



BOOMITRA GRASSLAND RESTORATION IN NORTHERN MEXICO



Document Prepared by Boomitra Inc.

Project Title	Boomitra Grassland Restoration in Northern Mexico
Version	8.0
Date of Issue	20/09/2024
Prepared By	Boomitra Inc.
Contact	400 Concar Dr, San Mateo CA 94402, USA info@boomitra.com https://boomitra.com

CONTENTS

1	PROJECT DETAILS	4
1.1	Summary Description of the Project.....	4
1.2	Sectoral Scope and Project Type	5
1.3	Project Eligibility	6
1.4	Project Design	7
1.5	Project Proponent	10
1.6	Other Entities Involved in the Project	11
1.7	Ownership	12
1.8	Project Start Date	13
1.9	Project Crediting Period	14
1.10	Project Scale and Estimated GHG Emission Reductions or Removals	14
1.11	Description of the Project Activity	15
1.12	Project Location	27
1.13	Conditions Prior to Project Initiation	29
1.14	Compliance with Laws, Statutes and Other Regulatory Frameworks	37
1.15	Participation under Other GHG Programs	41
1.16	Other Forms of Credit	41
1.17	Sustainable Development Contributions	42
1.18	Additional Information Relevant to the Project	44
2	SAFEGUARDS	45
2.1	No Net Harm	45
2.2	Local Stakeholder Consultation	46
2.3	Environmental Impact	49
2.4	Public Comments	49
2.5	AFOLU-Specific Safeguards	49
3	APPLICATION OF METHODOLOGY	58
3.1	Title and Reference of Methodology	58
3.2	Applicability of Methodology	58
3.3	Project Boundary	63
3.4	Baseline Scenario	65
3.5	Additionality	74

3.6	Methodology Deviations	77
4	QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS.....	77
4.1	Baseline Emissions.....	77
4.2	Project Emissions	87
4.3	Leakage	90
4.4	Uncertainty Quantification	92
4.5	Net GHG Emission Reductions and Removals	109
4.6	Estimated Reductions and Removals	112
5	MONITORING	114
5.1	Data and Parameters Available at Validation.....	114
5.2	Data and Parameters Monitored	119
5.3	Monitoring Plan.....	146
	APPENDIX 01: STAKEHOLDER MEETING DETAILS	156
	APPENDIX 02: FLORA AND FAUNA.....	164
	APPENDIX 03: BASELINE QUESTIONNAIRE	165
	APPENDIX 04: BASELINE SURVEY LIVESTOCK DATA (ANIMAL TYPE AND COUNT) .	168
	APPENDIX 05: SEQUESTRATION RATES ACROSS DIFFERENT VEGETATION STRATA IN RANCHES IN NORTHERN MEXICO	192

1 PROJECT DETAILS

1.1 Summary Description of the Project

In this project, we work with ranchers in northern Mexico who raise livestock on individually owned or community-owned grasslands and enable those ranchers to adopt Improved Grassland Management (IGM). Ranchers in this region have traditionally followed practices such as continuous grazing, without any sustainable grazing or water management plans in place. This has resulted in overgrazing, leading to severe soil degradation and loss of vegetative cover. Through this project, ranchers are adopting new management practices. These practices include rotational grazing and a variety of water conservation measures. In rotational grazing, livestock are rotated between different sections of a pasture over the course of days, weeks, or months, while other sections of the pasture are allowed to rest. These sections are known as “paddocks”. This practice allows plants to recover and grow in the paddocks that are allowed to rest, and thus allows them to sequester carbon, gradually regenerating the land. In addition, for arid regions like northern Mexico, water conservation measures help increase the availability of water (which would otherwise be lost) for the growth of the biomass, contributing to the regeneration. The livelihoods of the communities utilizing these ranches are improved directly through the carbon credit payments, which provide an additional source of income, and indirectly through the increased productivity of their lands. The regenerated lands also become much less likely to undergo land use change, because the ranchers are better able to sustain their livelihoods. This in turn ensures that crucial habitats for the flora and fauna of the region are protected.

This project is located in northern Mexico, which is covered by vast arid regions and has two major deserts – the Chihuahuan Desert and the Sonoran Desert. The Chihuahuan Desert spans 647,500 km² and the Sonoran Desert spans 260,000 km² across Northern Mexico and the Southwestern United States of America. The Chihuahuan Desert is the largest desert in North America, covering the states of Chihuahua, Coahuila, Durango, Zacatecas, Nuevo León, and San Luis Potosí in Mexico and Arizona, New Mexico, and Texas in the United States of America. The Sonoran Desert is primarily located in the states of Sonora, Baja California and Baja California Sur in Mexico, and Arizona and California in the USA. These deserts have vast areas of grasslands that have very high levels of biodiversity, including many endemic species.

The grasslands of these deserts are now under threat from a variety of anthropogenic causes, particularly overgrazing and water availability. Overgrazing occurs when plants are subject to heavily intensive grazing from livestock, leading to severe loss of vegetation. These types of unsustainable ranch management by pastoralists throughout the region has led to severe land degradation, desertification, and loss of soil carbon, resulting in CO₂ emissions – lands that were formerly vibrant grasslands have been converted into barren surfaces with loosely scattered shrub vegetation. And when they become unable to sustain their livelihoods on their degraded ranches, ranchers are sometimes forced to sell their land to farmers who convert the grasslands into croplands, resulting in further CO₂ emissions. In addition, land

conversion represents a significant loss of habitat for the fauna of the region, coupled with the replacement of the natural flora with crops^{1,2}.

Grasslands are very vulnerable to changes in water availability because it intrinsically affects the physical characteristics of grass³. In the project area, a lack of water is affecting overall grass growth, resulting in fluctuations in available forage for livestock. Water scarcity is a common and natural condition in this arid region⁴. Changes in precipitation and temperature due to anthropogenic climate change are also contributing to scarcity of water in the region⁵.

In addition to increasing Soil Organic Carbon (SOC) in grasslands, this project is expected to generate several community and biodiversity benefits and contribute to the UN Sustainable Development Goals (SDGs) 2, 6, 8, 13 and 15 (see section 1.17).

At the time of validation, a total of 575,515.16 hectares of land have been reported. However, Boomitra is in contact with many other ranchers in the grouped project area, whose properties span more than 2,700,000 ha and is in the final stages of enrolling them into the project. This area (2,700,000 ha) is on a grouped project-level. This project will be broken down into many instances during the course of the crediting period.

This project quantifies only GHG removals from new project activities, through the use of the VM0042 methodology. We estimate an average yearly GHG removal of 1,233,480 tons of CO_{2e} from the project and the number of ranchers participating in the program is also projected to grow over the course of the crediting period through additional instances. The total emissions reductions from this project is 24,669,598 tons of CO_{2e} after deducting buffer credits (over a 20-years crediting period).

1.2 Sectoral Scope and Project Type

Sectoral Scope: 14. Agriculture, Forestry and Other Land Use (AFOLU)

AFOLU Project Category: Agricultural Land Management (ALM)

Project Type: This is a large project and a grouped project.

¹ Briggs, Mark & Lozano-Cavazos, E. & Poulos, Helen & Ochoa-Espinoza, Javier & Rodriguez-Pineda, Jose. (2019). The Chihuahuan Desert: A Binational Conservation Response to Protect a Global Treasure. 10.1016/B978-0-12-409548-9.11966-9.

² State of North America's Birds 2016. 2016. *Grasslands*. [online] Available at: <<https://www.stateofthebirds.org/2016/habitats/grasslands/>> [Accessed 19 January 2022].

³ Witwicki, D., Munson, S. and Thoma, D., 2016. Effects of climate and water balance across grasslands of varying C 3 and C 4 grass cover. *Ecosphere*, 7(11).

⁴ Silva-Hidalgo, H., Estrada-Gutiérrez, G., Calderón-Fernández, M., Astorga-Bustillos, F. and Lourdes Villalba, M., 2017. EFFECTS OF CLIMATE CHANGE ON WATER AVAILABILITY IN A HYDROLOGICAL WATERSHED LOCATED IN AN ARID REGION IN THE NORTH-CENTRAL PORTION IN MEXICO. In: *IWRA World Water Congress*. [online] Cancun, Mexico. Available at: <https://www.iwra.org/member/index.php?page=286&abstract_id=4108> [Accessed 28 March 2022].

⁵ Thomson, B., 2006. *Saving water, saving the river: Chihuahua, Mexico*. [online] World Wildlife Fund. Available at: <https://wwf.panda.org/wwf_news/?69260/Saving-water-saving-the-river-Chihuahua-Mexico> [Accessed 28 March 2022].

Activity Type: Improved Grassland Management (IGM): This category includes practices that demonstrably reduce net GHG emissions of grassland ecosystems by increasing soil carbon stocks.

1.3 Project Eligibility

The proposed project meets all the requirements set forth in the VCS Standard, VCS program and VCS methodology VM0042 “Methodology for Improved Agricultural Land Management⁶”, Version 01.

This is a voluntary project with the objective of promoting improved grassland management in the project area and meets all the six principles set out in section 2.2 of the VCS standard V4.4. Furthermore, to describe and justify how the project is eligible under the scope of the VCS Program, we use the criteria listed in section 2.1.1 of the VCS standard, V4.4, outlined in detail in the table below:

Criterion	Fulfilled (Yes / No)	Justification
The six Kyoto Protocol greenhouse gases.	Yes	The project results in GHG removals through soil carbon sequestration, removing CO ₂ from the atmosphere and storing it as soil carbon. Transitioning to rotational grazing is a proven way to achieve soil carbon sequestration in grasslands.
Project activities supported by a methodology approved under the VCS Program through the methodology approval process.	Yes	The project activity is supported by the VCS methodology VM0042: Methodology for Improved Agricultural Land Management (version 1.0).
Project activities supported by a methodology approved under a VCS approved GHG program, unless explicitly excluded under the terms of Verra approval.	Yes	The proposed project activity does not belong to any project categories that are excluded by VCS from being part of the VCS program.
Jurisdictional REDD+ programs and nested REDD+ projects as set out in the VCS Program document Jurisdictional and	Not Applicable	This is not a Jurisdictional REDD+ program, hence this eligibility criterion is not applicable.

⁶ https://verra.org/wp-content/uploads/imported/methodologies/VM0042_Methodology-for-Improved-Agricultural-Land-Management_v1.0.pdf

Criterion	Fulfilled (Yes / No)	Justification
Nested REDD+ (JNR) Requirements.		
Ozone-depleting substances.	Not Applicable	The proposed project activity does not involve any Ozone depleting substances

As per Annex 1 of VCS standard V4.4, this project qualifies under Agricultural Land Management (ALM) activities that increase carbon stocks in soils by adopting sustainable grazing practices.

Apart from the above, the project does not degrade any hydrological functions in the area and does not negatively affect any native ecosystems. Detailed LULC analysis of the project area has been done to ensure the project area is not cleared of native ecosystems within the 10-year period prior to the project start date.

The Global Forest Change database⁷, Global Land Cover and Land Use Change⁸ (2000–2020), and MODIS⁹ and GLAD¹⁰ datasets have been used to check the LULC of the enrolled polygons and found none of the project polygons have been developed as grasslands after clearing the native ecosystems as per VCS requirements. (Please see section 1.11 of this PD for information on the impacts of the project activities on the soil and natural vegetation). Overall, this project contributes to the development of native ecosystems and conservation of water resources.

None of the project activities in this project will involve clearing native ecosystems. Moreover, all the activities promoted help in the conservation of native grasses in the grasslands, thereby improving the organic carbon content of the soil.

1.4 Project Design

This is a grouped AFOLU project will have multiple project instances within the defined project boundary. At the time of validation, this grouped project has one project instance. In future monitoring reports, new project instances will be added. All the new instances will be verified as per the eligibility criteria outlined below and applicable guidelines and standards.

Eligibility Criteria

Inclusion Criteria for new project activity instances

⁷ Global Forest Change (storage.googleapis.com)

⁸ Potapov P, Hansen MC, Pickens A, Hernandez-Serna A, Tyukavina A, Turubanova S, Zalles V, Li X, Khan A, Stolle F, Harris N, Song X-, Baggett A, Kommareddy I and Kommareddy A (2022) The Global 2000-2020 Land Cover and Land Use Change Dataset Derived From the Landsat Archive: First Results. Front. Remote Sens. 3:856903. doi: 10.3389/frsen.2022.856903

⁹ LP DAAC - MCD12Q1 (usgs.gov)

¹⁰ GLAD | Global Land Analysis & Discovery (umd.edu)

The following paragraphs describes the minimum general eligibility criteria to be satisfied by new instances and evidence for how every criterion is fulfilled as per paragraph 3.6.16 of VCS Standard V4.4.

1. Meet the applicability conditions set out in the methodology applied to the project.

As per VM0042 version 1, each new project activity instance must demonstrate compliance with the applicability conditions set out in the methodology. The project current instance meets all the applicable conditions as detailed further in Section 3.2. and subsequent part of this section.

2. Use the technologies or measures specified in the project description.

All the new project activity instances must implement one of the activities mentioned in the project activity description in Section 1.11 of the PDD.

3. Apply the technologies or measures in the same manner as specified in the project description.

Each project activity instance must adhere to the technology specifications (mentioned in methodology / standard) employed by project activity. See Section (1.11) for more details on eligible project technologies.

4. Are subject to the baseline scenario determined in the project description for the specified project activity and geographic area.

Each new Project Activity Instance must demonstrate that the baseline scenarios comprise one or more of unsustainable grazing practices such as, but not limited to lack of clear paddock demarcation with fencing, lack of water conservation activities, continuous grazing, etc.

5. Have characteristics with respect to additionality that are consistent with the initial instances for the specified project activity and geographic area. For example, the new project activity instances have financial, technical and/or other parameters (such as the size/scale of the instances) consistent with the initial instances, or face the same investment, technological and/or other barriers as the initial instances.

Each new Project Activity Instance must demonstrate additionality as per methodology and VCS standard requirements. See section 3.5 of PD for additionality information.

6. **Where grouped projects include multiple baseline scenarios or demonstrations of additionality, such projects will require at least one set of eligibility criteria for each combination of baseline scenario and demonstration of additionality specified in the project description.**

Each new Project Activity Instance must demonstrate which of the baseline scenarios listed in the methodology will be applicable. See section 3.4 of the PD for baseline information.

In addition to the above, the following eligibility criteria for the inclusion of new project activity instances, as per clause 3.6.17 of the VCS Standard, V4.4 must be satisfied.

1. **Geographical boundaries: all new project activity instances must be located within the boundary of the United Mexican States.**

Each project activity instance included must be within the boundaries of the United Mexican States. (Details of the grasslands with geocoordinates and KML files will be part of the evidence). All the grasslands included under this project instance are in the Northern Mexico region, which is covered by vast arid regions and has two major deserts – the Chihuahuan Desert and the Sonoran Desert. (Please see section 1.12 of the PDD for more details).

2. **Comply with at least one complete set of eligibility criteria for the inclusion of new project activity instances. Partial compliance with multiple sets of eligibility criteria is insufficient.**

New Project Activity Instances must comply with the full set of eligibility criteria for the inclusion of new project activity instances in this section. The selected lands are grasslands prior to project initiation and will remain as grasslands during the project lifecycle. A detailed Land Use/Land Cover (LULC) analysis has been carried out and is available in Section 3.4 of the PDD.

3. **Be included in the monitoring report with sufficient technical, financial, geographic and other relevant information to demonstrate compliance with the applicable set of eligibility criteria and enable sampling by the validation / verification body (VVB).**

Each new Project Activity Instances must have monitoring plans that define technical, financial, geographic, and other relevant information. A detailed monitoring plan and other relevant information has been provided in Section 5 of this PDD.

4. **Be validated at the time of verification against the applicable set of eligibility criteria.**

Each new project activity Instance must be validated at the time of verification against the applicable set of eligibility criteria as listed in this section.

5. **Have evidence of project ownership, for each project activity instance, held by the project proponent from the respective start date of each project activity instance (i.e., the date upon which the project activity instance began reducing or removing GHG emissions).**

New project activity instances must demonstrate ownership by the project participant, from the start date of the project activity instance. See Section 1.7 of PDD more information.

6. Have a start date that is the same as or later than the grouped project start date:

All the new project instances must provide evidence that the activities started after the group project start date. See Section (1.8) for more information.

7. Be eligible for crediting from the start date of the instance through to the end of the project crediting period (only).

All the new Project Activity Instances must be eligible for crediting from the start date of the instance through to the end of the project crediting period (only). See Section 1.9 of PDD for more information.

8. Where inclusion of a new project activity instance necessitates the addition of a new project proponent to the project, such instances shall be included in the grouped project within two years of the project activity instance start date.

The addition of a new project proponent to Project Activity Instances shall be included in the grouped project within two years of the project activity instance start date. Boomitra will be the project proponent of this project. However, this project may have multiple implementation partners.

9. The new project activity instance must only have IPCC climate zones and USDA soil texture classes that are represented in the calibration dataset of the remote sensing technology used for soil organic carbon stock measurement.

In order for the remote sensing of soil organic carbon stock, which is used as the input to the biogeochemical model, to be considered appropriate and representative of the conditions of the new project activity instance, the new instance may not have any climate zones or soil textures that fall outside of those present in the calibration dataset of the remote sensing.

1.5 Project Proponent

Organization name	Boomitra Inc
Contact person	Chethan T. R.
Title	Director - Carbon Projects
Address	400 Concur Dr, San Mateo CA 94402, USA

Telephone	+16502825671
Email	info@boomitra.com

1.6 Other Entities Involved in the Project

Organization name	Pronatura Noreste AC
Role in the project	Recruitment, Implementation and Monitoring Partner
Contact person	Rosario Alvarez Gutierrez
Title	Executive Director
Address	Loma Grande #2623 Col. Loma Larga, Monterrey, Nuevo Leon, Mexico
Telephone	+52 818 345 1045
Email	ralvarez@pronaturane.org

Organization name	Soluciones Ganaderas de Chihuahua SRLMI
Role in the project	Implementation and Monitoring Partner
Contact person	Judith G.
Title	Biologist
Address	21 de Marzo, Guillermo Prieto 5160, Benito Juárez, 31540 Cd Cuauhtémoc, Chih., Mexico
Telephone	+52 625-138-0632
Email	ventas@sganaderas.com

Organization name	Manejo Regenerativo de Ranchos AC
Role in the project	Implementation and Monitoring Partner
Contact person	Pedro Lombana
Title	Partner
Address	Calle Los Lince 20117, Campestre Las Carolinas C.P. 11183, Chih., Mexico

Telephone	+52 (614) 493-2365
Email	pedrolombana@gmail.com

1.7 Ownership

Boomitra brings together different implementation partners who work to promote improved grazing practices by giving trainings and technical support to ranchers and bringing behavioral change in ranching practices. Boomitra has a 30-year contract and meets the longevity requirements of VCS.

Land Ownership

The project has two forms of landowners onboarded for this project – private ownership of land by individuals or organisations, and community-owned parcels of land known as Ejidos. The private ranchers have land records to substantiate their claims to the land, and these are recorded in the Public Property Registry of each state in Mexico¹¹. The ranchers enrolled under this project are required to submit the land records and Boomitra will verify the land records along with cross-verification with the partners about the ownership of land of these ranchers. The Ejidos are modelled after traditional Amerindian models of land ownership. The rights to these lands exist with the respective communities, and any activities that leverage those rights are required to get the consent of the entire community, or at least the “Ejido Council” that governs the community. All Ejidos are protected by Mexico’s La Ley Agraria (The Agrarian Law) and are recorded in the Registro Agrario Nacional¹² in Mexico City. The land records submitted by the Ejidos are cross-verified and partners have confirmed the ownership.

Credit Ownership

A carbon rights agreement is signed between the rancher (with individual private ranchers and head/president of ejidos called **ejidal commissioner**) and Boomitra where the individuals or entities enrolling their lands irrevocably assign the right, title and interest to the Greenhouse Gas Reductions and Removals thus generated on their lands during the project to Boomitra through legal agreements. This is covered by legal agreements with the individuals and/or entities enrolling their lands. Please refer to the signed carbon agreements with private ranchers and head of ejidos for further details.

