNN Cueva de los Guácharos. Link

Project proponent: Corporación Autónoma Regional del Río Grande de La Magdalena
Project developer: ONF Andina
Validation body: SCS Global Services*[4]
Methodolgoy: CCB-VCS
Avoided emissions (10 years): 1,292,150 tCO2-e
Avoided deforestation: 1,724 hectares

This project seeks to reduce deforestation and forest degradation in a protected area through participatory planning of land use to strengthen the capacity of civil society, the development and promotion of alternative production models, and the sensitization of local communities to protect the environment. It also includes activities such as marketing support for agricultural products, strengthening of governance, monitoring and control, and the increase of the value of standing forests through financial incentives such as the Payment for Environmental Services (PES).

Field data are collected in association with the following indicators:

a. Carbon stocks (tCO_2e/ha): Sum of carbon stocks in aerial and belowground biomass and detritus or dead wood biomass (standing dead trees and thick detritus) by type of forest or forest strata identified and weighted average by area. This data is gathered through measurements on a system of field plots. Methods and equipment are determined by Colombia's national forest agency, the Institute of Hydrology, Meteorology and Environmental Studies—IDEAM.
b. Illegally harvested timber: Accomplished via local community "control" groups. Methodology not specified.
c. Social capital: A variety of indicators using interviews and field surveys, such as numbers of families that have membership in conservation organizations, number of project beneficiaries, number of families implementing sustainable activities, household energy use, female participation.
d. Biodiversity: Trends in key species are monitored using transect data such as presence of droppings, scratches on bark of trees, nests and food residues, among others.
e. Environmental indicators: Quality of running water, chemical applications and wood consumption – all through field surveys.

(2) Paraguay, Chaco Region - Corazón Verde del Chaco Project Link

Project proponent: Quadriz Paraguay S.A., Atenil S.A. (project owner)
Project developer: Ostrya Conservation Inc.*
Validation body: Aster Global Environmental Solutions, Inc.*
Methodology: CCB-VSC

[4] Hereafter * will indicate candidates for follow up interviews or email discussions.

Avoided emissions (30 years): 5,861,365 tCO2e
Avoided deforestation: 20,515 hectares

Quadriz plans to implement a large-scale, VCS-CCB avoided planned deforestation REDD+ project to alleviate pressure on natural forest habitat in the Chaco Region in Paraguay. Quadriz's actions will: (1) reduce greenhouse gas (GHG) emissions from the agricultural conversion process; (2) sustain local and regional water quality by limiting nutrient and sediment inputs to local waterways which result from conversion of forest land to agriculture; (3) conserve fast disappearing stream, wetland, and forest ecosystems; (4) undertake local consultations and develop community projects; and (5) protect local fauna and flora. Quadriz's project is the first, large-scale carbon project in the Chaco region. Proponents claim that the Corazón Verde del Chaco Project is a unique and high-impact REDD+ project, which conserves tropical forest under immediate threat of deforestation.

Field data are collected in association with the following indicators:

a. Carbon stocks (tCO_2e/ha): Detailed methods are specified in standard operating procedures. Stocks will be measured at each verification event and every five years and include information on DBH, tree height, tree species, dead wood, and other data gathered along transects. Field equipment will include DBH tape, measuring tape, GPS, clinometer.
b. Mean wood density: Mean wood density of dead wood in the density class (dc) – sound (1), intermediate (2), and rotten (3); t d.m. m-3. Equipment includes DBH tape, measuring tape, and a drying oven.
c. Illegally harvested timber: Emissions due to illegal logging will be estimated from surveys conducted by families residing in areas adjacent to the project property and communities within 20km of the project. Surveys will follow the Participatory Rural Assessment (PRAs) methods.
d. Community impacts: There will be four community surveys used. One is the PRA, which will include seven questions about community decision-making, perceived impacts, ecosystem services provided, topics that engage women and other social topics. One is a degradation survey. Another will be used at the visitor center, and a fourth will be eventually used with Chaco Med. The degradation survey asks questions about communities' consumption of fuelwood, charcoal, and timber.
e. Biodiversity: The deployment of wildlife cameras throughout the project area is expected to demonstrate the impact of the conservation activities on wildlife, including the effect of conserved forest canopy and wildlife corridors. The cameras will be installed to verify the presence, abundance, habitat and diversity of medium-to-large mammals.

<u>Afforestation, reforestation and revegetation (ARR) methodologies and project profiles</u>

ARR stands for afforestation: creating a new forest, reforestation: recreating a forest that has disappeared, and revegetation: replanting and rebuilding the soil of disturbed land. There are many standards related to ARR, but two of the most well developed are maintained by Verra and the American Carbon Registry.