The individuals and/or entities who are legally authorized to sign these agreements are those who own the carbon rights currently and for the foreseeable future extending to the longevity of the project.

At the time of validation, there are a total of 140 participating ranches(polygons) in this project. Details of their ownership has been outlined below.

¹¹ Gob.mx. 2022. Registro Agrario Nacional. [online] Available at: <<https://www.gob.mx/ran>> [Accessed 17 January 2022].

¹² Lexology. 2022. Real estate rights and registration in Mexico. [online] Available at: <<https://www.lexology.com/library/detail.aspx?g=b45b0151-eaef-4a6a-bea7-f5718f144fb7>> [Accessed 17 January 2022].

Ownership Type	Number of Ranches	Total Area (hectares)
Ejido	8	54,308.54
Private	131	499,178.01
Grand Total	139	553,486.55 ¹³

In case of private ranchers, individual owners are authorized to sign the agreement. On the other hand, in case of Ejidos, the head or president who is referred to as ejidal commissioner is authorized to sign the agreement on behalf of the community. In this project, ranchers may have signed the agreement physically on paper or using digital tools, including smartphone apps. Under the 1st Instance, Boomitra has planned 625,000 hectares of land to be part of this project and overall, we plan to onboard 2,700,000 hectares for this project under multiple instances. At the time of validation, only 553,486.55 hectares have been reported and another 71,000 hectares are under final review to be added into the 1st instance during verification. As per VCS Standard V4.4, section 3.11.4, Boomitra's control on total area is more than 80% of the total area planned in the 1st instance.

1.8 Project Start Date

Project Start Date: 4th September 2018

According to the VCS Standard, the project start date of an AFOLU project is the date on which activities that led to generation of GHG emission reductions or removals are implemented. The earliest ranchers participating in the project have incorporated improved grazing practices that has been gradually improving since 2018.

In the case of the first instance of the project the start date is the date on which ranchers began an improved livestock management practice developed by the rancher in conjunction with an implementation partner. (Supporting documents are available in a supplementary folder containing management plans for the ranches). Start dates vary from ranch to ranch, and the carbon removal is estimated uniquely for each ranch from their individual start dates.

Typically, planning and procurement for starting better livestock management is conducted immediately before the rainy season in the region (which occurs from July to September, as elaborated in Section 1.13), and the new livestock management program is put into action towards the end of the rainy season.

As the project start date, the labour hiring and wages paid receipts for Ranch El Morrión, dated September 4, 2018, is considered. These receipts mark the commencement of fencing activities, including tasks such as digging holes and demarcating paddocks, to enable rotational grazing. These efforts were further substantiated by the purchase of fencing materials, documented in an invoice dated November 15, 2018, to establish the fencing necessary for creating paddocks. The primary action that resulted in the actual generation of GHG ERRs was the implementation of rotational grazing through the

¹³ This area has been calculated using open-source software QGIS's EPSG:3857 as Coordinate Reference System (<https://epsg.io/3857>).

creation of paddocks using fencing materials. As the reduction or removal of GHG emissions began on September 4, 2018, this date is deemed the project's starting point.

It is to be noted that not all ranchers share same start date. Each ranch has different start dates and hence ER generation will depend on start date of the project activity for that ranch. Revised ERR sheet has accommodated this ERs calculated based on the start dates of the ranch.

The project is being implemented with the help of local partners who are working in this region for many years.

1.9 Project Crediting Period

The duration of the VCS project crediting period is initially 20 years with a possibility for renewal four times. The present project crediting period starts on September 4th, 2018 and ends on September 3rd, 2038.

1.10 Project Scale and Estimated GHG Emission Reductions or Removals

Project Scale	
Project	
Large project	☒

The estimated greenhouse gas emission reductions for the first Project Activity Instance (Instance 01) are summarized in the following table (after deducting buffer).

Year	Estimated GHG emission reductions or removals (tCO ₂ e)
Year 2018*	Not applicable
Year 2019	1,275,037
Year 2020	999,661
Year 2021	1,398,426
Year 2022	1,270,186
Year 2023	1,232,893
Year 2024	1,232,893
Year 2025	1,232,893

Year	Estimated GHG emission reductions or removals (tCO ₂ e)
Year 2026	1,232,893
Year 2027	1,232,893
Year 2028	1,232,893
Year 2029	1,232,893
Year 2030	1,232,893
Year 2031	1,232,893
Year 2032	1,232,893
Year 2033	1,232,893
Year 2034	1,232,893
Year 2035	1,232,893
Year 2036	1,232,893
Year 2037	1,232,893
Year 2038	1,232,893
Total estimated ERs	24,669,598
Total number of crediting years	20
Average annual ERs	1,233,480

(*For the year 2018, as per equation 33 of methodology, the initial SOC is the same in both the baseline and project scenario at the outset of the project. As a result, carbon stocks in the soil organic carbon pool in the project scenario and baseline scenario are same and hence, there will be no GHG reductions or removals.)

1.11 Description of the Project Activity

This is a grouped project. This project promotes sustainable grazing practices in Mexican grasslands. All new project activity instances including instance 01 of the grouped project follow the below mentioned project activities.

1. Rotational grazing
2. Adaptive multi-paddock grazing (rotational, livestock numbers are adjusted to match available forage as conditions change)

3. Water conservation and management

The principle and primary project activity is the implementation of rotational grazing. We work with individual landowners or community owned Ejidos, educating and enabling their transition from conventional grazing to rotational grazing for their livestock (cattle, sheep, goats etc.). This is not just a discrete transition, as we continue to work with the ranchers throughout the lifetime of the project to help them continually improve their practices.

Here are the general principles or activities of rotational grazing, as implemented in this project.

1. The ranch is divided into organized paddocks roughly similar in livestock carrying capacity. (Having the same livestock carrying capacity is not always synonymous with having the same area. When there are significant differences in vegetation between different parts of a ranch, they can be very different.)
2. Livestock cycle between different paddocks and will spend anywhere from a single day to several months in a single paddock, to prevent overuse of any single paddock
3. Livestock will not return to the same paddock more than once or twice a year
4. Some paddocks may be rested for more than one year to allow recovery

Some of the major advantages of rotational grazing are:

- ✓ Increased soil fertility
- ✓ Decreased wastage of forage
- ✓ Increased quality of forage production
- ✓ Increase water infiltration and soil water holding capacity

Rotational grazing of livestock provides time for the vegetation to regrow following a grazing event and for the vegetation itself to reproduce and propagate further. Herds of livestock inside a fixed paddock under rotational grazing are less selective in their foraging patterns than those operating in a continuous grazing scenario. Under continuous grazing, the livestock prioritize eating their preferred grasses and plants¹⁴, often leaving undesirable invasive species and a variety of shrubs uneaten¹⁵. This phenomenon has directly resulted in the conversion of most of these grasslands to shrublands over the past centuries. On the other hand, herds undergoing rotational grazing lead to a uniform impact of foraging across different plant species, reducing the chance of promoting potentially invasive plant species that increase in the presence of continuous grazing. Herds confined to a paddock also produce concentrated hoof impacts on the soils within the paddock, breaking up harmful surface crusts that promote sheet erosion

¹⁴ List and discuss the types of grazing. Forage Information System. (2016, January 8). <https://forages.oregonstate.edu/nfgc/onlineforagecurriculum/instructormaterials/availabletopics/grazing/types>

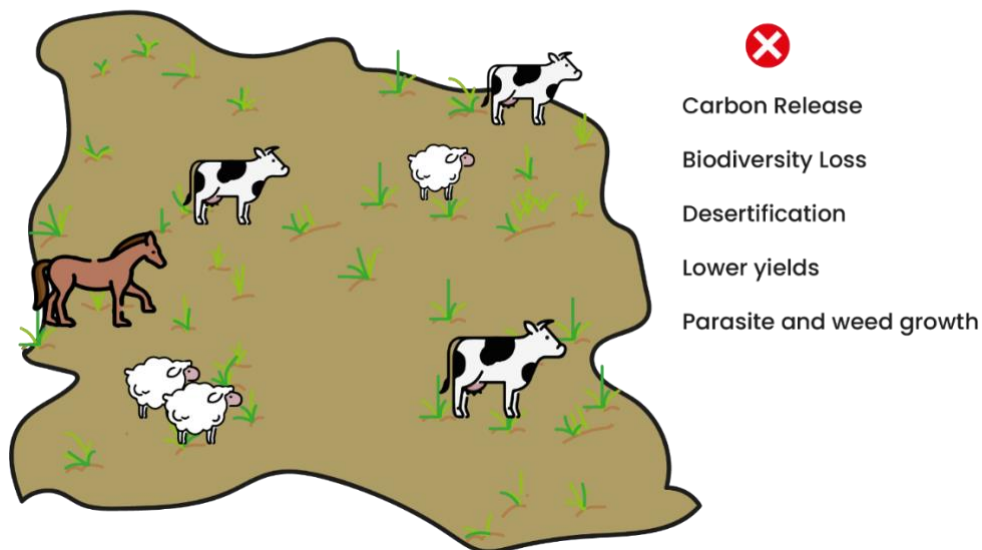
¹⁵ Annette C. Longland, 18 - Pastures and pasture management, Editor(s): Raymond J. Geor, Patricia A. Harris, Manfred Coenen, Equine Applied and Clinical Nutrition, W.B. Saunders, 2013, Pages 332-350, ISBN 9780702034220, <https://doi.org/10.1016/B978-0-7020-3422-0.00018-3>, (<https://www.sciencedirect.com/science/article/pii/B9780702034220000183>)

and decrease rainfall infiltration. This enhances the soil structure and environment, making it more amenable to both plant growth and the storage of carbon. Altogether, the decomposition of the roots of the regenerated vegetation over time, combined with the return of carbon to the soil from livestock dung, lead to increases in soil carbon levels, effectively sequestering CO₂. The rotational grazing process, as contrasted with continuous grazing, is displayed below.

At present, all the information on paddock demarcation for rotational grazing has been recorded manually in the notebook at the ranch level. It has been planned, with the help of Carbon Finance, to digitize all data collection related to rotational grazing. Many ranchers do not have a permanent fencing system. Wired fences are made temporarily, and these fences are kept moving throughout the year.

Continuous Grazing

Continuous grazing gives livestock ongoing access to the entire pasture and often leads to overgrazing.



Rotational Grazing

Under rotational grazing, only one portion of pasture is grazed at a time, allowing the rest of the pasture to 'rest'. To accomplish this, pastures are subdivided, and livestock are moved between paddocks according to changing conditions.

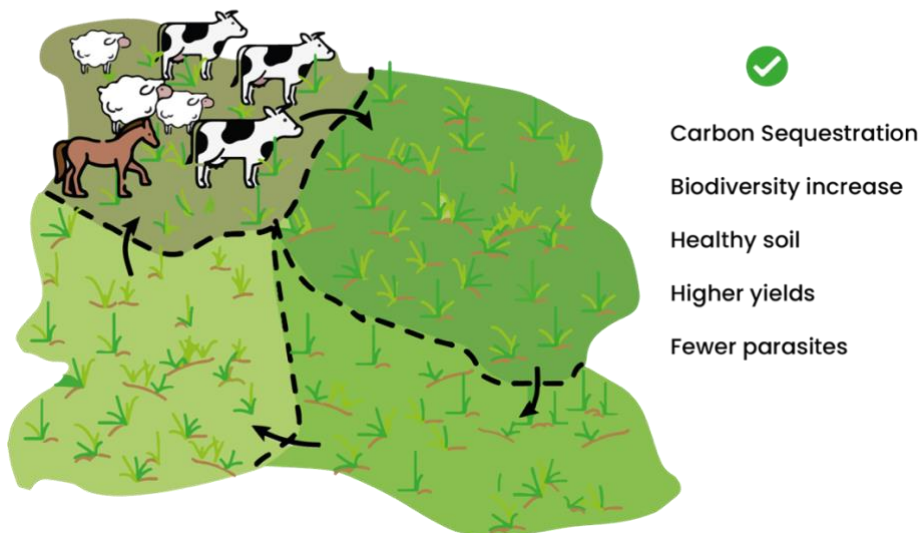


Figure 1: Baseline Scenario (Continuous Grazing) vs Project Scenario (Rotational Grazing)

On the other hand, continuous grazing has led to the loss of the upper soil, low regeneration of the plants/grass, promotion of invasive species, conversion of grasslands to shrublands or even barren lands, excess runoff of rainwater, inadequate forage for livestock, and more. Thus, the differences between ranches utilizing continuous grazing and rotational grazing are quite stark, as seen in Figure 2.



Figure 2: A ranch participating in the project (left) with healthy grass and a ranch not participating in the project (right) with observable overgrazing

Optionally, since this is an arid region, some ranchers are also encouraged to adopt various water conservation related measures that enhance biomass growth and thus increase soil carbon. As discussed in Section 1.1 and in section 1.13, ranchers in the project area are facing serious water availability issues due to less rainfall in the region. Project areas are located in arid regions of northern Mexico and have been experiencing severe water scarcity. The region is highly prone to flash floods – wherein a large amount of rainfall occurs in just a few hours and the water from the ensuing rainfall moves very fast across the land surface before reaching the endorheic seasonal lakes of the region. Very little water infiltration occurs in highly degraded lands with sparse vegetation, and thus most of the rainwater is lost and unavailable for regenerating the land. Water conservation practices are used to mitigate this loss and some examples of these interventions include:

1) Keylines



Figure 3: Keylines freshly drawn on a sloped terrain

Keylines are lines that are selectively ploughed by the rancher (either with tractors or livestock) that are parallel to the natural contours. These may be utilized in ranches that have noticeable elevation variations and enable infiltration of rainwater to occur more effectively at the key line. This allows for biomass to grow better in and around the key line from the enhanced soil moisture and increases soil organic carbon.

2) Gabions



Figure 4: A gabion built on a seasonal stream of a ranch

Gabions are rock walls/dams that are set up in areas that have streams or other significant regions of sloped water flow. They hold back water, allowing for its accumulation and thus gradual infiltration increasing soil moisture, enhancing biomass growth and thus soil carbon. The gabions are constructed with rocks and stones sourced from the surroundings.

3) Ponds & Microbasins



Figure 5: A microbasin (left) and a pond (right) dug a few years ago. Part of the ridge surrounding the edges of the pond can be seen near the rancher in the top-right portion of the image

These features also lead to water accumulation and aid in gradual infiltration of water into the soil¹⁶. The improved soil moisture allows grass to grow better in these areas than in others. These features are

¹⁶ Sui, Yuanyuan & Ou, Yang & Yan, Baixing & Xu, Xiaohong & Rousseau, Alain & Zhang, Yu. (2016). Assessment of Micro-Basin Tillage as a Soil and Water Conservation Practice in the Black Soil Region of Northeast China. PloS one. 11. e0152313. 10.1371/journal.pone.0152313.

usually made using tractors or livestock. Sometimes the ponds and Microbasins are also seeded by collecting seeds from grasses in the surroundings.

In the rugged terrains of northern Mexico, ranchers have embraced a dynamic approach to grazing, despite the challenges posed by steep slopes. These ranchers have diverse array of livestock like cattle, sheep, and horses, harmoniously roaming across the varied landscapes of paddocks including these steep hill terrains. Through careful management and strategic planning, these ranchers facilitate grazing practices that not only sustain their livestock but also nurture the delicate balance of the ecosystem. Grazing in the steep terrains of northern Mexico grasslands is common due to lack of forage availability in all seasons and combination of factors, including the adaptability of livestock, innovative ranching techniques, and the natural resilience of the ecosystem. Despite the rugged terrain, certain grasses, and vegetation types of flourishes in these areas, providing sustenance for grazing animals. Especially during summer, the forage on the plain lands and foothills of the mountain is scarce. Ranchers are forced to move towards the higher slopy mountains. Since they have to move cattle to the top of the mountain, ranchers face challenges in providing water to the cattle. Under continuous grazing, the cattle could simply walk across the ranch to water points, but in order to implement rotational grazing, water points must be strategically located within or near the paddocks, even in the mountainous areas. To tackle this problem ranchers have started building water storing structures by pumping water from lowlands using solar energy.



Figure 6: Water storage structure for Livestock grazed at Hilly terrains

Furthermore, ranchers' deep knowledge of local topography, weather patterns, and vegetation cycles and well-designed management plans allows them to make informed decisions about when and where to graze their animals. They understand the importance of balancing livestock needs with the long-term

health of the ecosystem, particularly in fragile mountain environments where vegetation recovery can be slow.

A few examples of implementing paddocking in these ranches is represented in the following figures.

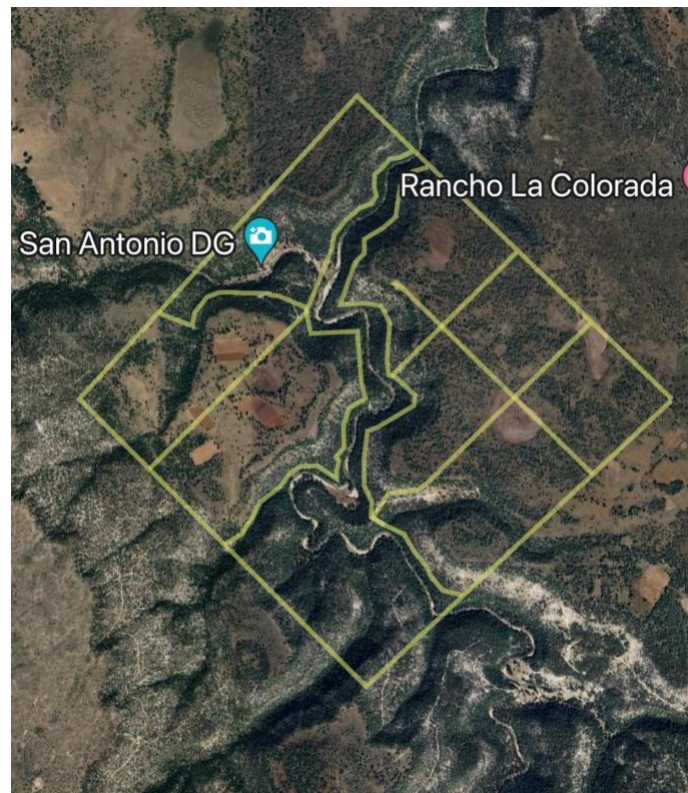
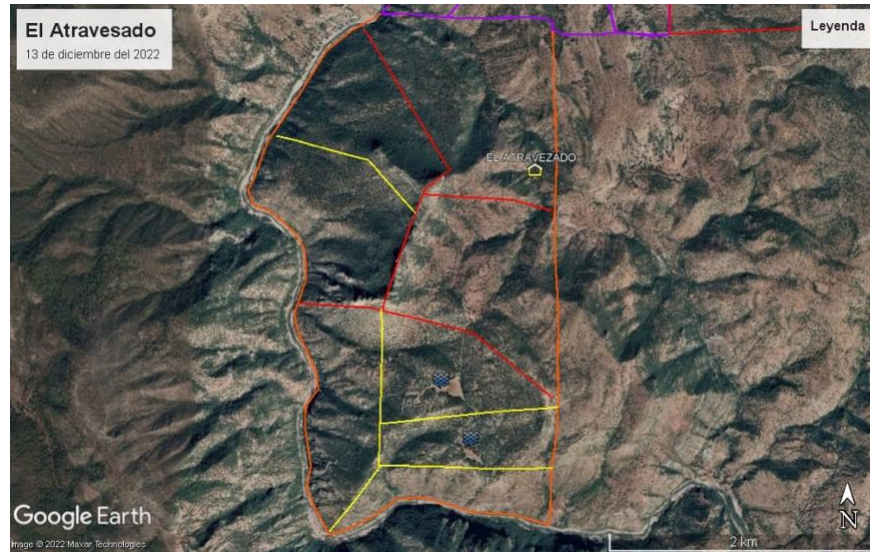


Figure 7: A plan of Project Ranch Paddock Demarcation



Figure 8: Paddock Demarcation



Figure 9: Images from Ranch Los Robles of Cattle Grazing. An example of an implementation schedule used by one of the ranchers is given in Figure 9. This figure shows that this ranch uses 4 paddocks (“potreros”) of 157, 174, 103 and 178 hectares respectively and the rancher uses each paddock for 15-25 days during the wet season (“verde”) and 50-80 days during the dry season (“seco”). A real comparison between a freshly grazed paddock and an actively grazed paddock in a ranch participating in the project is shown in Figure 7.