Verra ARR combined methodology

In 2021 Verra consolidated older methodologies into one comprehensive set listed as version 1 of the Methodology for Afforestation, Reforestation and Revegetation Projects.[5] Based on a review of data needed at initial validation and data needed via monitoring, field data comes into play in association with a number of important variables including measurement of root to shoot ratios, tree mortality, live biomass stocks, volume of commercial timber removed, carbon stock in standing dead wood, carbon stock in lying dead wood, dry mass burned in planting units, litter dry mass, and soil organic carbon. The field protocols are rigorous. Appendix A provides an example for measurement of litter dry mass.

American Carbon Registry ARR

American Carbon Registry standards include detailed methods for earning credits from afforestation and reforestation of degraded land.[6] The methodology requires establishment of permanent sample plots within each ecological strata in the project area and within Regeneration Monitoring Areas (RMAs) used as controls. Field data requirements are similar within both, and include wet and dry litter biomass, dead wood volume, tree diameter, tree height, and tree decomposition class.

Project samples

(1) Mindo Cloud Forest Ecuador – Reforestation with Native Species in the Pachijal and Mira River Watersheds for Carbon Retention Link

Project proponents: Mindo Cloudforest Foundation (MCF) and BOS+
Project developer: Mindo Cloudforest Foundation (MCF)
Validation body: SCS Rainforest Alliance – Smart Wood Program*
Methodology: CDM Executive Board AR-AMS0007, now included in VCS
CO_2 removals (30 years): 209,184 tCO2-e
Reforestation area: 346 hectares

This project activity groups together 13 private landowners to reforest with native species 346 hectares of degraded grasslands in two different areas of the western slope of the Andean mountains in Ecuador: the Río Pachijal and Río Mira watersheds in Pichincha and Imbabura provinces, respectively.

Field data are/were collected in association with the following indicators:

- Carbon stocks: The project relies on a network of 39 permanent sample plots across 5 major forest types. Circular shaped PSPs of 201 m2 (radius of 8 m) will be used, since

[5] Available online here: https://verra.org/wp-content/uploads/imported/methodologies/VCS-ARR-Methodology.pdf.
[6] Winrock International. 2017. Methodology for the Quantification, Monitoring, Reporting and Verification of Greenhouse Gas Emissions Reductions and Removals From Afforestation and Reforestation of Degraded Lands. Available online at: https://americancarbonregistry.org/carbon-accounting/standards-methodologies/afforestation-and-reforestation-of-degraded-lands.

these are easy to establish and re-measure within the terrain of the project boundary. Field data forms are used to collect information on tree diameters, tree species, tree heights and soil carbon.

- Forest management and condition: Monitoring of project activities, including site preparation, planting, replanting, and natural disturbances.
- Survival rate: For 1-3 years after establishment the site was monitored in the field for the survival rate of seedlings.
- Firebreaks: Monitoring of fire breaks during establishment and maintenance phases during the first 3 years.
- Biodiversity: Transects were established by the monitoring plan, and data forms are used to record point counts of various bird species. Note: "Since developing a full biodiversity-monitoring plan can be costly, it is accepted that some of the plan details may not be fully defined at the design stage, when projects are being validated against the Standards."

(2) Mississippi Alluvial Valley - GreenTrees ACRE (Advanced Carbon Restored Ecosystem)

Project proponents: Green Trees*
Project developer: Green Trees
Validation body: Ruby Canyon Environmental*
Methodology: American Carbon Registry
CO_2 removals (30 years): 11,060,752 tCO2-e
Reforestation area: 89,000 acres

The project uses tree planting to establish trees on lands that have been in continuous agricultural use and have not been in a forested state for 10 years. Landowners commit to protecting the trees. Limited harvest is allowed after trees grow to the point where crowding of trees is expected to cause some trees to die, but in no case may harvesting occur if it would result in a basal area of live trees of less than 100 square feet per acre after the harvesting. The GreenTrees Program has enrolled 89,000 acres. GreenTrees is a programmatic offset program and continues to enroll new landowners and plant lands.

Field data are/were collected in association with the following indicators:

- Basal diameter: DBA or DRC (diameter at root collar) measured with a caliper as close to ground level as possible.
- Diameter at breast height (DBH): Measured with caliper, diameter tape, or laser.
- Decomposition class: Decomposition condition of dead trees.
- Tree height: Height of tree from ground to end of growth leader, measured as length of stem with measurement pole, clinometer, or laser tool.
- Prism factor: Factor describing the prism angle, such that tallied trees each represent the prism factor of basal area. Recorded with data for each plot.
- Tree species: Recorded once per plot via check cruise procedure.

III: Waste disposal

According to Ecosystem Marketplace there are five credit categories associated with the solid waste stream – recycling, waste gas recovery, waste gas avoidance, waste incineration, and an 'unspecified' category. Of these landfill methane capture and destruction is the largest category. Credits generated are relatively straightforward to document and monitor since their basis is gas monitoring equipment installed at the landfills. However, trained field personnel are needed on a regular basis to take readings from this equipment and calibrate the meters. This needs to be done by independent third parties, so there may be an opportunity for citizen scientists trained by Adventure Scientists in consultation with landfill project managers. Two methodologies summarized here have been published by the American Carbon Registry and the UN Clean Development Mechanism program.

American Carbon Registry – landfill gas destruction and beneficial use

According to ACR, the collection and combustion of landfill gas (LFG) is an effective method for decreasing the greenhouse gas (GHG) emissions from landfills that would have otherwise been vented to the atmosphere. The ACR methodology provides the quantification and accounting frameworks, including eligibility and monitoring requirements, for the creation of carbon offset credits from the reductions in GHG emissions resulting from the destruction or utilization of landfill gas at eligible landfills.[7]

Field checks are part of the monitoring plan, which generate data on landfill gas flow using a flow meter and methane content analysis using a handheld methane analyzer. Field check protocols must adhere to the following standards:

- Field checks must be performed in accordance with manufacturer's specifications and methodologies.
- Field checks must be performed by the manufacturer or other appropriately trained third-party personnel.
- All field checks must be documented and made available for review during the validation and verification process. Documentation must include specific results of the field checks including the percent error demonstrated by the instrumentation capturing the before (as-found) and after (as-left) status.
- Should the instrumentation demonstrate an error in the reading or output of either landfill gas flow or methane content that is greater than or equal to 5%, written documentation must be provided as to the correction applied during the field check and the resulting accuracy of the instrumentation. In situations where the flow meter or methane analyzer percent error is greater than or equal to 5%, all data from the previous field check through to the most recent field check shall be scaled by the percent error documented in the most recent field check.

[7] ACR Landfill Gas Destruction and Beneficial Use Projects methodology available online at: https://americancarbonregistry.org/carbon-accounting/standards-methodologies/landfill-gas-destruction-and-beneficial-use-projects.

UNFCCC ACM001 - CDM Large-Scale Consolidated Methodology for Flaring or use of landfill gas v. 19

This UNFCCC methodology applies to project activities that include the destruction of methane emissions and displacement of a more-GHG-intensive service by capturing landfill gas from the landfill site and/or flaring and/or using to produce energy (i.e. electricity, thermal energy); and/or using to supply consumers through natural gas distribution network, dedicated pipeline or trucks.[8] Field data are collected in association with monitoring and verifying the proper functioning of installed equipment related to flaring, electricity generation, and heat generation. Data on gas flow rate, gas composition, moisture content, temperature and pressure are recorded.

Project samples

(1) Wake County, NC: South Wake Landfill GHG Emissions Reduction Automated Collection of Landfill Gas

Project proponents: LoCI Controls, Inc., Ingenco Wholesale Power, LLC – Apex, Wake County
Project developer: SCS Engineers, Richmond VA
Validation body: Ruby Canyon Environmental
Methodology: ACR730
CO_2 removals (10 years): 709,388 tCO2-e

The Project Activity is replacing existing manually monitored and adjusted landfill gas collection wells (Manual Technology) with the LoCI automated control system at the South Wake landfill. LoCI Controls, Inc. (LoCI) owns and operates the LoCI automated control system. As with most landfill projects, field data are collected mainly to verify the integrity of onsite equipment.

Field data are/were collected in association with the following:

- Flow data: Field Confirmation is performed by trained third-party personnel. Field confirmation of flow meter shall be performed once every 12 months or more frequent as needed per manufacturer guidance. Field confirmation is performed using Fluke 718 and Fluke 87V to confirm accuracy of measurements at 0%, 25%, 50%, 75% and 100% of instrument range for differential pressure, static (gauge) pressure, and temperature. Also mAmp current test confirms accuracy of signal outputs at 0%, 50% and 100% of range. If greater than 5%, instrument is calibrated.
- Methane content: Field confirmation of methane analyzer is done once per month or more frequently. Field confirmation is performed using a calibration gas to confirm accuracy of measurement. Field calibration is automatic using calibration gases.
- Thermocouple: Inspected annually. Measurements include hours of flare operation and whether the flame is at a temperature that ensures gas destruction. No emission reductions are claimed for thermocouple readings less than 500 degrees F while the flare is operating.

[8] UNFCCC ACM0001 available online at: https://cdm.unfccc.int/methodologies/DB/JPYB4DYQUXQPZLBDVPHA87479EMY9M.

(2) Turkey, Mersin Province: Landfill Gas (LFG) Capture and Combustion Project

Project proponent: Eko En Enerji Elektrik Imalat Sanayi ve Ticaret Anonim Sirketi (Inc.)
Project developer: CS Climate Solutions*
Validation body: TBD
Methodology: UNFCCC ACM0001
CO_2 removals (8 years): 3,120,198 tCO2-e

According to proponents, the main purpose of this project is to operate landfills in Mersin with minimal impact to environment with efficiency. To accomplish this, three most populated districts of Mersin have landfill sites as managed solid waste disposal site (SWDS), with LFG capture and combustion systems to generate electricity, reduce GHG emissions, prevent negative effects of unmanaged SWDS and take a step through sustainable future. There is no distribution of natural gas through pipelines nor trucks to end users and it is not used for heat generation.