FÓRMULA DE PASTOREO
EJEMPLO

TAMADO DEL POTRERO 103 HAS DEL RANCHO 612 X PERIODO
DE DESBANDO 90 EN VERDE O 275 EN SECO
INICIO 3-JULIO - 2021

POTRERO DE LA ISLA 157 HAS 23 DIAS VERDE 19 AGO - AL	70 DIAS SECO	POTRERO DE LA CUBA 174 HAS 25 DIAS VERDE 29-JULIO AL 19 AGO - 210	78 DIAS SECO
POTRERO DEL RANCHO 103 HAS 15 DIA VERDE	46 DIAS SECO	POTRERO DE LOS CARPENTEROS 178 HAS 26 DIAS VERDE DEL 3 AL 9 JULIO - 60 17 AL 29 JULIO - 120	79 DIAS SECO

Figure 9: The “formula” or management plan used by one of the project’s ranchers to manage their livestock, as implemented since July 3, 2021



Figure 10: Cows entering a new, fresh paddock (left) that has just been opened to them after a year of rest, compared to a freshly eaten paddock (right) that the cows just left.

A significant amount of dung can be observed in the freshly eaten paddock – which ultimately contributes nutrients to the further growth of the grass. Furthermore, a uniform foraging impact across the freshly eaten paddock is visible.

Project Implementation Process

The implementation of the project will be conducted in the following steps:

1. **Initiation and Onboarding:** Identifying the stakeholders and conducting an exhaustive consultation with ranchers to understand their needs and gather inputs for field procedures. Gathering the latest research findings to incorporate into the project's field procedures. The

Technical training materials and tools are developed for recording data to be used during rancher training sessions.

2. **Training & Data collection:** Provide comprehensive training to ranchers on utilizing technical tools for accurate data recording. Monitor field activities with ground implementation staff to ensure correct data capture, specifically focusing on the number of cattle grazing and the duration of grazing in specific paddocks. Data related to baseline practices is captured during this process. Recording and maintaining data on the number of cattle and grazing durations in each paddock is conducted at this step. Conduct regular training programs and awareness campaigns aimed at improving grazing practices and fostering behavior change among ranchers.
3. **Development of Ranch Management Plan and training and capacity building of the ranchers:** Develop a generic standard operating procedure (SOP) for project implementation to guide ranchers. Facilitate each rancher in creating a customized grassland management plan in collaboration with implementation partners, considering local variables. Collaborate with private landowners or Ejidos to implement their unique rotational grazing schedules. Engage ground partners to advise landowners on best practices and develop tailored practice packages for each ranch.
4. **Monitoring and Control:** Regularly monitor and evaluate the implementation process and its impact on grassland management and cattle grazing practices. Analyze the effectiveness of implemented measures and revise strategies if needed for continuous improvement.

Training and awareness creation programs

As a part of the capacity building programs, training and awareness creation programs are planned for the ranchers. The content of the training will depend on participatory evaluation of the project's key stakeholders, ranchers. These trainings and capacity building programs help ranchers in adopting new techniques by developing the skills required. Our implementation partners have conducted various trainings cum awareness creation programs in the region to educate ranchers on sustainable grassland management practices. With the aid of carbon finance, these kinds of initiatives will continue throughout the project's lifespan to encourage ranchers to practice improved grassland management practices and boost soil organic carbon.

The following guiding principles are agreed to by ranchers to implement above grazing plan:

Private Ranchers			
Objectives	Activity	Outcome	Impact
1. Enhance Grassland Biodiversity	Collaborate on biodiversity surveys & conduct species inventories and monitoring	Increased understanding of grass species diversity and documentation on plant and animal species	Improved conservation strategies
2. Restore Degraded Grassland Areas	Implement rotational grazing plans	Regeneration of native grass species and	Enhanced ecosystem resilience

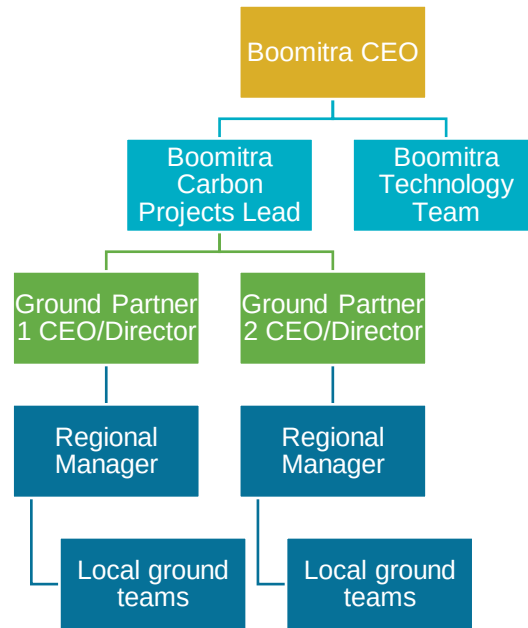
		vegetation and habitat revival	
3. Promote Sustainable Land Use Practices	Offer workshops on sustainable grazing	Improved soil fertility and grassland health	Increased productivity and sustainability
4. Engage Private Ranchers	Establish partnerships for conservation	Heightened awareness of grassland preservation	Collaborative engagement for sustainability

Ejidos (Community Ranchers)			
Objectives	Activity	Outcome	Impact
1. Enhance Grassland Biodiversity	Collaborate on grassland surveys	Increased documentation of unique grass species	Improved conservation strategies
2. Restore Degraded Grassland Areas	Implement communal land restoration plans	Restoration of native grassland habitat	Enhanced ecosystem resilience
3. Promote Sustainable Land Use Practices	Conduct workshops on sustainable land management	Improved soil quality and vegetation cover	Increased productivity and sustainability
4. Engage Ejidos	Foster community-led conservation programs	Heightened community awareness of grassland value	Empowered local stewardship

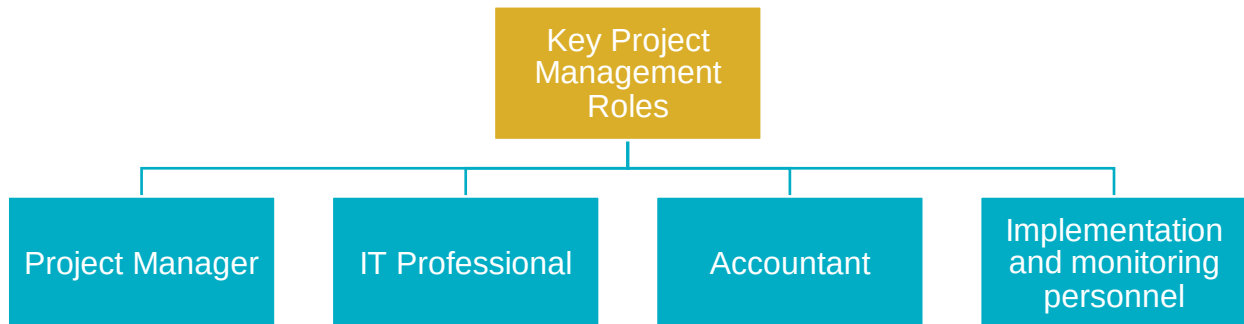
Table 1: Theory of Change

1.11.1 Project organizational setup

The project will operate under the guidance of the Boomitra carbon projects team and technology team, along with our partners. All technical support will be provided by Boomitra, and all project activities will be executed by our partners. Agreements have been made between Boomitra and local partners clearly explaining the roles and responsibilities of both Boomitra and local partners. The following organizational setup has been adopted for this project's implementation and monitoring.



Our local ground partners have been working with ranchers for many years to promote sustainable grassland management to improve soil health and create carbon sequestration. Boomitra has developed the key technology components required for the project, including the measurement of soil carbon up to a 30 cm depth and the tools and interfaces for rancher enrollment, implementation, and monitoring activities.



1.11.2 Jurisdictional REDD+ Programs

This project activity and location are not covered by any jurisdictional REDD+ program.

1.12 Project Location

Country: Mexico

States: Aguascalientes, Baja California, Baja California Sur, Chihuahua, Coahuila, Durango, Guanajuato, Nuevo Leon, San Luis Potosi, Sinaloa, Sonora, Tamaulipas, Zacatecas.

State	Longitude (W)	Latitude (N)
Aguascalientes	102°52'26.40" W 101°50'06.00" W	21°37'20.28" N 22°27'34.56" N
Baja California	118°21'54.00" W 112°17'49.20" W	28°00'00.00" N 32°43'07.32" N
Baja California Sur	115°13'26.40" W 109°24'46.80" W	22°52'19.20" N 28°00'00.00" N
Chihuahua	109°04'30.00" W 103°18'25.20" W	25°33'31.68" N 31°47'04.20" N
Coahuila	103°57'36.00" W 99°50'35.16" W	24°32'33.72" N 29°52'48.00" N
Durango	107°12'36.00" W 102°28'22.80" W	22°20'42.36" N 26°50'41.64" N
Guanajuato	102°05'49.20" W 99°40'16.68" W	19°54'46.08" N 21°50'21.84" N
Nuevo Leon	101°12'25.20" W 98°25'17.76" W	23°09'45.72" N 27°47'56.76" N
San Luis Potosi	102°17'45.60" W 98°19'33.60" W	21°09'36.72" N 24°29'29.40" N
Sinaloa	109°26'52.80" W 105°23'31.20" W	22°28'01.56" N 27°02'32.28" N
Sonora	115°03'10.80" W 108°25'26.40" W	26°17'49.20" N 32°29'38.04" N
Tamaulipas.	100°08'42.00" W 97°08'39.12" W	22°12'25.20" N 27°40'44.76" N
Zacatecas	104°21'14.40" W 100°44'30.00" W	21°02'30.84" N 25°07'30.72" N

Table 2: Geocoordinates of the States¹⁷

¹⁷ INEGI. 2020. México en cifras. [online] Available at: <<http://en.www.inegi.org.mx/app/areasgeograficas/default.aspx>> [Accessed 19 January 2022].

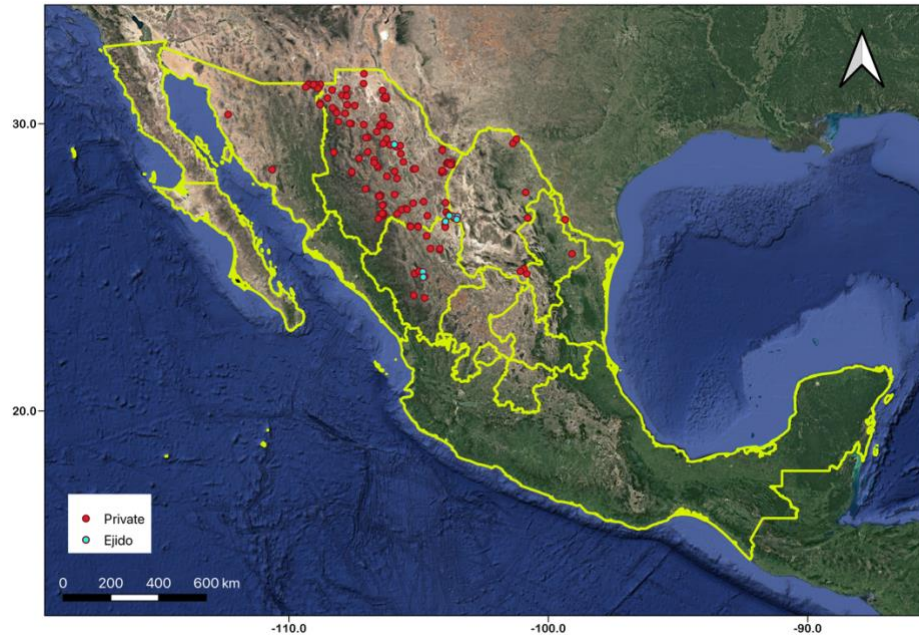


Figure 11: Instance 01 private and Ejido rancher locations



Figure 12: Political Map of Mexico¹⁸

A KML file with a more detailed set of coordinates is available separately.

1.13 Conditions Prior to Project Initiation

The conditions prior to project initiation are the same as the baseline scenario. Please refer to Section 3.4 of PDD for detailed information. This project does not have negative impacts on environmental conditions, including climate, hydrology, topography, soils, vegetation, ecosystems etc., so the present and prior environmental conditions of this project are the same. The below paragraphs give a general

¹⁸Embamex.sre.gob.mx. 2016. *Maps of Mexico*. [online] Available at: <<https://embamex.sre.gob.mx/nigeria/index.php/en/information-about-mexico/maps-of-mexico>> [Accessed 19 January 2022].

description of the existing environmental conditions of the region where the project takes place, which covers both the expansion region and the area of the first instance.

The project areas include vast lands of the Chihuahuan and the Sonoran deserts. These deserts have very rich and diversified ecosystems. The Chihuahuan Desert is considered the most diverse desert in the Western Hemisphere and one of the most diverse arid regions in the world. At the same time, due to the prevailing land management conditions, it is also one of the most endangered regions of the world.

Climate

The project location is characterized primarily by the Köppen classification BWh (hot desert), with significant areas of BWk (Cold desert), BSh (Hot semi-arid) and BSk (Cold semi-arid). Being a desert region, the project location receives very low rainfall for most of the year, with the exception of the summer months from July to September. The climate consists of hot summers and cool to cold, dry winters.

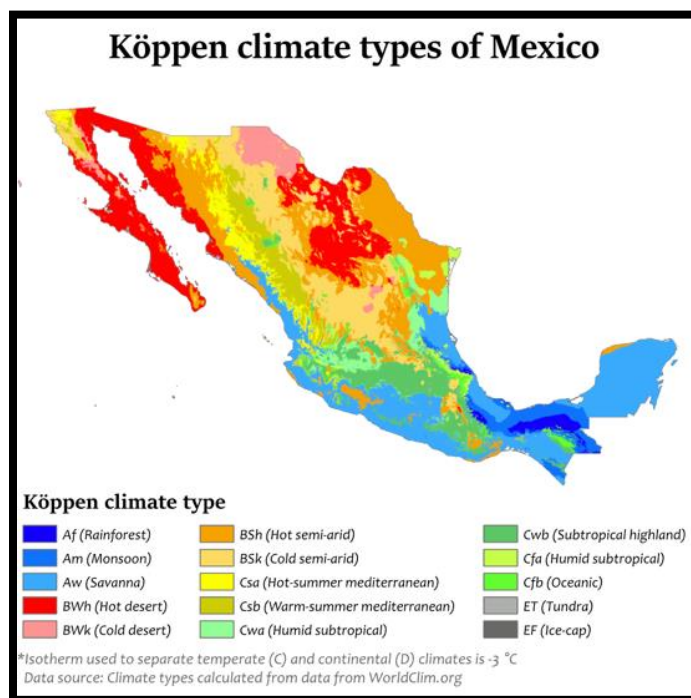


Figure 13: Köppen Climate zones of Mexico¹⁹

Hydrology

Northern Mexico has several endorheic basins, where playas form and fill during the summer rainy season²⁰. Beyond the rains of the summer months, the region is arid and as a result, there are few permanent streams or rivers, with the vast majority being seasonal. A few notable seasonal rivers are the

¹⁹ Fick, S.E. and R.J. Hijmans, 2017. WorldClim 2: new 1km spatial resolution climate surfaces for global land areas. *International Journal of Climatology* 37 (12): 4302-4315.

²⁰ Nps.gov. 2018. *Chihuahuan Desert Ecoregion*. [online] Available at: <<https://www.nps.gov/im/chdn/ecoregion.htm>> [Accessed 19 January 2022].

Nazas River and the Aguanaval River, which both drain into the Comarca Laguna region of the Chihuahua desert, an endorheic basin. The mouth of the Colorado River is in the very northern portion of the region near the border of Baja California with the state of California in the USA – however, due to prolonged droughts in the Western US and overextraction of river water for human use in the US, the river often does not reach its mouth and does not contribute meaningfully to the hydrology of the region²¹. The region is bounded in the northwest by the watershed of the permanent Rio Grande River (known as the Rio Bravo del Norte in Mexico), including the Rio Conchos, its largest tributary and the largest river in the state of Chihuahua. These hydrological features are shown in the watershed and basin maps below.



Figure 14: Major Watersheds of Mexico²²

²¹ Runyon, L., 2019. *Five Years Later, Effects of Colorado River Pulse Flow Still Linger*. [online] News.azpm.org. Available at: <<https://news.azpm.org/p/news-topical-sci/2019/4/9/149304-five-years-later-effects-of-colorado-river-pulse-flow-linger/>> [Accessed 19 January 2022].

²² Paulo Petry and Leonardo Sotomayor. 2009. Mapping Freshwater Ecological Systems with Nested Watersheds in South America. The Nature Conservancy. Available at: <<https://databasin.org/datasets/5637f67d31d94a1cb165cdbddb8c4257/>> [Accessed 19 January 2022].



Figure 15: Mexico Hydrological Basin Map

Topography

The Northern Mexico region consists of broad desert valleys (basins) bordered by terraces, mesas, and mountains (ranges)²⁰. The two main ranges are the Sierra Madre Occidental in the western portion and the Sierra Madre Oriental in the eastern portion. These are part of the North American Cordillera. The higher elevations tend to produce “sky islands” with wetter climates and coniferous forests different from the desert landscape of the surrounding region, but the sky islands are not a target implementation area for the project activity. The remaining region is largely part of the so-called Altiplanicie Mexicana or Central Mexican Plateau. It is a region with an average elevation of 1,825 m above sea level.

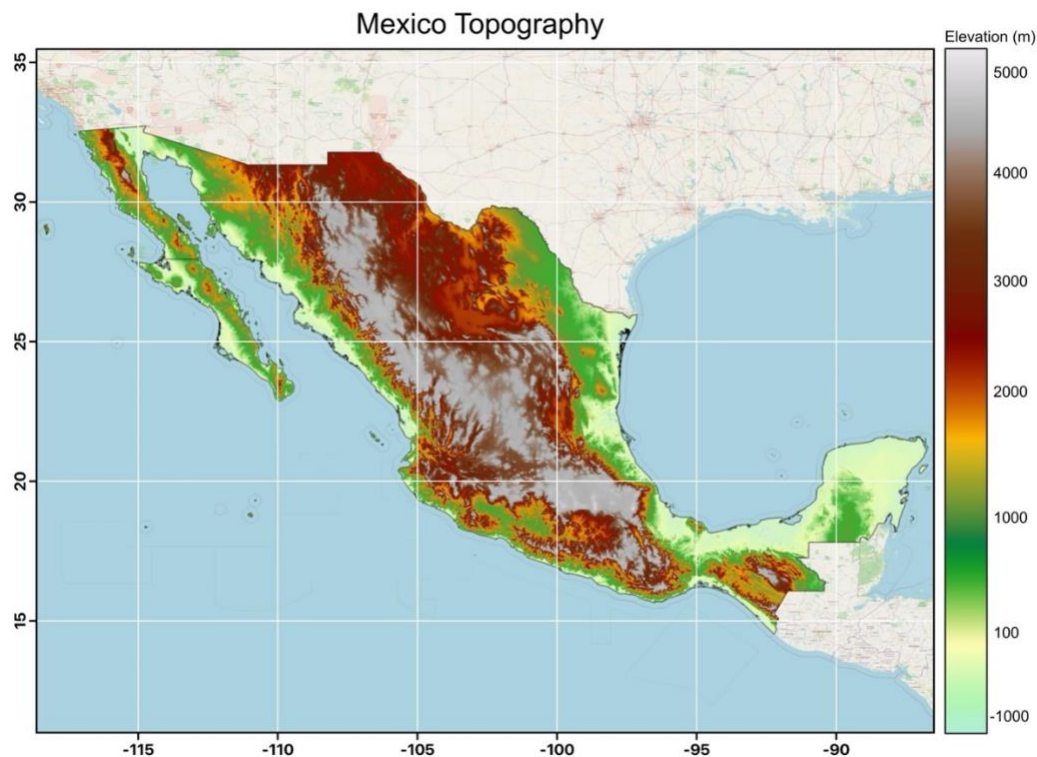


Figure 16: Mexico Topography Map

Soils

The largest soil groups in the northern regions of Mexico in the project location are Calcisols, and Leptosols. Calcisols are characterized by a strong accumulation of lime – leading to very fertile soils with high potential for natural biomass generation. Leptosols are characterized by a gravelly or stony texture and can be low in fertility and can be representative of significant erosion taking place. This erosion may be related to the existence of overgrazing in the region leading to land degradation.