Field data are collected as part of the monitoring plan, which is described below:

- The responsible entity for the monitoring system is Eko En Enerji personnel. The monitoring activities will primarily involve four types of personnel: the Operation Site Manager, Field Operator, Electrical & Mechanical Operator, and the Laboratory Operator.
- The Field Operators will perform activities such as monitoring and adjusting LFG extraction wells, checking operations of the blower and flare, recording data at the blower/flare station, routine maintenance of collection system components, preparing daily logs and completing checklists, and send data to the Operation Site Manager.
- The Operation Manager's responsibilities include reviewing the data collected both manually by the Field Technicians and the one recorded automatically by analytical equipment, making recommendations and/or implementing system adjustments to maximize methane capture and destruction, scheduling monitoring and O&M activities, performing quality assurance checks on operations, coordinating with system component manufacturers as needed, to maintain proper operations and calibration, and compiling data as required by the Methodology.
- Only for manual data collection, the Operation Manager will be responsible for reviewing the data collected.

IV: Household and community projects

These credits are earned through a variety of projects designed to reduce household and community sources of GHG emissions through clean water distribution, lighting efficiency, clean cookstoves, biogas, energy efficiency and rural solar. Clean cookstove distribution is by far the largest single category, earning 50% of credits in this category in 2022. Clean Cookstove projects not only reduce emissions by using less fuel than "business as usual", but also improve livelihoods by reducing the time and effort of collecting fuelwood and lowering indoor air pollution. Important methodologies in this broad household and community category include Verra's VMR0006 and the Clean Development Mechanism methodology AMS-I.D. v. 5.

VMR0006 v. 1.2 – Energy efficiency and fuel switch measures in thermal applications

This methodology applies to project activities that introduce energy efficiency and fuel switch measures in thermal applications (including cookstoves ovens and dryers) that increase thermal efficiency to reduce the consumption of nonrenewable biomass; or switch from fossil fuel (coal or kerosene) to renewable biomass in new or existing improved thermal energy generation units.

Field data is required as part of the monitoring plan. Variables include the quantity of renewable biomass consumed by project devices via community surveys of representative households and efficiencies of project and baseline devices via water boiling tests.

CDM AMS-I.D. v. 5. – Small-scale grid connected renewable electricity generation

This methodology comprises renewable energy generation units, such as photovoltaic, hydro, tidal/wave, wind, geothermal and renewable biomass that supply electricity to a national or a regional grid; or supply electricity to an identified consumer facility via national/regional grid through a contractual arrangement such as wheeling. Field data are collected in association with the following: monitoring electricity meters, determining the quantity of biomass used (mass or volume-based measurements), moisture content of biomass and caloric value of biomass via samples collected on site.

Project samples

(1) Tramontana ICS-01 – Distribution of improved cookstoves to indigenous communities across rural India.

Project proponents: Tramontana Impact Limited*
Project developer: Tramontana Asset Management*
Validation body: Earthhood Services Private Limited
Methodology: VMR0006
CO_2 removals (7 years): 13,632,220 tCO2-e

The Tramontana ICS-01 project involves the distribution of up to 400,000 heavy-duty, energy-efficient improved cookstoves (ICS), free of cost through carbon finance, to indigenous communities across rural India that currently use traditional stoves such as mud clay and three-stone stoves. The target communities, who are statutorily recognized under the Indian Constitution as either Scheduled Tribes or Scheduled Castes, are considered the most marginalized and socio-economically disadvantaged communities in India. The project aims to directly and immediately enhance the health, well-being and livelihoods of these communities, and particularly of the women and children who are the most affected. Deforestation which is widespread across the project region owing to the significant demand for firewood, will also be drastically reduced as a result of the project activity. The Tramontana ICS-01 project achieves 9 of the UN's Sustainable Development Goals and these will be monitored throughout the project life. The total greenhouse gas emissions reductions estimated from the project activity over the first crediting period is 13,632,220 tCO2e, with an annual average of 1,947,460 tCO2e.

Field data collection process and variables addressed are summarized below:

- All data collection under the project is done using a purpose-built software application by local community members who have been employed and trained for the purpose.
- Fraction of woody biomass saved by project activity: Taken from community surveys on firewood sourcing and consumption.
- Annual quantity of woody biomass that would be used by a household in the absence of the project (expressed in kg/day): Derived from random household baseline surveys.
- Number of project devices in use: After establishing a database on stove distribution, the parameter is monitored based on representative sampling of households.
- Stove use adjustment factor accounting for any continued use of non-project devices: Monitoring surveys are used to check for any non-project devices being used that would affect the GHG savings calculations.
- Date of commissioning of project device: Exact date of installation recorded on surveys using the Transmontana improved cookstove software.

(2) Rajasthan, India – Biomass in Rajasthan – Electricity generation from mustard crop residues

Project proponent: Kalpataru Power Transmission Limited
Project developer: Kalpataru Power Transmission Limited
Validation body: Evelop BV
Methodology: CDM AMS-I.D. v. 5
CO_2 removals (10 years): 313,743 tCO2-e

The project involves the implementation of a biomass-based power generation plant using direct combustion boiler technology. The installed capacity of the plant is 7.8 MW. The fuel used is primarily mustard crop residue, which is abundantly available in the vicinity of the site. The electricity generated will be sold primarily to the state grid with the balance sold to third parties (large industrial customers). The generated electricity will replace a mixture of coal and gas-based power generation.

Field data are collected as part of the monitoring plan, which is summarized below:

- The project proponent has recruited and groomed a team of supervisors and field representatives to effectively control and monitor the complete process of fuel procurement, quality issues, and the handling and storage of material in the plant area.
- All have undergone classroom sessions by respective experts coupled with "on the job" training all performed by the proponent's engineers.
- Random checks are carried out to monitor the quality of the biomass fuels received (moisture content, purity of the material).
- The monitoring parameters relevant for the CDM activity i.e. biomass input flow, biomass energy content, electricity production (and eventual fossil fuel input) are part of the regular monitoring scheme of the plant.
- The monitoring data required for the CDM verification are taken from the regular digital and manual logs.

- Additional training was given to the surrounding farmers in their local villages, educating them on the benefits of selling their agricultural waste to KPTL rather than burning it on the fields, and ways of transporting their biomass to the site.
- Qualified local villagers were employed who were aware of local areas and issues and are from agricultural backgrounds. All training was performed on site.

V: Agriculture

These credits are earned through projects that reduce GHG emissions from intensive cropping and livestock or by substituting feedstocks for materials or energy with agricultural crops with a lower carbon footprint. Cropping related credits can be earned through practices such as planting cover crops, adopting no-till, establishing riparian, wetland and forest buffers, retiring land, agroforestry and eliminating chemical use. Credits associated with improved grazing practices include those associated with better management of cattle numbers and rotations. Sample methodologies include Verra's VM0026 and CDM AR-AMS0007.

VM0026 – Sustainable grassland management

This methodology applies to Agricultural Land Management (ALM) project activities that introduce sustainable grassland management practices such as improving the rotation of grazing animals between grassland areas, limiting the number of grazing animals on degraded grassland, and restoring severely degraded grasslands by replanting with grasses and ensuring appropriate management over the long-term into a grassland landscape.

Field data – mainly gathered from survey plots – are used wholly or in part as the basis for a dozen variables tracked in monitoring plans, including mass of synthetic nitrogen fertilizer applications, area burned, above ground biomass, head of livestock, grazing days per type of livestock, average grazing hours per type of livestock, area of trees and shrubs, soil organic matter,[9] annual area of nitrogen fixing species, weight of annual dry matter returned to the soil from nitrogen fixing species, aboveground biomass burned,[10] percent rocky cover, and soil depth.

CDM AR-AMS0007 – Afforestation and reforestation activities on lands other than wetlands

This methodology is applicable to small-scale afforestation and reforestation (A/R) project activities under the clean development mechanism (CDM). It does not apply to large-scale A/R CDM project activities. It is limited to three types of activities: (a) grassland to forested land; (b) cropland to forested land, and (c) settlement to forestland. It should be noted that tree crops, including bamboo, are classified under the cropland to forestland category.

Under this methodology, field data are gathered from periodic surveys that adhere to host country protocols for forest inventory and analysis. Those inventories provide all of the basic data

[9] Generally, under this method, the project proponent must follow the procedures for the sampling and measurement of soil properties, including bulk density and organic carbon concentrations.

[10] More details on how this variable is measured: Measure the aboveground biomass of grassland before and after the fire management for at least three plots (1m*1m). The difference of the aboveground biomass is the aboveground biomass burnt.

needed to monitor changes in carbon stocks and carbon emissions associated with management activities, and include such variables as volume of removals, net growth, soil carbon, mortality, and road densities.

Project samples

(1) China, Mongolia Region – Sodom Hanba Improved Grassland Management Project

Project proponents: Inner Mongolia Chengyao Grassland, Forestry and Animal Husbandry Ecological Technology Co., Ltd.
Project developer: Shenzhen Cypress Carbon Environmental Technology Service Co., Ltd.*
Validation body: CTI Certification Co., Ltd.
Methodology: VM0026
CO_2 removals (40 years): 16,329,869 tCO2-e

Sodom Hanba Improved Grassland Management Project is located in Ejin Banner, Alashan League, Inner Mongolia Autonomous Region of China. The project is aimed to restore the local degraded grassland ecosystem from adoption of sustainable grassland management practices, such as improving the rotation of grazing animals between summer and winter pastures, limiting the time and number of grazing animals on degraded pastures, and restoration of severely degraded land by replanting with perennial grasses and ensuring appropriate management over the long-term.