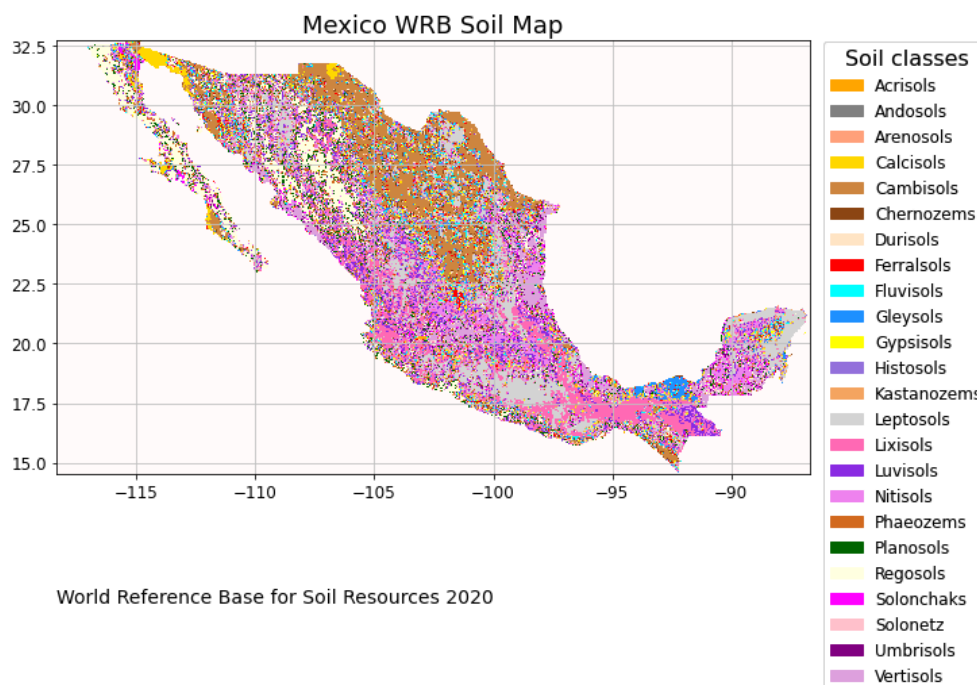


Figure 17: Detailed Soil Map of Mexico

Rainfall

Over recent years, droughts have intensified over the entire Northern Mexico region. In 2020 the region experienced a severe drought, which even led to riots²³. These kinds of severe weather events will only become more common with climate change. A recent report on drought conditions in Mexico forecasts a period of water scarcity, with supplies unable to keep up with growth in agricultural and residential water use²⁴. Also, a study states that Chihuahua is witnessing downward trend in annual precipitation and reduction in number of wet days²⁵.

²³ Agren, D., 2020. *Mexican farmers revolt over sending water to US during drought*. [online] The Guardian. Available at: <<https://www.theguardian.com/world/2020/sep/25/mexico-water-debts-us-farmers>> [Accessed 19 January 2022].

²⁴ Chavez, L., 2021. *Drought Conditions in Mexico and Its Effect on Agriculture*. [online] Available at: <https://reliefweb.int/sites/reliefweb.int/files/resources/Drought%20Conditions%20in%20Mexico%20and%20Its%20Effect%20on%20Agriculture_Monterrey%20ATO_Mexico_06-02-2021.pdf> [Accessed 19 January 2022].

²⁵ Uribe, Indalecio. (2021). Identification of changes in the rainfall regime in Chihuahua's state (México). Cuadernos de Investigación Geográfica. 10.18172/cig.5049.

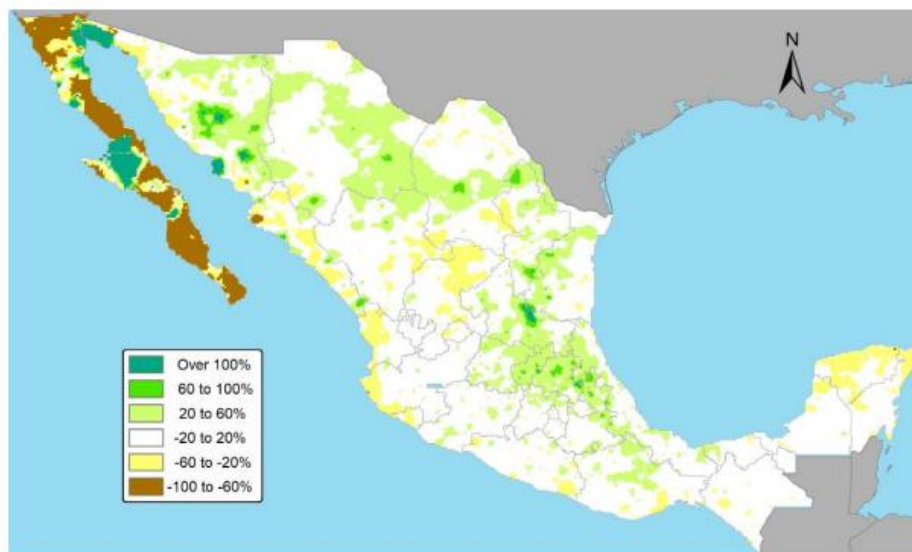


Figure 18: Deviations in rainfall from 30yr averages, for June 2021. Source: INIFAP

Mean annual precipitation is 725 mm, with steady rainfall occurring throughout the year, but occurring mostly from June to October. In the far north, rainfall is less than 50 mm per month throughout the year, while the southern regions and central highlands experience a distinct wet season from June to October, which averages 550 mm per month in the southernmost regions²⁶.

Ecosystem, Flora & Fauna and Vegetation

Northern Mexico is considered among the world's most biodiverse arid regions, with a significant presence of unique flora and fauna. For example, the Chihuahuan desert has one fourth of the world's cactus species, 170+ reptile and amphibian species, 130+ mammal species and 400+ bird species. These lands also fall in the migratory paths of many North American migratory birds who prefer to spend the winter months in these regions. Nearly 1,000 plant species can be found in this area. Some distinctive habitat types in the Chihuahuan Desert include yucca woodlands, playas, gypsum dunes, and a diverse array of freshwater habitats. Vast desert grasslands and a wide variety of yuccas and agaves, including many endemic species, also make this desert extremely unique²⁰.

The general vegetation cover is dominated by grasses, complemented by cacti, mesquite, agave and other local species²⁷. However, in degraded areas, there may be very few grasses and mostly shrubs dominating the landscape, along with reduced biodiversity. Biodiversity coexists along with the livestock that are owned by the ranchers – primarily cattle, goats, sheep and horses.

²⁶ Mexico - Climatology | Climate Change Knowledge Portal (worldbank.org)

²⁷ Williams, C., Olson, D., Valero, A. and Allnut, T., n.d. *Southern North America: Northern Mexico into southwestern United States*. [online] World Wildlife Fund. Available at: <<https://www.worldwildlife.org/ecoregions/na1303>> [Accessed 19 January 2022].



Figure 19: Some of the vibrant fauna observed on the ranches participating in the program. From left to right: a Rattlesnake, a Chihuahua Desert Horned Lizard, a Bolson Tortoise (or Mexican Giant Tortoise), and a Mexican Prairie Dog. The latter three are endemic.

Historical Conditions

Please refer to Section 3.4 Baseline Scenario for the historical conditions of how the land has been managed prior to the project activity being implemented. Due to the maintenance of this baseline scenario and the knowledge barriers noted in the Additionality checks (Section 3.5), it is clear that GHG emissions were not purposefully generated for their subsequent reduction/removal/destruction.

Centuries prior to the establishment of the baseline scenario of Section 3.4 (before the Spanish Conquest), the region was dominated by nomadic tribes. Livestock grazing was unknown in the region, as there were no cattle, goats, sheep or horses in the Americas. Furthermore, prior to the Conquest, herds of bison would move in migratory groups throughout the “Great Bison Belt” ranging from Canada

to Northern Mexico²⁸. As the bison migrated, they would naturally move from pasture to pasture, without causing any given section of land to become degraded. The threat of predation by wolves caused the bison to graze in tight herds, resulting in localized grazing similar to a managed paddock. The project activity of rotational grazing effectively mimics the kinds of conditions that existed before the arrival of land ownership structures and livestock rearing businesses as we know today.

1.14 Compliance with Laws, Statutes and Other Regulatory Frameworks

Project activities are intended to follow all applicable legal and regulatory requirements of local, state and national policies. There are no laws today in Mexico that prevent the implementation of the proposed project activity. The below table lists the relevant laws and how the project complies with them.

Law name and description	Project Compliance
Article 4 of the Political Constitution of the United Mexican States, which says that any person has the right to a healthy environment for their development and well-being. Environmental damage and deterioration will generate a liability for whoever provokes them in terms of the provisions by the law ²⁹ .	The project does not have any activity that has negative effects on the health of the environment and the communities. Please see SDGs in Section 1.17 (SDG 2, 13 and 15).
General Law on Climate Change (2012): This law stipulates aligning activities on mitigation and adaptation between the different government entities. It sets certain emission reduction goals for the future to generate at least 35% of power with clean technologies by 2024 and to reduce emissions by 30% by 2020, and 50% by 2050 compared to 2000 ³⁰ . This law also emphasizes adaptation measures to strengthen the resilience of natural and human systems. These measures aim to reduce social and environmental vulnerability.	The project has activities that are aligned to activities on mitigation and adaptation between the different government entities as discussed in the law. Please see SDGs in Section 1.17.
The General Law of Ecological Balance and Environmental Protection (Ley General del Equilibrio Ecológico y Protección al Ambiente) (Ecology Law); the General Wildlife Law (Ley	The project helps to improve biodiversity in the region. Vegetation is allowed to grow and stay on the ground for longer, thereby allowing for degraded grasslands to be

²⁸ Isenberg, Andrew C. The Destruction of the Bison: An Environmental History, 1750-1920. New York: Cambridge University Press, 2000.

²⁹ Universidad Nacional Autónoma de México. 2015. *Constitución reordenada y consolidada*. [online] Available at: <<https://www2.juridicas.unam.mx/constitucion-reordenada-consolidada/en/vigente>> [Accessed 19 January 2022].

³⁰ IEA. 2012. *General Law of Climate Change (Mexico)*. [online] Available at: <<https://www.iea.org/policies/8683-general-law-of-climate-change-mexico>> [Accessed 19 January 2022].

Law name and description	Project Compliance
General de Vida Silvestre); and the Fisheries Law (Ley de Pesca) and the Regulation to the Fisheries Law (Reglamento de la Ley de Pesca). Recently Mexico repealed the Official Mexican Standard (Norma Oficial Mexicana (NOM)) NOM-059-ECOL-1994 and issued NOM-059-ECOL-2001. These laws and standards require that wild flora and fauna be broadly protected ³¹ .	gradually restored, and reversing desertification.
General Law for Sustainable Forest Development: this law promotes sustainable forest management to increase forest carbon stocks through active participation of vulnerable communities ³² .	The activities in this project do not involve forest carbon, but many of the general principles promoted by this law are also pertinent to running a grassland project with positive communal and environmental benefits.
Development of projects on social property: Article 9 of the Agrarian Law states that ejidos own all real property granted to them as well as any property that they may have acquired title to by any other means. The same themes are also present in Section VII of Article 27 of the Constitution, which states that Ejidos “shall have legal capacity to enjoy common possession of the lands, forests, and waters belonging to them or which have been or may be restored to them” ³³ .	Since the proposed AFOLU project involves the use of social lands (Ejidos), all contracts and agreements are based on the provisions of the Political Constitution of the United Mexican States, as well as the Agrarian Law and its regulations.
Convention on International Trade in Endangered Species of wild fauna and flora (CITES), 1973. Mexico is one of the parties that has signed this convention ³⁴ .	The project does not have any negative impact on flora and fauna. It instead helps to improve and conserve overall biodiversity and natural ecosystems.
Convention on Biological Diversity (CBD), 1992: The CBD’s aims are the conservation of biodiversity, sustainable use of biological	The project complies with this convention by promoting sustainable management of grasslands and their resources and

³¹ Commission for Environmental Cooperation. 2022. *Summary of Environmental Law in Mexico*. [online] Available at: <<https://moose.cec.org/moose/lawdatabase/mxdoc.cfm?varlan=english&topic=17>> [Accessed 19 January 2022].

³² Secretaría de Medio Ambiente y Recursos Naturales, Gobierno de México. 2018. *Ley General de Desarrollo Forestal Sustentable*. [online] Available at: <<https://www.gob.mx/semarnat/acciones-y-programas/ley-de-desarrollo-forestal-sustentable>> [Accessed 19 January 2022].

³³ *Constitution of Mexico*. [online] Available at: <https://web.oas.org/mla/en/Countries_Intro/en_mex-int-text-const.pdf> [Accessed 19 January 2022].

³⁴ Convention on International Trade in Endangered Species of Wild Fauna and Flora. 2022. *List of Contracting Parties*. [online] Available at: <<https://cites.org/eng/disc/parties/chronolo.php>> [Accessed 19 January 2022].

Law name and description	Project Compliance
resources and equitable sharing of benefits arising from their sustainable use.	improving the livelihood of dependent communities. Mexico also ratified this convention in 1992 ³⁵ .
Stockholm Declaration of the United Nations Conference in Human Environment (1972): Mexico is also one of the parties of this convention ³⁶ . The Stockholm Declaration stipulates a person's right to freedom, adequate condition of life and responsibilities towards the environment and sustainable future of the planet.	The project provides a framework whereby the Project Proponent, local communities and other relevant stakeholders can protect and restore grasslands and sustainably manage the resources available therein, leading to an improvement in the socio-economic conditions of the community.
Human Rights: Mexico has ratified all international human rights treaties ³⁷ .	This project complies with this law and does not involve any activity that violates the human rights of the communities. Boomitra follows international standards and abides with all local laws concerning labor rights and other aspects dealing with human interaction. We ensure an inclusive working environment free of discrimination at all stages of the employment life cycle, in accordance with Boomitra's ethics policy.
United Nations Declaration on the Rights of Indigenous Peoples: Mexico has voted in favor of this convention ³⁸ .	Currently, none of the lands are held by groups that are considered to be indigenous people today in Mexico – however, if any such lands are added in the future, the rights of indigenous people will be prioritized.
There are 81 International Labor Organization (ILO) conventions ratified by Mexico, out of which 68 are in force ³⁹ . Mexico has ratified ILO	The project activity does not involve production, trade or other commercial activity requiring a large labor force. The project activity does not deal with setting up

³⁵ Convention on Biological Diversity. 2022. *List of Parties*. [online] Available at: <<https://www.cbd.int/information/parties.shtml>> [Accessed 19 January 2022].

³⁶ Undocs.org. 1972. *United Nations Conference on the Human Environment: List of Participants*. [online] Available at: <<https://undocs.org/en/A/CONF.48/INF.5/rev.1>> [Accessed 20 January 2022].

³⁷ UN Treaty Body Database. n.d. *Ratification Status for Mexico*. [online] Available at: <https://tbinetnet.ohchr.org/_layouts/15/TreatyBodyExternal/Treaty.aspx?CountryID=112&Lang=EN> [Accessed 19 January 2022].

³⁸ Un.org. 2007. *GENERAL ASSEMBLY ADOPTS DECLARATION ON RIGHTS OF INDIGENOUS PEOPLES; 'MAJOR STEP FORWARD' TOWARDS HUMAN RIGHTS FOR ALL, SAYS PRESIDENT | Meetings Coverage and Press Releases*. [online] Available at: <<https://www.un.org/press/en/2007/ga10612.doc.htm>> [Accessed 20 January 2022].

³⁹ International Labor Organization. 2022. *Ratifications of ILO conventions: Ratifications for Mexico*. [online] Available at: <https://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:11200:0::NO::P11200_COUNTRY_ID:102764> [Accessed 19 January 2022].

Law name and description	Project Compliance
convention 29 and 105 on elimination of forced and compulsory labor.	a factory and recruiting employees, and hence is not complicit in restricting these freedoms and rights. The project does not involve and is not complicit in any form of discrimination based on gender, race, ethnicity, class, caste, language, religion, age, disability, nationality, sexual orientation or any other basis (ILO 100 and ILO 111).
Mexico, la Ley General de Consulta de los Pueblos y Comunidades y Afromexicanas ⁴⁰ mandates that local stakeholders from indigenous and Afro-Mexican communities be provided a very clear and communicative consultation for them to properly understand how any project impacts their communities.	Most of the inhabitants of this region and all of the participating ranches are not considered indigenous communities or Afro-Mexicans today. Regardless, this requirement is met by the full Local Stakeholder Consultation (Section 2.2).

Mexico has submitted its Nationally Determined Commitments (NDCs) to the UNFCCC, in which it has committed to reduce 22% of greenhouse gas emissions (GHG) and 51% of black carbon emissions by 2030 as compared to the baseline business-as-usual scenario (BAU). Additionally, it has committed a reduction of up to 36% of GHG emissions and 70% of black carbon emissions by 2030 compared to the BAU scenario. Economic activities included in the NDC include Transport, Power Generation, Residential and Commercial buildings, oil and gas industry, Agriculture and livestock, waste, Land use, land use change and forestry⁴¹. To achieve committed goals, Mexico has planned to improve and adapt energy efficient solutions across the sectors. Promoting sustainable agriculture, agroforestry, and other conservation practices are some of the important actions foreseen by the government. REDD+ is another important activity where the government wants to strengthen its policies and strategies to have zero deforestation.

The proposed project has a robust mechanism to identify each, and every parcel of land associated with the project to avoid any double counting of project carbon credits.

⁴⁰ CECIG. 2021. *Ley General de Consulta de los Pueblos y Comunidades Indígenas y Afromexicanas*. [online] Available at: <http://cecig.org.mx/wp-content/uploads/2021/04/Minuta_Pueblos_Indigenas_Afromexicanas_Senado_22042021.pdf> [Accessed 19 January 2022].

⁴¹ UNFCCC. 2020. *Nationally Determined Contributions*. [online] Available at: <<https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Mexico%20First/NDC-Eng-Dec30.pdf>> [Accessed 19 January 2022].

1.15 Participation under Other GHG Programs

1.15.1 Projects Registered (or seeking registration) under Other GHG Program(s)

This is a grouped project. This grouped project is neither registered in any other GHG program nor is going to register or participate in any other GHG Programs other than VCS. All new project instances to be added to this grouped project are required to demonstrate whether the project was part of any other GHG program.

Instance 01: This project instance is neither registered in any other GHG program nor going to register or participate in any other GHG Programs other than VCS.

1.15.2 Projects Rejected by Other GHG Programs

The project has not been submitted to any other GHG Programs and has not been rejected by any other GHG programs.

1.16 Other Forms of Credit

1.16.1 Emissions Trading Programs and Other Binding Limits

The project does not intend to reduce or remove, nor has reduced or removed, GHG emissions from activities that are included in an emissions trading program or any other mechanism that includes GHG allowance trading, for the GHG emission reductions or removals claimed under the VCS Program.

1.16.2 Other Forms of Environmental Credit

The project neither has nor intends to generate any other form of GHG-related environmental credit for GHG emission reductions or removals claimed under the VCS Program.