Field data are collected in association with the following monitoring plan variables:

- Livestock weight: Average weight of livestock in project boundaries, based on samples or expert judgement.
- Livestock grazing days: Grazing days for livestock of different types within a year.
- Average grazing hours for livestock: Average grazing hours for livestock by type during grazing season.
- Soil properties: The organic carbon, bulk density and sand-gravel ratio (percentage of rocks larger than 2mm, roots, and other dead residues with a diameter in the top 30 cm of soil) of soil samples were measured by a qualitied third party at project initiation and are periodically monitored at least every five years. Equipment includes a soil drill, ring knife, electronic scale, and sieve.
- Soil depth: Soil samples are taken with soil drill with a 30cm scale.
- Livestock numbers: Head of livestock by type in a given year.
- Management practices: Project areas of grassland managed under rest, reseeding, rotational grazing.
- Fuel consumption: Fuel consumption by type of machine by parcel each year.

(2) Montemilone, Italy - Basilicata Bamboo

Project proponent: Societa' Agricola Bambu' SRL
Project developer: Nucaro Mauro Company*
Validation body: Evelop BV

Methodology: AR-AMS0007
CO_2 removals (40 years): 55,346,701 tCO2-e
Bamboo plantation area: 35 hectares

The aim of the project is to demonstrate an agroforestry carbon project by establishing a bamboo plantation on degraded land. Project activities are implemented to promote sustainable agriculture through agroforestry and long-term sustainable forestry. Producers receive information on the effects of climate change, deforestation, and its consequences (soil erosion, decreased water availability, natural disasters, landscape degradation, decreased biodiversity and so on...) and how to mitigate them by planting trees or crops. They also receive information and training on agroforestry techniques and the combination of tree plantations with bamboo cultivation. The Bamboo Farm has chosen five species according to the specificities of its land and a combination of fast, medium, and slow growing bamboo species. Farmers are paid monthly to plant and care for the bamboo until the target is reached.

Field data are collected in association with the following monitoring plan variables[11]:

- Tree count: Number of trees by age strata observed each year.
- Tree diameters. A 20-tree sample is used to establish average diameter using diameter tape.
- Height of bamboo: 20 trees are sampled within each age strata using a clinometer.

VI: Chemicals and industry (fugitive emissions)

These credits are earned through various projects designed to make chemical and industrial processes more efficient or to prevent emissions from greenhouse gases generated during manufacturing or resource extraction. Projects include nitrous dioxide destruction, carbon capture and storage, climate friendly refrigerants, and control of fugitive emissions. Of these, fugitive emissions are the category most likely to involve the collection of field data. Two relevant standards include UNFCCC CDM AM0023 and Verra's VM0014.

AM0023 - Leak detection and repair in gas production, processing, transmission, storage and distribution systems and in refinery facilities.

This methodology is applicable to project activities that reduce physical leaks of greenhouse gases in components through the introduction of an advanced leak detection and repair (LDAR) program. The methodology is restricted to the following industrial components: valves, flanges and other connectors, pump seals, compressor seals, pressure relief valves, open-ended lines and sampling connections, diaphragms, drains, hatches, meters and vents.

[11] More specific information about how these data are gathered (from the project plan): The tape measure will be used to measure the diameter at breast height. Breast height is quantified at 1.4m and everyone working on monitoring will use a clearly marked 1.4m meter stick to ensure measurements are taken at the correct height. Each plant is recorded separately on a field data sheet and a separate page for each plant will allow you to record the number of culms and their diameter at breast height. The data will be recorded on field cards and then transcribed on electronic media.

A combination of automatic (via sensors) and field leak detection is used. Field data are gathered by trained third parties in relation to the initial detection of leaks and post repair monitoring. For leak detection, field protocols require a digital photo of the leak, tagging and recording the leak location, and (optionally) measurement of the flow rates. Equipment includes a Hi-Flow Sampler, calibrated bag, electronic gas detectors, organic vapor analyzers, toxic vapor analyzers, portable acoustic screening devices, optical gas imaging instruments (Appendix B).

VM0014 – Interception and destruction of fugitive methane from coal beds

This methodology applies to project activities that capture and destroy methane which would otherwise be released to the atmosphere from coal bed outcroppings. Projects using this methodology will be implemented on coal seams or where exposed coal bed outcroppings exist having documented coal bed methane seeps. The methodology applies to project activities that involve the use of any of the following extraction techniques: (1) the use of gas drainage wells and monitoring wells, serving as gas interception wells, drilled near locations where methane gas seeps are present, and (2) the use of gas membranes, surface covers or underground horizontal well fields to capture fugitive methane emissions at or just below the ground surface level.

Field surveys of the coal seam outcropping located up-dip of the interception systems using a methane flux chamber to establish ground level methane flux in mol/m2-day is one method used to establish baseline emissions. In addition, third party verification involves field checks of flow meters installed in project areas to document captured methane delivered to power plants, flared, or otherwise destroyed. Annual testing of captured gas is also performed to determine the fractional composition of this gas to delivered end users.

Project samples

(1) Bangladesh – Leak detection and repair in gas production, processing, transmission, storage and distribution systems and in refinery facilities.

Project proponents: EcoGas Asia, Ltd.
Project developer: EcoGas Asia, Ltd.
Validation body: Rina Services SPA
Monitoring and verification contractor: Climate Copass*
Methodology: AM0023
CO_2 removals or emission reductions (annual): 2,441,426 tCO2-e

The proposed CDM project aims to reduce gas leakages from components1 in the natural gas distribution system in Bakhrabad Gas Distribution Company Limited (BGDCL) in the People's Republic of Bangladesh. The length of the BGDCL natural gas distribution system is about 4000km. Construction began on the distribution system in the 1970s and over the years has not been adequately maintained. As a result, a significant percentage of the natural gas throughput which is more than 95% methane leaks from components in the system and is released into the atmosphere contributing to global warming. The project will identify and repair these leaks.

Field data are essential to the leak detection process and used to validate the repairs.[12] In particular:

- Surveys: The implementation of the project will involve an initial baseline survey and regular subsequent surveys of each component within the project boundary.
- Leak detection: Advanced leak detection equipment such as catalytic oxidation/thermal conductivity detectors or gas surveyors are used (Appendix B).
- Leak measurement: Hi-Flow samplers are used to establish leak rates (Appendix B).
- Leak repair monitoring: Verification and monitoring of leak repairs is done onsite via Climate Copass and a subcontractor MBS.
- Equipment and training: The project teams will be formally trained and certified by technical experts in leak detection and measurement techniques, and advanced repair techniques. The teams will be equipped with: Hi-flow™ samplers, calibration standards: 2.5% methane in air concentration; and 100% methane, GMI Gasurveyor™ (500 Series) (or similar electronic gas detector), digital camera on Smart Phone with GPS, tags.

(2) Ignacio, CO – Southern Ute Indian Tribe Westside CBM Seep Capture and Use Project

Project proponent: Southern Ute Department of Energy
Project developer: WSP Environment and Energy
Validation body: Det Norske Veritas Climate Change Services AS
Methodology: VM0014
CO_2 removals (10 years): 288,175 tCO2-e

The project will achieve emission reductions because methane which would otherwise continue to travel up the coal seam to the outcropping and be emitted to the atmosphere will be intercepted. The methane intercepted by the vent wells will be collected, pressurized, treated for hydrogen sulfide, water and CO2 removal and injected into a natural gas transmission pipeline at the site. From there, it will be distributed to end users and combusted. This project prevents CH4 emissions to the atmosphere and avoids the use of natural gas.

Two field operation companies are used as third-party monitoring and quality control and assurance. Red Willow Gathering &Treating Company provides maintenance support and operates the interceptor well system, the CDP and the gas upgrading facility. Red Cedar Production Company operates the gas compression station.

Field data are primarily collected in association with the following monitoring plan variables:

- Gas composition: Gas samples are taken monthly and sent to a lab.
- Methane concentration: The concentration of methane in CBM delivered and sold to Red Willow at the central delivery point. A portable gas chromograph is used at a specific sample point near a flow meter.

[12] EcoGas Asia have subcontracted quality assurance/control (QA/QC) responsibilities to Climate Compass as Project Manager.EcoGas Asia will mandate a third party Climate Compass undertake the monitoring report and annual CER verification assessment.

- Concentration of non-methane hydrocarbons: (same as above).

VI: Observations and discussion

This memo provides an overview of how field data, potentially gathered by Adventure Scientists, is important to the creation, monitoring, and validation of carbon projects. The overview is based on a detailed review of carbon offset credit methodologies and projects that fall into six of the credit categories established by Ecosystem Marketplace: (1) REDD+; (2) Afforestation, reforestation, and revegetation (ARR); (3) Landfill gas; (4) Households and communities; (5) Agriculture, and (6) Fugitive emissions.

I completed the overview through detailed reviews of project documents made available through one of three accessible registries – American Carbon Registry, Verra, or the UNFCCC – along with the methodologies employed by those projects. A focus for both the methodologies and project documents was the data needed upon project verification and the data included in required monitoring plans. A total of twelve projects and twelve methodologies in six categories are profiled. Many other projects and methodologies were reviewed but were excluded due to the lack of meaningful fieldwork opportunities.