Supply Chain (Scope 3) Emissions

The main occupation of the project ranchers is livestock rearing, and their livelihood is dependent on selling livestock. As per early conversations (after the release of VCS standard V4.4) with the ranchers, we have noticed that most of the project ranchers sell to local buyers who visit the rancher directly. These buyers sell these livestock to multiple butcher units across the country. The ranchers do not have any information on the specific butcher units their livestock goes to. A regular check across all the Standards will be conducted. Partners will regularly check, monitor, and create awareness among the ranchers about the problems of double counting. In order to prevent any double counting of credits, Boomitra will closely monitor and check the supply chain and will take appropriate actions by sending emails notifying about the project and the connected VCUs with it.

As per VCS requirements, Boomitra has posted a public comment⁴² saying VCUs may be issued for the greenhouse gas emission reductions and removals associated with its projects on its website.

⁴² <https://boomitra.com/projects/boomitra-grassland-restoration-in-northern-mexico/>

1.17 Sustainable Development Contributions

Mexico has adopted a national strategy to achieve all 17 SDG goals and has a long-term vision that aims to guide the actions of the state, civil society, and private-sector actors⁴³. Since 2015, Mexico has taken various initiatives to achieve SDGs. Before the pandemic, Mexico was making decent progress in achieving the targets of all SDGs. With the help of the UN Department of Economic and Social Affairs (UNDESA), the 2030 Agenda Partnership Accelerator and the UN Resident Coordination Office (RCO), Mexico has developed a framework (UN Sustainable Development Cooperation Framework of Mexico 2020-2025 (UNSDCF)) that identifies four thematic areas that contribute to SDGs. They are 1. Equality and inclusion, 2. Prosperity and innovation, 3. Green economy and climate change, 4. Peace, justice and rule of law; and two cross-cutting areas: gender equality and women and girl's empowerment, as well as migrants and refugees⁴⁴.

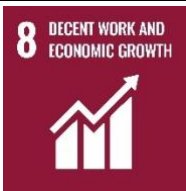
This project contributes both directly and indirectly to the mentioned thematic areas.

The grouped project contributes to the following SDGs. The below table explains about the parameter selected from each of the goals and the project impact on that particular goal.

SDG Goal	Thematic area covered	Chosen Parameter	Project Impact
	1. Equality and inclusion, 2. Prosperity and innovation, 3. Green economy and climate change,	2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.	The project activity improves soil quality by increasing Soil Organic Carbon (SOC). Higher SOC content leads to better productivity and improved soil fertility, making agricultural production more climate resilient.

⁴³ United Nations General Assembly, 2015. 70/1. *Transformar nuestro mundo: la Agenda 2030 para el Desarrollo Sostenible*.

⁴⁴ Angelino, D., 2021. *MEXICO PARTNERSHIP LANDSCAPE ASSESSMENT*. [ebook] United Nations. Available at: <<https://sdgs.un.org/sites/default/files/2021-09/Mexico%20Partnership%20Landscape%20reduced.pdf>> [Accessed 28 March 2022].

SDG Goal	Thematic area covered	Chosen Parameter	Project Impact
	Green economy and climate change	6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes	Increases in soil organic matter improve soil aggregates and structural stability, which help water infiltration into the soil by increasing soil aeration. This reduces excess runoff.
	1. Prosperity and innovation, 2. Green economy and climate change,	8.6 By 2020, substantially reduce the proportion of youth not in employment, education or training	The project provides employment to local communities during the implementation and monitoring process
	Green economy and climate change,	13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning	The project promotes sustainable grassland management practices in the project area, thereby removing CO ₂ from the atmosphere.
	Green economy and climate change,	15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world	Through rotational grazing practices, vegetation is allowed to grow and stay on the ground for more time, thereby allowing for degraded grasslands to be gradually restored, and reversing desertification.

Participating ranchers are the main affected stakeholder groups in this project. Local people from the rancher community are also employed in this project as implementation and monitoring staff. The livelihoods of the ranchers utilizing the participating ranches will be improved – both directly through the carbon credit payments and indirectly through substantial improvements to their land quality. For almost all the ranches in this project, the sole source of revenue is the sale of calves (young cattle) and kids (young goats) to the meat industry. This lack of revenue differentiation has made the ranchers very vulnerable and dependent on the grasslands for their revenue – this project provides an additional source of revenue through the carbon finance, while also improving the reliability of their primary source of

revenue (livestock sale) through improved grasslands in both quantity and quality. Rancher members have full and effective participation in defining the decision-making process and distribution mechanisms for the benefit sharing process. These are documented in the minutes of meetings. Training programs will be held for the communities during the overall implementation and monitoring process. Women and vulnerable communities will be encouraged to participate under this project. Local young people will be employed for the overall project implementation and monitoring. These employment opportunities will have a positive impact on their income. Indirect benefits of this project also include improved biodiversity in the region. Literature suggests that grazing management is an important tool to preserve biodiversity.

Furthermore, Ejidos are targeted in this project. Ejidos are communal land holdings in Mexico modelled after traditional Native American land holding customs. These Ejidos are often held by very poor and impoverished communities – our project activities are directly uplifting these communities.

The monitoring plan for the SDGs is discussed in Section 5.2.

1.18 Additional Information Relevant to the Project

1.18.1 Leakage Management

Grouped Project

Each new project instance will demonstrate that it has applied the leakage management conditions required by the methodology. If leakage is not relevant to the project activity instance, this shall be justified in the project description.

First Instance 01

There are no direct or indirect leakages expected from this project activity. The proposed activity is completely in-situ in nature, which does not contribute to indirect leakages or new emissions elsewhere. As clearly described in the project activity description section of the PDD, the activity proposed is purely to bring a behavioral change in the practices followed in the baseline. The project scenario does not involve any such activity that leads to new emissions elsewhere.

1.18.2 Commercially Sensitive Information

All information contained in this grouped project description document is not confidential and is available for stakeholders. However, information about commercials involved in project development, implementation and some of the procedures (financial audit reports, businesses forecasting model, etc.) may include commercially sensitive information because of the company's business activity.

Full information on internal procedures were shared with the VVB for auditing purposes, who can testify that all relevant information is present under this Project Description.

1.18.3 Further Information

There are no additional relevant legislative, technical, economic, sectoral, social, environmental, geographic, site-specific and/or temporal information that may have a bearing on the eligibility of the grouped project, the net GHG emission reductions or removals, or the quantification of the project's net GHG emission reductions or removals.

2 SAFEGUARDS

2.1 No Net Harm

The outcomes of the stakeholder consultations and experiences from project implementation were evaluated to assess potential negative impacts from the project activities.

As per the VCS Standard V4.4, Section 3.18, we do not foresee any net negative environmental outcomes because of project activities included in the project. For example, some of the water conservation measures can be interpreted as reducing the amount of water available to downstream locations. However, these downstream locations – the playas at the bottom of endorheic basins – do not, as of today, have significant water uses that would otherwise be detrimentally affected by water conservation measures upstream. In fact, the restored grasslands caused by the water conservation measures can lead to more rainfall in the long run (the transpiration of plants is a significant contributor to terrestrial precipitation). Finally, one could interpret the usage of restrictive paddocks as a measure that leads to environmental pressure on the livestock, as the livestock are forced to feed in a competitive manner from a restricted amount of land. However, the regeneration afforded by the paddocks leads to increased quantity and quality of grass in the long run, making it a net positive outcome for the livestock.

We also do not foresee any net negative socio-economic outcomes. Livestock numbers have not decreased, so there is no anticipation of revenue reductions from livestock rearing. In fact, revenue increases are observed for several of the ranchers since they have much healthier livestock. Furthermore, all project activities are wholly implemented within a given ranch, without any spillovers causing negative socio-economic side effects in surrounding areas.

We ensure that no invasive species are introduced into the project area. Prior to starting, experts conducted thorough checks in the project area and nearby regions to detect any invasive species. To prevent the introduction of new invasive species, strict protocols were adhered to. These protocols involved the use of native plants, thorough inspection of all items brought onto the site, and educating all involved parties about the significance of avoiding invasive species. Continuous monitoring was conducted throughout and after the project to prevent the introduction of invasive species, thereby safeguarding the environment and preserving the area's plants and animals. Additionally, the project does not endorse the presence of non-native species in the project area. No synthetic fertilizers, pesticides, herbicides, fungicides, biological agents, or other agrochemicals are currently used on the lands. These substances will not be employed in the project scenario as none of the project's components necessitate their use on the ranches.

All the information pertaining to Section 2.1 is proved at a grouped level. Hence, it is not applicable for new project instances.

As discussed in Sections 2.2 and 2.5 of this PDD, continuous and open communication channels were established to prevent and mitigate any potential previously unidentified negative impacts.

2.2 Local Stakeholder Consultation

Grouped Project

Local stakeholder consultations are undertaken at the level of the grouped project. As per the VCS Standard requirement, local stakeholder consultations have been conducted across the project location. Boomitra has devised a robust grievance mechanism (explained in detail in the below sections), which allows stakeholders to raise concerns about potential negative impacts or stakeholder grievances during project implementation.

All stakeholder consultations will:

1. Provide a non-technical project summary either on pamphlet or on electronic format to the stakeholder. The summary document contains information on project activities, the geographical location of the project, contributions to sustainable development, and key benefits to local communities.
2. Describe the grievance mechanisms available.
3. Describe risks, costs and benefits the project may bring to local stakeholders.
4. Publicize the date, time and place of consultation (if consultations are planned as group consultations)
5. Solicit feedback from stakeholders either on a physical form or through electronic media.
6. Receive stakeholders' consent and gauge their willingness to participate in this project.
7. Inform stakeholders of the process of VCS Program validation and verification, and the validation/verification body's site visit

Stakeholder consultations also include an ex-ante survey. Sampling is not applicable for this project since we are planning to meet 100% of ranchers within the project area. As a part of an ongoing consultation process and communication with local stakeholders, Boomitra, with the existing project management structure, is developing various digital platforms to provide information to stakeholders, help implementation and monitoring, and organize capacity building activities.

Local stakeholder consultations have already been completed to date. These include discussions with both the rancher communities and local academics:



Figure 20: Getting feedback from an Ejidatario (a member of an Ejido) – from left to right, the Ejidatario, Pronatura representative and Boomitra representative (Founder and CEO).



Figure 21: Discussing the project with the Director of the School of Animal Sciences of the Universidad Autónoma de Chihuahua (UACH), a major university in the region – from left to right, the Director, a university researcher and Boomitra representative (Founder and CEO)

Stakeholder meetings have been conducted as per VCS standard requirements.

As per the VCS standard 4.4, all the relevant stakeholders likely impacted by the project are consulted. Due to the COVID-19 pandemic, certain stakeholder consultations were conducted through virtual platforms such as Zoom. All ranchers who are primary stakeholders and are directly impacted by this project have been individually contacted. All other secondary stakeholders, such as the local communities excluding the specific ranchers directly involved, have been invited for meetings through local newspapers, email invitations, etc. A list of invitations and evidence is provided in Appendix 1. Local

authorities, including the Designated National Authority (DNA), were informed about this project with formal invitations. Local NGOs and academics were also invited to provide their opinions about the project. Our implementation partners have devised the management plan for each ranch in consultation with experts. So, the consultations are ongoing activity which are conducted regularly along with awareness creation programs.

Identification of stakeholder

All the relevant stakeholders are identified through a collaborative process involving Boomitra and implementation partners on the ground. The following table outlines the stakeholders identified for this project.

Primary Stakeholders	Secondary Stakeholders	Tertiary Stakeholders
Private ranchers and Ejido community ranchers	• Local authorities • DNA of the country • NGOs • Research Institutes • Local experts	• Policymakers • Government institutions • Media

As discussed in the ownership section, all lands included in this project are free from any conflicts as of now. There are two types of rancher communities – private landowners and Ejido communities. Please see Section 1.16 for details on ownership and a description of Ejidos. Beyond this distinction (private and Ejidos), there are no other substantial social, economic, or cultural differences within the rancher communities.

As discussed in Section 2.2, the stakeholders are informed about the project's contributions towards both the sustainable development of rancher communities and local biodiversity. Furthermore, they receive information on various ecosystem services that will improve from the implementation of this project, such as water purification, erosion reduction, carbon storage and climate regulation⁴⁵.

Details of specific stakeholder meetings are available in Appendix 1 of this document.

Mechanism for on-going communication with local stakeholders

To maintain ongoing communication with local stakeholders, Boomitra has devised a mechanism where all stakeholders can express their concerns through grievance mechanisms, which are discussed below in Section 2.5.

During stakeholder meetings, these mechanisms are discussed, along with the risks and benefits the project may bring to stakeholders. Through our local partners, the process of VCS registration and issuance and VVB site visits are explained. As part of the monitoring plan, monitoring personnel visit each ranch at regular intervals to observe and record the project activity status. Ranchers are provided with

⁴⁵ Fs.fed.us. n.d. *Ecosystem Services from National Grasslands*. [online] Available at: <<https://www.fs.fed.us/grasslands/ecoservices/index.shtml>> [Accessed 28 March 2022].

the contact details of project personnel to report any event or to seek any help to implement project activities. Regular trainings are provided to the ranchers on project activities and are well documented.

As discussed in Section 1.14 of this document, this project complies with all laws and regulations of Mexico, the host country.

2.3 Environmental Impact

The project activity proposed under this project does not involve the construction of new buildings or setting up new industry. The core project activity is to promote sustainable grazing practices among the ranchers. This activity does not generate any local co-pollutants or hazardous materials as a co-product.

Sustainable management of grasslands improves soil properties. Increases in soil organic matter improve soil aggregates and structural stability, which help water infiltration into the soil by increasing soil aeration and reducing excess runoff. Due to rotational grazing practices, the plants are allowed to grow and stay on the ground for more time, thereby restoring grasslands and even reversing desertification.

In addition, regenerated lands become much less likely to be converted to croplands, and the ranchers are able to maintain or improve their livelihoods without resorting to land use change. This will protect and restore biodiversity, by maintaining and improving crucial habitats for flora and fauna of the region.

There are no lands included in this project that are potentially culturally and/or ecologically sensitive. Agreements are signed between Boomitra and the ranchers, which clearly explain the rules and guidelines of the project and its associated activities.

The Mexican Secretariat of Environment and Natural Resources (SEMARNAT) is the regulatory authority that handles Environmental Impact Assessments (EIAs) of project and issues permits. Article 28 of the Mexican General Ecological Balance and Environmental Protection Law (Ley General Del Equilibrio Ecológico y La Protección al Ambiente) gives a list of the types of projects that need to undergo an EIA from the competent authority ⁴⁶. The proposed project does not require an EIA.

2.4 Public Comments

This Grouped Project was available for public comment during the period 09 March 2022 – 08 April 2022. There are no comments received during the public comments period.

2.5 AFOLU-Specific Safeguards

See section 2.2 of the PDD for local stakeholder identification process and Appendix 1 of the PDD for local stakeholder meeting results.

Grouped Project

⁴⁶ GENERAL LAW OF ECOLOGICAL BALANCE AND ENVIRONMENTAL PROTECTION. Mexico. Available at: <<https://www.global-regulation.com/translation/mexico/560296/general-law-of-ecological-balance-and-environmental-protection.html>>

All new project instances need to conduct stakeholders' consultations. However, during the baseline data collection process, key information has been exchanged with stakeholders and feedback has been taken. Please see Section 2.2 and Appendix 1 for the complete process followed for this project.

Detailed analysis of all the risks associated with the project is assessed with respect to the project area and activity (Figure 19). The outcome of the assessment will help in designing the risk criteria and indicators through analyses of the data available based on country-specific legal frameworks.



Figure 22: Risk Identified and Mitigation Plans of the Project

The above risks and mitigation plan have been discussed during the local stakeholder consultation. No risks to local stakeholder due to project implementation have been identified in the meeting. The nature of the project design is to improve stakeholder resilience to climate change.

The following table illustrates the criteria or risks assessed for this project.

Criteria	Safeguarding Principle	Assessment	Mitigation Measure
Social	Application of free, informed and fair consent	The proposed activity involves ranchers who are either private landowners or Ejidos. Our project implementation partners have been working with these rancher communities for a long time. They have conducted awareness	Not applicable

Criteria	Safeguarding Principle	Assessment	Mitigation Measure
		creation programs and capacity building trainings for the communities to address overgrazing in the area. Before the implementation of the project, the consent of the ranchers has been obtained.	
	Vulnerable groups involved	Ejidos are often poverty-stricken rural communities that do not have significant sources of income. These groups are key participants in the project activity.	Not applicable
	Support tenure and resource rights	In Mexico, land ownership consists of 2 forms. One form consists of community-owned parcels of land known as “Ejidos”, modelled after traditional Amerindian models of land ownership. The rights to these lands exist with the respective communities, and any activities that leverage those rights are required to get the consent of the entire community, or at least the “Ejido Council” that governs the community. In some instances where the Ejidos have subdivided the rights associated with a certain domain or piece of land to a subset of the community, the consent of that subset of the community is required. All Ejidos are protected by Mexico’s La Ley Agraria (The Agrarian Law) and are	Not Applicable

Criteria	Safeguarding Principle	Assessment	Mitigation Measure
		recorded in the Registro Agrario Nacional ¹¹ in Mexico City. In addition to Ejidos, there are also direct private ownerships of land by individuals or organizations, who have land records to substantiate their claims to the land, and these are recorded in the Public Property Registry of each state in Mexico ¹² .	
	Benefit Sharing	An agreement is signed with the ranchers that has information regarding the carbon revenue sharing mechanisms and other necessary legal clauses required to implement the project. An agreement is also signed with each ground implementation partner, outlining their responsibilities and revenue sharing.	Not Applicable
	Improve livelihoods, decent work and economic growth	The project provides employment to local communities during implementation and monitoring.	Not applicable
Environmental	Mitigate negative environmental impacts	This project does not have any project activity component which will result in a negative environmental impact. Instead, the project activity will allow communities to use and manage grasslands in a sustainable way. This project also does not allow for any change in land use, as per the	Not applicable

Criteria	Safeguarding Principle	Assessment	Mitigation Measure
		requirements of the adopted methodology.	
	Enhancement of Biodiversity and ecosystems	Sustainable management of grasslands will improve soil properties. Increases in soil organic matter improve soil aggregates and structural stability, which help water infiltration into the soil by increasing soil aeration and reducing excess runoff. As a result of the rotational grazing practices, the vegetation is allowed to grow and stay on the ground for more time, thereby regenerating the lands gradually and reversing desertification. These measures also restore crucial habitats for the flora and fauna of the region.	Not applicable
	Address reversals and displacement of emissions	There are reversal and non-permanence risks associated with any AFOLU project due to both human induced activities and natural disasters. There is a possibility that ranchers might go back to traditional grazing practices, or even change their land use to farming due to either internal pressures from their own community or external pressure from fluctuating parameters such as the weather. Natural risks such as heavy rainfall, drought and earthquakes	Boomitra is employing the latest VM0042 methodology from VCS to estimate net carbon removals from the project. As per the methodology, a project-level buffer needs to be created and the number of buffer credits to be contributed to the AFOLU pooled buffer account must be determined by applying the latest version of the

Criteria	Safeguarding Principle	Assessment	Mitigation Measure
		cannot be reasonably forecasted in the long term, which will affect the overall efficacy of the project. These risks are beyond human control. Our methodology of choice, VM0042, assumes no leakage/displacement of emissions, given that various aspects of the methodology are met, which are expatiated further in Section 4.3. Our project meets these requirements.	VCS AFOLU Non-Permanence Risk Tool. This is an exhaustive tool that accounts for possibilities of direct and indirect (avoidable/unavoidable) reversals of the carbon removals. Beyond the buffer pool, the project also directly works to mitigate risks that can be controlled through human activities. For example, the possibility of ranchers returning to traditional grazing practices or changing their land use to farming is reduced through the educational work of our ground partners, who are chosen for their high level of trust in their local communities, which has been acquired over the course of decades. As a result, rural communities strongly trust the recommendations of our ground partners,

Criteria	Safeguarding Principle	Assessment	Mitigation Measure
			making them less likely to cause reversals due to changes to their behavior. Hence, the project is capable of tackling the risks resulting from reversals – through both a buffer credit pool, and the efforts of locally-trusted ground partners.
Procedural	Legal compliance	As discussed in section 1.14, the project will adhere to all requirements of local and national laws.	Not applicable
	Transparency and Stakeholder engagement	All the project related documents are available at the VCS website. Simultaneously, local stakeholders' consultations will be held, and information related to the project activities will be discussed. Workshops for the ranchers are held regularly and local stakeholder consultations are held whenever communities are enrolled.	Not applicable
	Monitoring and reporting	A detailed monitoring plan will be developed to monitor the parameters (both quantitative and qualitative information) through monitoring surveys. As and when we go for verification, we conduct a detailed monitoring survey of	Not applicable.

Criteria	Safeguarding Principle	Assessment	Mitigation Measure
		the stakeholders with exhaustive questionnaires to get their feedback. Simultaneously, we undertake several capacity-building programs and awareness creations programs in the project area, and we collect feedback from the stakeholders. This will enable us to understand the project's impacts on sustainable development of the communities, as well as the grasslands.	
	Grievance mechanism	Boomitra has developed a proper multi-level grievance addressal model to handle any grievances arising during the project cycle. This is one of the key requirements to be met as per global standards. The grievance address mechanisms are discussed in all stakeholder consultations. (See the below paragraphs for details)	Not applicable

Along with above safeguards, Boomitra and its implementation partners do not involve in any form of discrimination or sexual harassment. Boomitra follows international standards and abides with all local laws when it comes to workforce and other sensitive aspects of project. We ensure an inclusive working environment free of discrimination at all stages of the employment life cycle, promote and create plans to allow different cultures to thrive by providing a conducive environment to flourish.

As per VCS Standard v4.4, Section 3.18, a local stakeholder consultation meeting (see Appendix for more details) was conducted to evaluate impacts and raise concerns about potential negative impacts and mitigation strategies have been designed based on the discussions. Through the outcomes of the consultation, it is clear that the project does not have any negative impact on the local stakeholders.

Institutional setup for Safeguards

Boomitra has developed a proper multi-level grievance addressal model to handle any grievances arising during the project cycle. This is one of the key requirements to be met as per global standards. These grievance addressal mechanisms are discussed in all stakeholder consultations and made available to all relevant stakeholders in the project area. All project participants that will be implementing AFOLU activities need to operate in a synchronized manner in order to take better and effective decisions, and for carbon finance and Boomitra to incentivize actions that are in alignment with national policies and internationally agreed objectives. Achieving the desired results requires adequate supporting human resources, including dedicated professional staff at different levels. A mutually accepted Safeguard and Safeguard information System will be formulated to ensure that AFOLU activities do no harm to people or the environment, mitigate the risks of adverse environmental and social impacts of AFOLU activities, and promote benefits beyond carbon emission reductions.

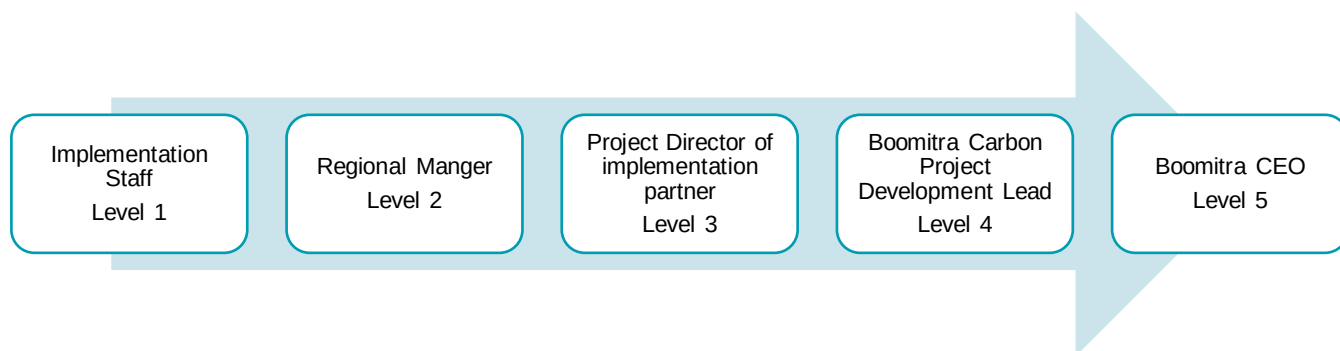


Figure 23: Level-wise grievance mechanism

Figure 20 depicts the level-wise grievance mechanism adopted under this project. Project participant communities will be provided with access to all channels (registers maintained at regional offices/head offices, phone numbers, and emails) available for them to register grievances.

The following table outlines the structure of the grievance mechanism channels available for stakeholders.

Mechanism type	Method Chosen (include all known details e.g., location of book, phone, number, identity of mediator)	Justification of Choice (best practice)
Continuous Input / Grievance Expression Process Book	Physical register has been maintained at each implementation partner head office.	Ranchers who do not have access to internet or phone can come directly to the office and register their grievance.
Telephone access	Pronatura Noreste AC : +52-818-345 1045	Ranchers can call this number to register their grievance
	Soluciones Ganaderas de Chihuahua SRLMI: +52-625-138-0632	

	Manejo Regenerativo de Ranchos AC: +52-614-493-2365	
Internet/email access	info@boomitra.com	Ranchers who have an internet connection can contact through this method

Boomitra has established a response time of 20 business days to respond to any grievance received from stakeholders.

3 APPLICATION OF METHODOLOGY

3.1 Title and Reference of Methodology

The details of the methodology and tools applied for the grouped project are given below:

Title	Improved Agricultural Land Management ⁶
Version	1.0
Reference	Approved VCS Methodology VM0042
Version date	19 th October 2020
Sectoral Scope	14
Tools and Modules Applied	1. AFOLU Non-Permanence Risk Tool to estimate buffer credits as per VCS standard requirement⁴⁷ (Dated 19th September 2019, version 4.0) 2. VMD0053 Module: Model calibration, validation, and uncertainty guidance for the methodology for improved agricultural land management⁴⁸ (dated 19th October 2020, version 01)

3.2 Applicability of Methodology

Grouped Project

All new activities must meet applicability conditions listed in the below table, which must be demonstrated with justification in the project document.

Instance 01

47 AFOLU Non-Permanence Risk Tool - verro.org. https://verro.org/wp-content/uploads/2019/09/AFOLU_Non-Permanence_Risk-Tool_v4.0.pdf

48 VMD0053 model calibration, validation, and uncertainty guidance for the methodology for improved agricultural land management, 1.0

The following table provides details of how project Instance 01 is eligible under Section 4 of the VM0042 methodology:

Applicability Condition	Justification
Projects must introduce or implement one or more new changes to pre-existing agricultural management practices Which • Reduce fertilizer (organic or inorganic) application; • Improve water management/irrigation; • Reduce tillage/improve residue management; • Improve crop planting and harvesting (e.g., improved agroforestry, crop rotations, cover crops); and/or • Improve grazing management.	The project activities are new activities implemented by the landowners relative to the baseline scenario. The current baseline scenario is continuous unsustainable grazing on community-owned or privately-owned grasslands. The proposed project activity introduces and expands new sustainable improved grassland management practices such as rotational grazing on subdivisions of ranches known as paddocks.
Project activities must be implemented on land that is either cropland or grassland at the project start date and remains cropland or grassland throughout the project crediting period (i.e., land use change is not eligible, including conversion from cropland to grassland and grassland to cropland).	The project is implemented on grasslands. The land has remained grassland prior to the project and after the start of the project. This is the natural state of the land, which has been verified by satellite images over the past 10 years (provided separately in a folder named Ranch_landsat_images_2007-2021)
The project area must not have been cleared of native ecosystems within the 10-year period prior to the project start date.	Detailed LULC analysis of each participating grassland has been carried out. Analysis of these satellite images and LULC confirms that these lands have remained grasslands and are not converted or cleared of any native ecosystems.
The project activity is not expected to result in a sustained reduction of greater than 5% in productivity, as demonstrated by peer-reviewed and/or published studies on the activity in the region or a comparable region.	Literature on rotational grazing has been developed for several decades and does not suggest any significant changes to productivity. During the interactions with the ranchers, we have received the same opinion on productivity. There are various studies conducted at different grasslands and suggests that productivity and sustainability may be compatible by replacing continuous with rotational grazing⁴⁹.

⁴⁹ Jacobo, Elizabeth & Rodríguez, Adriana & Bartoloni, Norberto & Deregibus, Victor. (2006). Rotational Grazing Effects on Rangeland Vegetation at a Farm Scale. Rangelands. 59. 10.2458/azu_jrm_v59i3_jacobo. (http://dx.doi.org/10.2458/azu_jrm_v59i3_jacobo)

Applicability Condition	Justification
	This will be confirmed during the verification stage with proper studies.
If the project activity involves the application of biochar, it must be produced using feedstock that would otherwise have been left to decay in aerobic or anaerobic conditions or been burned in an uncontrolled manner. Eligible feedstocks include one or more of the following categories of biomass: • Crop residues; • Material from pruning or thinning of woody vegetation (not including merchantable timber) in agricultural systems such as shade trees, orchards, windbreaks, stream buffers, silvopasture, or invasive removal on rangeland; • Off-cuts, sawdust, and other material produced as a by-product of forest management or harvesting operations; • Diseased trees or deadwood felled during plantation or woodland management; and/or • Residential, commercial, or industrial organic food or yard waste. There may not be any other carbon incentive awarded for the production of biochar applied on the project area.	This is not applicable for this project since no project activity promotes biochar as a soil amendment.
The project activity cannot occur on a wetland. Note that this condition does not exclude crops subject to artificial flooding where it can be demonstrated that crop cultivation does not impact the hydrology of any nearby wetlands.	The project area is not a wetland. The project is implemented on grasslands. The land has remained a grassland prior to the project and will remain the same after the start of the project. It is an arid land as noted in Section 1.13

Table 3: Applicability Criteria

Additional conditions where models are applied:

The project uses the process-based RothC model to estimate stock change/emissions in both the baseline scenario and with-project scenario.

1. Is this model publicly available?

Yes, RothC is publicly available and fully documented at the Rothamsted Research website⁵⁰.

⁵⁰ Rothamsted Carbon Model (rothc). Rothamsted Research. <https://www.rothamsted.ac.uk/rothamsted-carbon-model-rothc>

2. **Shown in peer-reviewed scientific studies to successfully simulate changes in soil organic carbon and trace gas emissions resulting from changes in agricultural management included in the project description.**

RothC has been shown to be applicable in grasslands around the world, for various management conditions including continuous grazing^{51,52}, and rotational grazing^{53,54}.

3. **Able to support repetition of the project model simulations. This includes clear versioning of the model use in the project, stable software support of that version, as well as fully reported sources and values for all parameters used with the project version of the model. Where multiple sets of parameter values are used in the project, full reporting includes clearly identifying the sources of varying parameter sets as well as how they were applied to estimate stock change/emissions in the project. Acceptable sources include peer-reviewed literature and statements from appropriate expert groups (i.e., that can demonstrate evidence of expertise with the model via authorship on peer-reviewed model publications or authorship of reports for entities supporting climate smart agriculture, such as FAO or a comparable organization), and must describe the data sets and statistical processes used to set parameter values (i.e., the parameterization or calibration procedure).**

RothC 26.3, the most widely available and used version, is used for all calculations. Specific calibration methods to determine parameters for each Practice effective/Crop Functional Group in each climate zone are determined using field trial data from peer-reviewed literature, and these details will be provided in the latest model validation report at the time of each verification.

4. **Validated per datasets and procedures detailed in VMD0053 “Model Calibration and Validation Guidance for the Methodology for Improved Agricultural Land Management”, with model prediction error calculated using datasets as detailed in the same module, using the same parameters or sets of parameters applied to estimate stock change/emissions in the project**

The Model Validation Report will provide the validation methods and prediction error quantification, as detailed in VMD0053 at the time of each verification.

General description of RothC model

The Roth-C model, also known as the Rothamsted Carbon (RothC) model, is a biogeochemical model widely used for simulating carbon dynamics in agricultural and natural ecosystems. Developed by scientists at the Rothamsted Research Institute in the United Kingdom, the model aims to understand

51 Smith, S. W., Vandenbergh, C., Hastings, A., Johnson, D., Pakeman, R. J., Wal, R. van der, & Woodin, S. J. (2013, December 6). Optimizing carbon storage within a spatially heterogeneous upland grassland through sheep grazing management - ecosystems. SpringerLink. <https://link.springer.com/article/10.1007/s10021-013-9731-7>

51

52 Jebbari, A., Álvaro-Fuentes, J., Pardo, G., Almagro, M., & Prado, A. del. (n.d.). Estimating soil organic carbon changes in managed temperate moist grasslands with Rothc. PLOS ONE. <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0256219>

53 Bolinder, M. A., Chan, K. Y., Farage, P. K., Janssen, P. H. M., Jeffrey, S. J., Kemmitt, S. J., Lal, R., Lima, A. M. N., Liu, D. L., Moore, A. D., Paul, K. I., Smith, P., Bertora, C., Brumme, R., Chen, G., & Coleman, K. (2011, August 4). Simulation of soil organic carbon dynamics under different pasture managements using the ROTH carbon model. Geoderma. <https://www.sciencedirect.com/science/article/pii/S0016706111001947>

54 Poeplau, C. (2016, August 24). Estimating root: Shoot ratio and soil carbon inputs in temperate grasslands with the ROTH carbon model - plant and Soil. SpringerLink. <https://link.springer.com/article/10.1007/s11104-016-3017-8>

and predict the processes involved in carbon cycling, specifically the decomposition and turnover of organic matter in soils over time.

The Roth-C model operates based on a pool-based approach, where organic carbon is categorized into different pools based on its decomposition rate and stability. The model considers several key processes and factors that influence carbon dynamics.

Carbon Inputs: The model takes into account the inputs of organic carbon, such as plant residues, root exudates, and other organic materials added to the soil.

Decomposition: Roth-C simulates the decomposition of organic carbon, considering factors like temperature, moisture, and microbial activity. It distinguishes between active, slow, and passive carbon pools based on their turnover rates.

Climate and Soil Factors: The model incorporates climatic variables like temperature and precipitation, as well as soil properties such as texture, organic matter content, and pH, to estimate decomposition rates and carbon turnover.

Management Practices: Roth-C considers the effects of agricultural and grassland management practices on carbon dynamics, such as tillage, crop rotation, and organic amendments. These practices can influence the input of organic carbon and its subsequent decomposition rates.

Soil Carbon Balance: By simulating the inputs and outputs of carbon in the soil, the Roth-C model provides estimates of the net carbon balance over time, including carbon sequestration or loss.

The model has been calibrated and validated using field measurements and long-term experiments, allowing it to be applied in various agricultural and grassland systems and land use scenarios. It has been used globally to assess the impacts of management practices, land use changes, and climate change on soil carbon stocks, greenhouse gas emissions, and overall soil health. The RothC model used in this project has been shown to be applicable in grasslands around the world, for various management conditions including continuous grazing^{55,56} and rotational grazing^{57,58}. Several peer-reviewed field trial

⁵⁵ Smith, S. W., Vandenberghe, C., Hastings, A., Johnson, D., Pakeman, R. J., Wal, R. van der, & Woodin, S. J. (2013, December 6). *Optimizing carbon storage within a spatially heterogeneous upland grassland through sheep grazing management - ecosystems*. SpringerLink. <https://link.springer.com/article/10.1007/s10021-013-9731-7>

⁵⁶ Jebari, A., Álvaro-Fuentes, J., Pardo, G., Almagro, M., & Prado, A. del. (2021). *Estimating soil organic carbon changes in managed temperate moist grasslands with Rothc*. PLOS ONE. <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0256219>

⁵⁷ Bolinder, M. A., Chan, K. Y., Farage, P. K., Janssen, P. H. M., Jeffrey, S. J., Kemmitt, S. J., Lal, R., Lima, A. M. N., Liu, D. L., Moore, A. D., Paul, K. I., Smith, P., Bertora, C., Brumme, R., Chen, G., & Coleman, K. (2011, August 4). *Simulation of soil organic carbon dynamics under different pasture managements using the ROTHc carbon model*. Geoderma. <https://www.sciencedirect.com/science/article/pii/S0016706111001947>

⁵⁸ Poeplau, C. (2016, August 24). *Estimating root: Shoot ratio and soil carbon inputs in temperate grasslands with the ROTHc model - plant and Soil*. SpringerLink. <https://link.springer.com/article/10.1007/s11104-016-3017-8>

datasets exist for the proper validation of the model within the IPCC climate zones and soil textures found in this project^{59,60}.

The above referred literature studies suggest that when a RothC model is properly calibrated, the uncertainty in measuring SOC change compared to field trial data is 0.2-0.5 ton CO₂eq/acre/year for each field trial simulation site (in this project, this would constitute each ranch). Given that the net carbon sequestration estimated in this project per acre per year is much higher than this uncertainty threshold (see Sections 4.4.2 and 4.4.3), the uncertainty is expected to be sufficiently low to permit the measurement of the carbon sequestration to statistical significance.

Hence, the RothC model is valid and applicable for this project.

3.3 Project Boundary

Grouped Project

The Grouped Project and each new project instance will define their project boundaries as per the VM0042 V1.0 methodology.

The carbon pool included is outlined in the following table.

⁵⁹ Ryan C. Byrnes, Danny J. Eastburn, Kenneth W. Tate, & Leslie M. Roche. (2018). Journal of Environmental Quality - ACSESS - Wiley Online Library. <https://acsess.onlinelibrary.wiley.com/doi/abs/10.2134/jeq2017.08.0313>

⁶⁰ Elsevier. (2017, November 6). *Critical review of the impacts of grazing intensity on soil organic carbon storage and other soil quality indicators in extensively managed grasslands*. Agriculture, Ecosystems & Environment. <https://www.sciencedirect.com/science/article/pii/S0167880917304693>

Carbon Pool	Included?	Justification/ Explanation of Choice
Aboveground tree biomass	No	None of the project activities promoting any activities which increase woody biomass. Due to rotational grazing, biomass of grass does increase, but it is herbage dry matter, rather than woody biomass ⁶¹ . Hence, the above ground biomass is not included in the carbon pool in the project.
Aboveground non-tree biomass	No	As per VCS rules this has been excluded. (VM0042, table 2)
Belowground biomass	No	Project does not involve any activity which contributes to belowground tree biomass and there is no provision set aside to monitor this parameter
Dead wood	No	As per VCS rules, this has been excluded. (VM0042, table 2)
Litter	No	As per VCS rules, this has been excluded. (VM0042, table 2)
Soil Organic Carbon	Yes	Included as per VCS AFOLU Requirements as the landcover under the baseline scenario is comprised of grasslands. The proposed project activity increases this pool in the project scenario.
Wood Products	No	As per VCS rules, this has been excluded. (VM0042, table 2)

Table 4: Carbon Pools

The GHG sources project boundary is outlined in the following table.

Source		Gas	Included?	Justification/Explanation
Baseline	Soil Organic Carbon	CO2	Yes	Primary stock changing due to rotational grazing and other project activities
	Soil Organic Carbon	CO2	Yes	Primary stock changing due to rotational grazing and other project activities

Project activities are taking place throughout the project area, and primarily affect soil organic carbon. All other stock or pool changes are deemed de minimis relative to the total net anthropogenic GHG reductions and removals. Insignificant emission sources are excluded according to the VCS rules.

All other GHG sources (CH₄ and N₂O) have been excluded from the project boundary since none of the project activity involves impacting these sources. As per the methodology (Section 5), where the increase in greenhouse gas emissions from any project emissions or leakage source, and/or decreases in carbon stocks in carbon pools, is less than five percent of the total net anthropogenic GHG emission reductions and removals due to the project, such sources and pools may be deemed de minimis and may be ignored.