The profiles of methods and projects provides a wealth of information about field data requirements, equipment, training and project participants, including those flagged with an asterick (*) who may provide partnership opportunities for Adventure Scientists. I recommend following up with these specific individuals and organizations during the interview phase.

Key generalized conclusions from this analysis are the following:

- Field data is gathered and used rather extensively across most carbon offset credit types. There is a significant range of requisite expertise – forest surveys, soil sampling, leak detection, wildlife surveys, gas composition analysis, participatory rural assessment, to name a few.

- Field data is primarily generated by sampling of plots or transects for land-based projects, through surveys and questionnaires for demographic and community impacts, and through site visits with technicians at industrial facilities.

- Many projects involve the use of equipment that varies in complexity of use (i.e. gas analyzers, soil samplers, diameter tape). Training in use of sophisticated measurement equipment is often part of the monitoring plans.

- Field data is used primarily to establish project baselines, verify emissions removals or reductions, and meet monitoring plan obligations. Most registered project plans include a list of monitoring plan variables and for each variable have identified the source of data, whether it be automated or derived from fieldwork.

- Project proponents and project developers often employ third-party contractors to gather field data or provide monitoring services. Several projects employed the services of

university-based professors. This group may provide natural partners for Adventure Scientists.

This concludes a brief review of field data requirements associated with carbon offset credits. The next memorandum will report the results of interviews with key market participants, including the individuals and organizations flagged with a (*), to scope out potential partnership opportunities.

Appendix A – VCS ARR v 1.0 Field protocols associated with measurement of litter dry mass.

Data / Parameter:	$DM_{WP_{LI,t}}$
Data unit:	t dry matter ha^{-1}
Description:	Litter dry mass in the project scenario in year t
Equations	(22)
Source of data:	Measured in the project area
Description of measurement methods and procedures to be applied:	Litter (dead organic surface material of <10 cm diameter) is collected from within fixed-area sampling frames, harvested at ground level and dried at 70 °C to a constant weight to determine dry weight biomass. In cases where sample bulk is excessive, the green weight of the total sample and of a representative sub-sample are recorded in the field and the sub-sample taken for moisture content determination in the lab (i.e., oven dry weight to green weight ratio), from which the dry weight biomass of the total green weight recorded in the field can be estimated. Further guidance is provided in the IPCC *Good Practice Guidance for Land Use, Land-Use Change and Forestry*.[37]
Frequency of monitoring/recording:	At $t = 0$ and subsequently every 10 years or less frequently
QA/QC procedures to be applied:	Standard QA/QC procedures for soil inventory, including field data collection and data management, must be applied. Use or adaptation of QA/QC procedures available from published handbooks, such as those published by FAO and available on the FAO Soils Portal[38] or from the IPCC *Good Practice Guidance for Land Use, Land-Use Change and Forestry* is recommended.
Purpose of data:	Calculation of project emissions
Calculation method:	N/A
Comments:	N/A

Appendix B – Sample Equipment Used in Fugitive Emissions Leak Detection Protocols (AM0023)

1. Leak Detection technology:

During the proposed project activity, leaks will be detected using advanced technologies such as catalytic oxidation/thermal conductivity detectors; GMI Gasurveyor™ (500 Series) (Figure 5)[4]. The GMI Gasurveyor™ (500 Series) is a highly flexible, electronic portable gas detector designed as per latest standards and is certified for use in hazardous areas. The detector has LCD screen with automatic backlighting, audio, visual and fault alarms and are one of the state-of-the-art gas detectors. During the monitoring phase, all project inspections will be carried out with accuracy not less than that of the GMI Gasurveyor™ (500 Series).

Figure 1 Gasurveyor Model

2. Leak Measurement technology:

For most leak measurements, Hi-Flow™ samplers[5] will be applied. Hi-Flow™ samplers (Figure 6) capture all the emissions from a leaking component to accurately quantify leak emissions rates. Leak emissions, plus a large volume sample of the air around the leaking component, are pulled into the instrument through a vacuum sampling hose. A dual-element hydrocarbon detector (catalytic-oxidation/ thermal-conductivity) measures hydrocarbon concentrations in the captured air stream ranging from 0.01 to 100 percent. Sample measurements are corrected for the ambient hydrocarbon concentration, and mass leak rate is calculated by multiplying the flow rate of the measured sample by the difference between the ambient gas concentration and the gas concentration in the measured sample. Hi-Flow™ samplers measure leak rates up to 10.5 cubic feet per minute (equivalent of 0.297 m^3/min), equal to 15.1 thousand cubic feet (428.2 m^3) per day, with the accuracy of calculated leak rate of +/- 10%. As per the methodology, a calibrated bag or other bagging techniques specified by the methodology may be employed as needed.

Figure 2 High-flow Sampler