⁶¹ M. W. Jordon, K. J. Willis, P.-C. Bürkner, G. Petrokofsky, Rotational grazing and multispecies herbal leys increase productivity in temperate pastoral systems – a meta-analysis. Agriculture, Ecosystems & Environment. 337, 108075 (2022).

(i.e., their value may be accounted as zero). This will be assessed in the verification stage using the tool (CDM A/R methodological Tool) specified in VM0042 methodology.

There is no statistically significant leakage because livestock numbers are not decreasing in a statistically significant manner, at least as seen for the initial crediting period – as measured through continuous rancher-attested livestock counts, which will be presented in the monitoring report. Furthermore, the methodology explicitly requires that decreases in livestock emissions due to a reduction in livestock numbers not be accounted for credit. Hence, livestock-associated enteric emission changes are not included, as they are also considered de minimis.

Spatial Boundaries

The spatial boundaries of the project area consist of the grasslands located in the Mexican states of Aguascalientes, Baja California, Baja California Sur, Chihuahua, Coahuila, Durango, Guanajuato, Nuevo Leon, San Luis Potosi, Sinaloa, Sonora, Tamaulipas and Zacatecas. The geo-fenced boundaries of individual project areas will be clearly demarked as per Section 5 of the methodology and will be available at any point when new areas are added. The digital files of individual ranches have been submitted as Keyhole Markup Language (KML) files, as required by the VCS Standard.

At the current time, 553,486.55 hectares (at the time of validation⁶²) are covered by this project, out of the 647,500 sq.km total area of the Chihuahuan Desert and 260,000 sq.km total area of the Sonoran Desert, which will serve as areas for future project instances to expand into.

3.4 Baseline Scenario

Grouped Project

As per the methodology, *“For each sample unit, a schedule of activities in the baseline scenario will be determined by assessment of practices implemented during the period prior to the project start date. The interval over which practices are assessed, x years, must be a minimum of 3 years and include at least one complete crop rotation, where applicable. Where a crop rotation is not implemented in the baseline, x = 3 years”*.

The baseline scenario is identified as unsustainable grazing practices that have led to grassland degradation to a large extent. In the absence of this project activity, ranchers will continue unsustainable grazing, which further degrades grasslands.

The current “baseline” practice is continuous or otherwise unsustainable grazing, whereby animals repeatedly graze throughout a ranch in small groups, simply as a consequence of the most convenient and least time and energy demanding deployment of livestock. Such types of grazing have been maintained for at least 3 years prior to the ranchers’ starting their current improved management practices. However, in almost all cases, it has been maintained for much longer – with many decades of continuous grazing occurring. This is substantiated by the lack of significant local knowledge on rotational

⁶² As mentioned in Section 1, the number of ranchers participating in the program is projected to grow over the course of the crediting period through additional instances. However, Instance 01 area will be fixed at the first verification stage.

grazing prior to its introduction by ground partners, and the general history of the land use over the past few centuries. Overgrazing over the course of this period of time has changed the grassland composition in the project area – resulting in the promotion of invasive species at the expense of native perennial grasses that are preferably eaten by livestock. The populations of nearly 20 vertebrate species have been detrimentally affected and the land’s capacity to support livestock has decreased⁶³.

Mexican grassland grazing history dates back to the 16th century, soon after the Spanish Conquest. It was the Spanish who brought cattle, sheep, goats, donkeys and horses to Mexico, as they were not endemic to the New World. The conquest of Northern Mexico occurred several decades after the establishment of New Spain – and a major allure for Spanish settlers around the end of the 16th Century was the existence of vibrant grasslands. The grasslands were exceptionally vibrant to the point where even wild cattle that escaped from ranches in southern and central Mexico and formed their own herds would make their way to the north to feed on the grass. The settlers in the region (who were often nobility of New Spain, missionaries or other wealthy individuals) quickly established massive haciendas (the imperial Spanish term for an estate), with over 150,000 cattle per a hacienda, which itself could be larger than 65,000 km². The pastures were, in the words of contemporary observers, “inundated with cattle”, suggesting that the quantity of livestock was already in extreme excess. This trend of large haciendas with even larger amounts of cattle continued through the end of the colonial period and even past Mexican independence in 1821, all the way up to the early 20th Century. Notably, the largest landowner in North America at the time was Luis Terrazas of Chihuahua, who owned 6,740,000 acres and raised as many as 140,000 calves a year. Many of the ranches participating in the project today from the state of Chihuahua were originally part of Terrazas’ ranch⁶⁴.

Then came the Mexican Revolution in 1910 – which was largely fomented by rural unrest due to this significant level of inequality. One of the key measures that came out of the revolution was the codification in the new Mexican Constitution that every ranch could only have as much land as needed to raise 500 cattle, or equivalents for other kinds of livestock⁶⁵. Thus, in pursuit of land reform, the federal government began confiscating large ranches and either selling smaller pieces of land to private individuals or assigning them to “Ejidos”. An Ejido (from the Latin word exitus or way-out) means a field outside human settlements or towns that is used for livestock or orchards. Today, in Mexico, it refers to communal lands granted to rural communities unconditionally by the government in the aftermath of the Mexican Revolution to reduce rural inequality and the rural unrest that led to the Revolution. In Mexico, there are about 53,000 ejidos with approximately 3,000,000 ejidatarios (2.6% of the total population) that occupy about 82,420,000 hectares, representing 42% of the total area of the country⁶⁶.

⁶³ Eric Mellink, Mónica E. Riojas-López; Livestock and grassland interrelationship along five centuries of ranching the semiarid grasslands on the southern highlands of the Mexican Plateau. *Elementa: Science of the Anthropocene* 1 January 2020; 8 20.

⁶⁴ Brand, D., 1961. The Early History of the Range Cattle Industry in Northern Mexico. *Agricultural History*, [online] 35(3), pp.132-139. Available at: <<https://www.jstor.org/stable/3740624>> [Accessed 19 January 2022].

⁶⁵ Constitute Project. 2015. *Mexico’s Constitution of 1917 with Amendments through 2015*. [online] Available at: <https://www.constituteproject.org/constitution/Mexico_2015.pdf?lang=en> [Accessed 19 January 2022].

⁶⁶ Data Basin. 2017. *Ejidos of Mexico*. [online] Available at: <<https://databasin.org/datasets/a5e789aa10fb4efbbd8b7b5a1cf8d423/>> [Accessed 19 January 2022].

Northern Mexico is covered by vast arid regions and 2 major deserts – the Chihuahuan Desert and the Sonoran Desert. The Chihuahuan Desert spans 647,500 km² across Northern Mexico and the Southwestern United States of America. It is the largest desert in North America, covering the states of Chihuahua, Coahuila, Durango, Zacatecas, Nuevo León, and San Luis Potosí in Mexico and Arizona, New Mexico and Texas in the United States of America. Furthermore, the Chihuahua Desert holds a unique position among deserts in the Americas from other perspectives: it receives much more rain, a necessity for building biomass and enabling carbon sequestration, than nearby deserts such as the Sonoran and Mojave deserts. Another side-effect of this increased precipitation is enhanced biodiversity. The Chihuahua desert is considered among the world’s most biodiverse arid regions, with a significant presence of unique flora and fauna, including one-fourth of the world’s cactus species, 170+ reptile and amphibian species, 130+ mammal species and 400+ bird species²⁰.



Figure 24: The Chihuahuan Desert

The Sonoran Desert spans 260,000 km² across Northern Mexico and the Southwestern United States of America, and is primarily located in the states of Sonora, Baja California and Baja California Sur in Mexico, and Arizona and California in the USA. This desert also has some very unique endemic flora and fauna, including the famous Saguaro Cactus, and 350 bird species, 20 amphibian species, and more⁶⁷.

These arid regions of Northern Mexico are now under threat from a variety of anthropogenic causes, particularly overgrazing. Overgrazing occurs when plants are subject to heavily intensive grazing from livestock, leading to severe loss of vegetation. Unsustainable ranch management by pastoralists throughout the region has led to severe land degradation, desertification and loss of soil carbon, resulting in CO₂ emissions – lands that were formerly vibrant grasslands have been converted into barren surfaces with loosely scattered shrub vegetation. And when they become unable to sustain their livelihoods on their degraded ranches, ranchers are sometimes forced to sell their land to farmers who convert the

⁶⁷ Malone, M., n.d. *Birds of the Sonoran Desert*. [online] Available at: <<https://animals.mom.com/birds-sonoran-desert-3312.html>> [Accessed 19 January 2022].

grasslands into croplands, resulting in further CO₂ emissions. In addition, it represents a significant loss of habitat for the fauna of the region, coupled with the replacement of the natural flora with crops^{68,69}.



Figure 25: Ejidos Lands

Since the land reforms of the 20th century, there has been a mixture of livestock grazing on these lands including sheep, goats, horses and donkeys, with the vast majority being cattle. Paradoxically, the division of the huge landholdings into smaller private ranches and Ejidos has led to further overgrazing and loss of grass due to poor management. Particularly in Ejidos, a tragedy of the commons has developed, leading to significant grassland loss⁷⁰. This trend of subdivision coupled with loss of grass cover has also led to further devastating consequences for the biodiversity – not only are native flora under heightened pressure from invasive plants, but even major fauna, such as the American Bison, went extinct in this region over the past century⁷¹.

⁶⁸ Briggs, Mark & Lozano-Cavazos, E. & Poulos, Helen & Ochoa-Espinoza, Javier & Rodriguez-Pineda, Jose. (2019). The Chihuahuan Desert: A Binational Conservation Response to Protect a Global Treasure. 10.1016/B978-0-12-409548-9.11966-9.

⁶⁹ State of North America's Birds 2016. 2016. *Grasslands*. [online] Available at: <<https://www.stateofthebirds.org/2016/habitats/grasslands/>> [Accessed 19 January 2022].

⁷⁰ Morett-Sánchez, J. and Cosío-Ruiz, C., 2017. Panorama de los ejidos y comunidades agrarias en México. *Agricultura Sociedad y Desarrollo*, 14(1), p.125.

⁷¹ Maldonado, C., 2021. *México reintroduce el bisonte americano 100 años después de su desaparición*. [online] El País. Available at: <<https://elpais.com/mexico/2021-01-07/mexico-reintroduce-el-bisonte-americano-100-anos-despues-de-su-desaparicion.html>> [Accessed 19 January 2022].

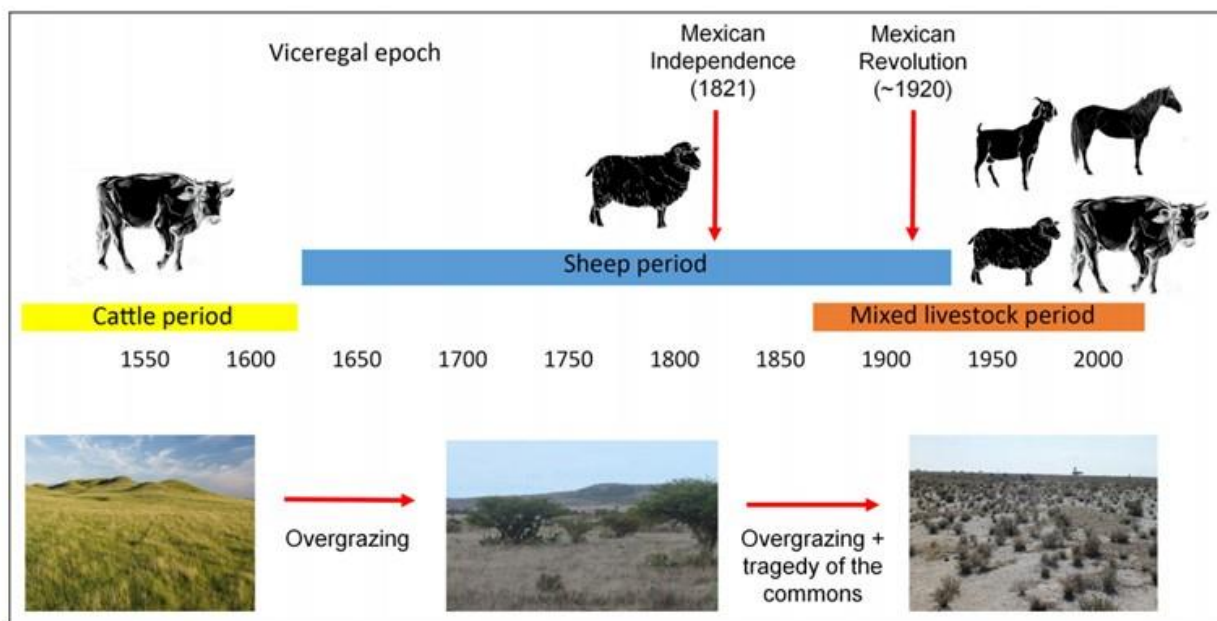


Figure 26: Livestock ranching on grasslands in the southern part of the Mexican Plateau⁶³

The above image shows the consequences of unsustainable grazing practices that have led to land and soil degradation.

As per the VM0042 methodology's Table 4 on minimum specifications on management practices for baseline scenario, a baseline survey was conducted.

The baseline survey was conducted to evaluate the scenario in the project area before the start of the project. The baseline questionnaires used for the survey are attached in Appendix 03. All the ranchers' part of the project were interviewed for the survey. Each of these ranchers have attested the survey and provided their responses. Details of livestock stocking rates and grassland management activities have been captured in the survey.

Based on the analysis of this survey the results were developed. The primary attributes from VM0042's table 4 that are relevant to this project are the "Animal Type" and "Animal Stocking Rate". Since these are open rangelands, crops are not grown on these lands, and there is no irrigation, tillage or any kind of nitrogen application used (these practices are unheard of for rangelands in Mexico). Continuous grazing in Mexico involves allowing livestock to roam freely over a pasture without rotational rest periods. This unsustainable practice leads to overgrazing, where livestock continuously feed on the same areas, depleting vegetation and compromising soil health. Without proper rest periods, plants don't have time to recover, leading to reduced forage quality, soil erosion, and diminished biodiversity, ultimately degrading the grassland ecosystem^{67,68}. Continuous livestock grazing is the primary land use and livelihood activity. No active grazing management is taking place, so livestock continuously graze the available grasslands in a deregulated approach. The primary types of livestock grazed are cattle, sheep, goats, and horses at varying stocking rates across the project areas. The baseline survey was conducted to collect information for a period of 3 years ($t=-3$) prior to the project start date i.e., from 2015 to 2018.

In accordance with VM0042 Methodology Box 1, Option 3 was followed⁷² i.e., determination via consultation with, and substantiated with a signed attestation from the landowner of the sample field during that period was chosen to collect quantitative and qualitative data. Hence the data gathering was done via consultation & discussions with ranchers, verified and attested by the landowner of the ranches. However, this project solely considers SOC (Soil Organic Carbon) for calculating emission reductions; none of the survey parameters are utilized in these calculations. Furthermore, an expert opinion has been sought to analyze the status of all chosen project activities in the region during the project's commencement, as detailed in the additionality section.

Baseline data collection process

All the ranchers that are part of the project were interviewed for the survey; hence the sampling is 100%. The survey was followed by a telephonic conversation with the ranchers to understand the scenario better and get deeper understanding of the baseline scenario. The following observations have been summed up after careful observation of the baseline surveys. (Refer baseline survey excel sheet for complete data):

1. Ranchers confirmed that the ranches were not involved in any cropping or harvesting activities as the area was and is under grazing practice only.
2. As per the survey conducted, the ranch was not under the usage of synthetic or nitrogen fertilizer. All the ranchers confirmed this through the attested baseline survey.
3. The specifications related to crop planting and harvesting, nitrogen fertilizer application, tillage and/or residue management are not applicable. All the respondents have mentioned that no crop production, compost, and synthetic N fertilizers are used or practiced in the baseline scenario. Any area defined as cropland is considered non-eligible area and excluded from the eligible project areas.
4. None of the respondents have mentioned about practicing tillage and crop residue removal as a management activity in the baseline scenario as the land parcels are grasslands and involved in grazing.
5. Irrigation and water management practices like gabions, keylines, ponds etc., was not a part of the rancher's management practices in the baseline scenario.
6. Among the 171 surveyed respondents, it was noted that three years prior to the project's commencement, the ranchers employed continuous or unplanned grazing methods. Between 2015 and 2017 i.e., in baseline scenario, all the ranchers maintained continuous or unplanned grazing, yet following the project's initiation there was a shift in the practices towards improved grazing. In the

⁷² As per Box 1 of the methodology, certain quantitative information inputs required by the model selected in qualification approach 1 needs to be collected using any one of the 4 options provided in Box 1. In this project, combination of option 1 and 3 have been used to collect some baseline information. Since this is a grassland project and there are no cropping practices involved in this project, many of the sub-options suggested in the methodology are not applicable. For example, receipts or invoices, farm equipment specifications, logs or files containing machine and/or sensor data, etc. is not applicable since there are no activities in the baseline scenario which are associated with the given options. Only the stocking rates and type of animals need to be reported for the parameter P_{bsl} and Day_{bsl} which have been collected after checking rancher cattle logbooks maintained at the ranch level. Rest of the baseline information has been collected using option 3 which is via consultation and substantiated with a signed attestation from the rancher of the sample field during that period.

first instance of this grouped project, at the time of validation, 106 ranchers out of the 171 surveyed ranchers are participating in the project. All the 106 ranchers who are part of the project practiced continuous grazing or unplanned grazing. However, this is to note that the rancher who were practicing improved grazing before the project start date are not part of the project.. Before the project implementation, the cattle were grazed throughout the ranch throughout the year i.e.. 365 days

7. The ranchers have diverse array of animal type present in surveyed ranches during the baseline scenario include cattle, horses, sheep, etc. Ranchers have provided the count of each of the animal type present in the ranch. (Please refer Appendix 4 for the count of animals and types during the baseline scenario).
8. Livestock count of various breeds of animals grazed at the ranch was also collected to understand the year-on-year change and general productivity of the ranch. Among the animals grazed on the ranch, cattles are the animals predominantly grazed which include various breeds of bulls, cows, heifers, steers, and calves in the project area. These ranchers rear and graze a combination of different animals. The total count of cattle on a ranch are in the range between 20 to 3500 animals per ranch. The ranch also includes horses ranging between 10 to 300 per ranch and a few sheep, goat, donkey, etc as well. (Please refer Annexure 4 for the count of animals and types during the baseline scenario).
9. The annual livestock count on the ranch was collected for the years of 2015 to 2021. Data pertaining to livestock count from 2015 to 2017 was gathered, revealing a consistent upward trend in the total number of animals present on the ranch.
10. Information gathered from ranchers regarding the number of herds and details about grazing areas or paddocks indicates a lack of proper herd division and paddock allocation. Additionally, there was a failure to appropriately allocate resting days for the paddocks or grazing areas.

The baseline soil carbon levels at each project site (ranch) have been measured using remote sensing technology⁷³ using satellites throughout the entire electromagnetic spectrum in a proprietary data fusion and machine learning model. This satellite mix allows Boomitra to directly probe the soil at depths around ~30cm. (Details of this technology usage are being provided to the VVB during validation and verification process). The soil carbon stock change in the baseline scenario is further dynamically modeled for each project site (ranch) for each monitoring period by using the Roth-C model. Further information on baseline procedures is also in Section 3.4.

Livestock Population

This project involves rancher communities in the project area. These rancher communities comprise both private individual ranchers, and community ranchers known as Ejidos. Cattle, horses, sheep, goats, and donkeys are grazed. The grazing area and livestock stocking rate varies from person to person and community to community. The ranchers manage a diverse array of livestock, predominantly consisting of cattle, horses, goats, sheep, etc. (as seen in Figure 26). The composition of animals on each ranch varies.

⁷³ VM0042, Version 1: table 6 of the methodology allows project developer to use remote sensing to measure SOC and bulk density in both baseline and project scenario.

A complete list of ranchers with all livestock details will be provided separately in an excel sheet for the VVB.

In the absence of the project, there are no plans, and no anticipation of future interventions that would be sufficient to address the various factors that contribute to depletion of SOC due to unsustainable overgrazing.

Overgrazing is the main threat to the grasslands in the project area. Severe loss of vegetation and loss of biodiversity is the outcome of overgrazing. This has led to the degradation of the grasslands and desertification to a great extent. Eventually, overgrazing has resulted in a loss of overall soil health and fertility. When perennial grasses are lost due to overgrazing, they are replaced by a sparse distribution of annuals and shrubs that do not meaningfully maintain soil organic carbon or the biodiversity. Additionally, without the project, the ranchers are incentivized to convert grasslands to croplands to continue to maintain their livelihoods. Flora, fauna and rancher livelihoods are at risk due to the trends and practices that prevail in the baseline scenario.

Livestock population density (stocking rates)

The baseline and project livestock stocking rates are not changing drastically. Appendix 4 has been added with stocking rates of the ranchers who are part of baseline data collection.

SOC stock changes under the baseline scenario are modeled using the Roth-C model for each ranch, on a monthly basis, throughout each monitoring period, following the guidelines of VMD0053. Further details on the calibration and validation of the Roth-C model are given in the Model Validation Report available at the time of verification. A draft Model Validation Report is available at the time of validation.

The baseline shall be updated every 10 years in accordance with Section 3.8 of the VCS Requirements on renewal of baselines. The procedure for updating the baseline shall be done with reference to Section 9.3 of the applied methodology. The baseline estimated for calculating carbon removals across the landscape will be re-evaluated at an interval of every 10 years from the project start date to reflect changing environmental, technological, and socio-economic scenarios. The baseline re-evaluation includes procedures available at the time of re-evaluation.

LULC analyses of Mexico reveal that the area covered by grasslands is decreasing, and open shrublands are increasing over time.

Landcover Type	2005	2008	2011	2014	2017	2019
Water	0.77	0.78	0.77	0.77	0.76	0.77
Evergreen Needleleaf forest	0.05	0.06	0.06	0.06	0.08	0.07
Evergreen Broadleaf Forest	7.81	7.76	7.41	7.56	7.31	7.34
Deciduous Broadleaf Forest	4.05	4.21	4.31	4.23	4.51	4.66
Mixed forest	0.32	0.37	0.34	0.39	0.44	0.41
Closed shrublands	0.30	0.31	0.32	0.33	0.31	0.34
Open shrublands	21.86	21.08	23.00	22.06	23.02	24.08
Woody savannas	10.72	10.99	10.75	11.01	10.97	11.65

Landcover Type	2005	2008	2011	2014	2017	2019
Savannas	17.43	17.28	18.33	18.86	18.65	18.19
Grasslands	25.29	25.93	23.96	24.33	23.51	22.40
Permanent wetlands	0.32	0.34	0.36	0.38	0.40	0.40
Croplands	7.01	6.89	6.31	6.22	6.32	6.15
Urban and built-up	0.35	0.36	0.36	0.37	0.38	0.39
Cropland/Natural vegetation mosaic	0.77	0.78	0.81	0.89	0.89	0.75
Barren or sparsely vegetated	2.95	2.88	2.90	2.53	2.45	2.40

Table 5: % of total land (by year)

Land Cover Classification	2005	2008	2011	2014	2017	2019
Evergreen Needleleaf forest	1,04,524	1,21,474	1,15,824	1,21,474	1,52,549	1,32,774
Evergreen Broadleaf Forest	1,53,33,967	1,52,35,093	1,45,48,624	1,48,45,247	1,43,65,001	1,44,15,850
Deciduous Broadleaf Forest	79,46,656	82,60,229	84,72,102	83,08,253	88,53,473	91,58,571
Mixed forest	6,21,495	7,20,369	6,58,219	7,68,393	8,67,267	8,07,943
Closed shrublands	5,90,420	6,10,195	6,21,495	6,44,094	6,18,670	6,72,344
Open shrublands	4,29,50,928	4,14,16,967	4,51,85,484	4,33,32,300	4,52,10,909	4,73,01,391
Woody savannas	2,10,51,718	2,15,79,988	2,11,25,167	2,16,30,838	2,15,43,264	2,28,79,477
Savannas	3,42,47,179	3,39,50,556	3,60,15,613	3,70,46,729	3,66,25,808	3,57,30,291
Grasslands	4,96,82,845	5,09,31,484	4,70,66,918	4,77,90,111	4,61,74,225	4,40,04,644
Permanent wetlands	6,24,320	6,61,044	7,03,419	7,54,268	7,93,818	7,82,518
Croplands	1,37,77,406	1,35,42,933	1,23,87,518	1,22,23,669	1,24,15,768	1,20,82,420
Urban and built-up	6,92,119	7,00,594	7,14,719	7,31,669	7,51,443	7,68,393
Cropland/Natural vegetation mosaic	15,14,187	15,25,487	15,98,936	17,57,135	17,45,835	14,74,637
Barren or sparsely vegetated	57,88,375	56,55,601	57,06,451	49,74,782	48,22,233	47,06,409
Water	15,11,362	15,25,487	15,17,012	15,08,537	14,97,237	15,19,837
Total Area	19,64,37,500	19,64,37,500	19,64,37,500	19,64,37,500	19,64,37,500	19,64,37,500
	Year-wise Area (in sq km)					

(Source for above LULC analysis: The MCD12C1 data product (the Terra and Aqua combined MODIS Land Cover Climate Modeling Grid (CMG) Version 6 data product⁷⁴).

Hence the grasslands in the region have declined and need priority attention to arrest further decline.

Though the project activity started in the year 2018, the grassland area has continued to decrease because the project does not currently work with every rancher in the region. The project aims to

⁷⁴ <https://lpdaac.usgs.gov/products/mcd12c1v006/>

eventually expand, aided by carbon finance, to reach every rancher in the region and collectively restore the grasslands.

3.5 Additionality

As per the latest VCS methodology requirements V4.3, section 3.5.3 and methodology (VM0042) v1, the additionality of this project is demonstrated below.

Regulatory Surplus

The proposed project is not mandated by any law, statute or other regulatory framework, or for UNFCCC non-Annex I countries, any systematically enforced law, statute or other regulatory framework. This project is a voluntary activity undertaken by Boomitra.

In addition to the demonstration of regulatory surplus, as per the VM0042 methodology, additionality is determined by a project method. We follow the 2-step process outlined in the methodology:

Step 1: Identify barriers that would prevent the implementation of a change in pre-existing agricultural management practices

There are several barriers that prevent implementation of the change in practices:

1. As per FAO study⁷⁵, there are several barriers to adopt sustainable management practices in grasslands. They are financial capital barriers: activities require high initial investment which defies the prevailing view of tropical cattle ranching as a low-investment activity, ii) knowledge barriers: the technical complexity of some demands a specialized knowledge that is not available among farmers, professionals, conventional academia, or commercial rural extension companies in the field (Calle, 2008),
2. Ranchers in these regions have not implemented significant changes to their practices in the past several decades and uptake rates for any changes are exceedingly slow, especially in communal lands⁷⁶. This is a combination of socioeconomic barriers and general resistance to change in the absence of incentives. As observed over a period of more than 10 years using satellite data, the lands have largely remained as grasslands, but the vegetative cover is either low or has been decreasing (See LULC⁷⁷ Excel file and folder).

⁷⁵ Food and Agriculture Organization of the United Nations. *Silvopastoral grazing in Colombia, Mexico and Brazil*. Sustainability Pathways: Projects detail. <https://www.fao.org/nr/sustainability/sustainability-and-livestock/database/projects-detail/en/c/239470/>

⁷⁶ GRÜNWALDT, J., CASTELLARO, G., FLORES, E., MORALES-NIETO, C., VALDEZ-CEPEDA, R., GUEVARA, J. and GRÜNWALDT, E., 2016. Pastoralismo en zonas áridas de Latinoamérica: Argentina, Chile, México y Perú. *Revue Scientifique et Technique de l'OIE*, 35(2), pp.543-560.

⁷⁷ Two sets of analysis has been done to check LULC variations among the participation ranchers. One set of analysis is done using MODIS/Terra Land Cover Types (500 m resolution) data. Because of its coarse spatial resolution and lack of data for particular region for particular time point, we found some issues with classifying the ranchers. Hence we used GLAD Global Land Cover and Land Use Change dataset which has 30-m spatial resolution we could find that all the project participant ranches remained grasslands.

3. A large number of the ranchers in the region have poor literacy^{78,79}. Literacy levels are low in many targeted ranch communities (particularly Ejidos) and their dependence on government financial support is high with very low access to social networks connecting them with higher levels of governance and decision-making. Their socioeconomic structure is very fragile and vulnerable⁷⁰. The ranches cannot independently adopt sustainable practices due to a lack of knowledge of techniques and their impacts on their grazing practices as well as their livelihoods. Many ranchers have been using the same practices their ancestors have been using for the past century.
4. For the Ejidos specifically, any change in practice occurring on communal land requires the consent of all the members, or at least the Ejido Council, to work⁸⁰, and achieving such a universal consent to create change is a difficult and unlikely task, presenting a strong adoption barrier. In addition, many Ejidos have weak internal cooperation due to social networks primarily being organized around nuclear families. Due to severe poverty, families are primarily incentivized today to focus only on their own conditions and are not incentivized towards cooperation⁷⁰.
5. There are a few laws that restrict ranchers from easily converting their grasslands to croplands or to sell^{81,82} but there are no rules or laws in place that prevent them from adopting new sustainable grazing practices. Apart from getting community consent to adopt any changes in practices, there are no adoption barriers in the region. Conversely, there are also no rules or laws that prevent overgrazing in Mexico. Unlike countries like the USA, there are also no federal incentives for the adoption of sustainable practices.
6. Our ground partners conduct awareness creation and capacity building work for the ranches. Due to financial constraints and other resource constraints, our ground partners are unable to expand the area of work and expedite the adoption of sustainable grassland management at scale. Hence, the activities have previously been confined to a small area. Carbon finance is the only mechanism that exists to promote these activities today, with the help of carbon credit payments going to local partners to fund their capacity building efforts. This funding stream is by far the largest funding source for the ground partners, often by an order of magnitude. Without these

⁷⁸ OECD. 2022. *Mexico Country Note*. [online] Available at: <https://www.oecd.org/skills/piaac/publications/countryspecificmaterial/PIAAC_Country_Note_Mexico.pdf> [Accessed 19 January 2022].

⁷⁹ Padilla Rodriguez, B., Armellini, A. and Traxler, J., 2021. The Forgotten Ones: How Rural Teachers in Mexico are Facing the COVID19 Pandemic. *Online Learning*, 25(1).

⁸⁰ Creekmore, M., 2000. EJIDO LAND VS. PRIVATE PROPERTY – WHAT’S THE DIFFERENCE?. *Arizona Journal of Real Estate & Business*, [online] Available at: <<https://www.stewart.com/content/dam/stewart/Microsites/mexico/pdfs/ejidoarticle.pdf>> [Accessed 19 January 2022].

⁸¹ Lexology. 2022. *In brief: agricultural land acquisition and use in Mexico*. [online] Available at: <<https://www.lexology.com/library/detail.aspx?g=568f5146-0f50-4ec5-b516-3ce5787d4732>> [Accessed 19 January 2022].

⁸² Key, N., Munoz-Pina, C., de Janvry, A. and Sadoulet, E., 1998. *Social and Environmental Consequences of the Mexican Reforms: Common Pool Resources in the Ejido Sector*. [online] University of California, Berkeley. Available at: <<https://are.berkeley.edu/~esadoulet/papers/ejido.pdf>> [Accessed 19 January 2022].

funds, these organizations could not do work at the level required to execute this project at its intended scale.

7. Although there are various national developmental banks operating in the region, access to rural finance is relatively low and government data also indicates that fewer than 3 of every 10,000 rural poor households have credit access. Additionally, 60% of the rural population live under the poverty line and 21.5% live under extreme poverty as per the latest government indicators⁸³. Project activities and typical ranch management do not involve cropping, and as a result, no farming-related loans are available to the ranchers at this point of time.

As describe above, ranchers do not have sufficient knowledge, awareness on new practices and socioeconomic conditions preventing them to adopt new practices.

Most of the ranches in the region are wholly dependent on the sale of livestock for meat production as their sole source of revenue. Thus, good quality and quantity of grass is paramount for their long-term sustainability in livestock production. Hence, we share carbon revenue with ranchers and landowners, so they can use the money to clearly demark the land as paddocks with proper fencing and take other interventions as necessary to continually improve their practices. Otherwise, the ranchers do not have the financial incentive to invest in these continued interventions. (The adoption of rotational grazing is not a binary process but rather falls on a continuum, with ample room for ranchers to continue to improve throughout the lifetime of the project and continue to restore their lands – as long as there is sufficient capital for continued investment).

In the long term, the Mexican agriculture sector (including livestock production) will be exposed to increasing climate change vulnerabilities and a degraded natural resource base. For example, droughts are expected to become more common in Northern Mexico due to an increase in severity of the El Nino⁸⁴. These conditions make it very difficult for the land to regenerate in the absence of good practices that are incentivized by carbon finance.

Step 2: Demonstrate that the adoption of the suite of proposed project activities is not common practice

Mexico is a country of grasslands. Nearly 55% of its total area is covered with fodder vegetation, with grazing occurring on the vast majority of those lands. Since the 16th century, grazing has been the common practice on these lands. The number of livestock has exponentially increased over time. There is a lack of new and improved sustainable grazing practices among the ranchers of this region. Hence, overgrazing has led to desertification of the grasslands in Mexico^{85,86}.

⁸³ Torres Munguía JA, Martínez-Zarzoso I (2021) Examining gender inequalities in factors associated with income poverty in Mexican rural households. PLoS ONE 16(11): e0259187. <https://doi.org/10.1371/journal.pone.0259187>

⁸⁴ United Nations. n.d. *COMMENTS OF MEXICO ON CLIMATE CHANGE AND SECURITY*. [online] Available at: <https://www.un.org/esa/dsd/resources/res_pdfs/ga-64/cc-inputs/Mexico_CCIS.pdf> [Accessed 19 January 2022].

⁸⁵ Manzano, Mario & Návar, José & Pando-Moreno, Marisela & Martínez, A.. (2000). Overgrazing and Desertification in Northern Mexico: Highlights on Northeastern Region. *Annals of Arid Zone*. 39. 285-304.

⁸⁶ Teague, R. and Kreuter, U., 2020. Managing Grazing to Restore Soil Health, Ecosystem Function, and Ecosystem Services. *Frontiers in Sustainable Food Systems*, 4.

The primary project activity is rotational grazing, and this activity is relatively unknown in this region. No recent quantitative statewide or nationwide surveys exist, but an expert has given his opinion (attested with date) on the adoption rates of the project activities. Details of the expert opinion are provided separately for the VVB. As per his opinion, only 5% of ranches have adopted rotational grazing in the region. This practice has been primarily adopted on private lands with intensively managed and irrigated forages production areas. Gabions and other ponds and microbasins areas have adoption rates of 5%, whereas keylines have an adoption rate of 1%. Thus, the 20% adoption rate threshold is met and each project activities is individually not common practice.

The adoption rate of rotational grazing in the project region is covered in the most recent agri-census dataset published by the government from 2007⁸⁷, with data available on a state level. It is to be noted that 2007 is the only agricultural census timepoint on adoption available at the current time. There are no older or newer census record on adoption currently available. Furthermore, the units of the adoption data are not fully aligned with the methodology, which requires adoption rate by acreage, whereas the aggregate census data only provide the number of ranches that have adopted the practice. Hence, as per methodology guidance, a signed and dated attestation statement from a qualified independent local expert⁸⁸ has been received. The expert was consulted for his opinion on insights into project activities about the local laws, barriers, adoption of improved management activities, climate and many other aspects, particularly within the Northern Mexico region. The resume of the expert along with his experience is provided to the VVB for review. The expert opinion provided is applicable to grouped project boundary level that includes northern Mexico region and is applicable to all future instances because all future instances will be within the northern Mexico region boundaries.

Without carbon finance, the ranchers would neither be incentivized to practice sustainable grazing, leaving their land in a degraded state, nor will they be able to receive scalable knowledge support to change their practices. Simply put, the project would not exist without carbon finance.

3.6 Methodology Deviations

No deviations from the procedures indicated by the methodology have been made in this project.

4 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

4.1 Baseline Emissions

⁸⁷ <https://en.www.inegi.org.mx/programas/cagf/2007/> (see provided excel sheet downloaded from the website.)

⁸⁸ Expert holds a PhD from the University of Montreal and a professor at the College of Postgraduates, one of the top research universities in Mexico.

As seen in Section 3.3, this project only includes Soil Organic Carbon stock change in the project boundary, which will be quantified with Quantification Approach 1 as given in VM0042, Version 1. Soil Organic Carbon levels are estimated using RothC model as described in the section 3.2 of PDD.

Soil organic Carbon (SOC) stocks are estimated under Quantification Approach 1, using Equation 2 below:

$$SOC_{bsl,i,t} = \phi SOC_{bsl,i,t}$$

Where

$SOC_{bsl,i,t}$	Carbon Stocks in the soil organic carbon pool in the baseline scenario for sample unit i at the end of period t ; tCO _{2e} /unit area
$\phi SOC_{bsl,i,t}$	Modeled soil organic carbon pool in the baseline scenario for sample unit i at the end of period t ; tCO _{2e} /unit area
i	Sample unit

As per methodology, baseline is modelled for each sample unit (each ranch in this project). As per the guidance provided in the table 6 of the methodology, baseline emissions are estimated. As discussed in section 3.2 of PDD, the RothC model requires certain inputs that need to be collected from appropriate sources. Some of the key inputs are Soil Organic Stock and bulk density. Soil carbon and bulk density are determined for t=0 via remote sensing⁸⁹.

The remote sensing system used in this project is calibrated using a ground-truth primary dataset⁹⁰, sourced from a government source, Mexico's National Institute of Statistics and Geography (INEGI)⁹¹, which has conducted country-wide soil survey studies. Country-wide soil surveys carried out by government agencies typically provide significant geographical coverage within countries and may be reputable sources due to standardized sampling protocols and testing procedures. In this case, for each sample, the calibration primary dataset has geocoordinates (latitude and longitude), sampling depth, date of sampling, soil texture, and both soil organic carbon weight percentage and bulk density of the fine soil fraction, and constitute country-wide soil surveys carried out from 2005 to 2012, across a diversity of dates within those years. In addition to the sample preparation, all quantitative analyses (lab tests) were carried out directly by INEGI⁹². The samples underwent the same analytical method for carbon – dry combustion. The dataset contains 3460 points, after limiting the data to only include points from within the spatial boundaries of the project (using the project location as defined in Section 1.11).

⁸⁹ The specific measurement approach is available in depth in the accompanying CarbonFocus Algorithm Theoretical Basis Document available at validation to the VVB. This report provides information on the theoretical basis of the remote sensing algorithm used in this project that measures SOC and BD to 30cm depth, and specific details with respect to its calibration and validation for this project.

⁹⁰ INEGI (2020). "Datos de Carbono Organico". Unpublished (Obtained from direct communication with INEGI)

⁹¹ <http://www.inegi.org.mx/>

⁹² Krasilnikov, P., Gutiérrez-Castorena, M. d. C., Ahrens, R. J., Cruz-Gaistardo, C. O., Sedov, S., & Solleiro-Rebolledo, E. (2013). The Soils of Mexico. Dordrecht: Springer Netherlands.

In order to analyze the data in a manner that is conducive to building the machine learning system, we need to ensure that the data is harmonized. For the purposes of this data, we ensure that (1) Sample collection procedures are consistent, at least to the extent that is feasible to compare; (2) the laboratory methods are consistent; (3) terminology and units in the datasets are consistent. These steps are based on the prevailing scientific consensus on the important items for soil data harmonization⁹³. All the INEGI data is tested at INEGI's own facility as noted above, and underwent the same analytical technique, so the laboratory method is believed to be consistent. The main observable difference in the sample collection procedures of the data is the difference in sampling depths. To ensure consistency of calculations, during implementation of the remote sensing algorithm, only points reported to be taken with 0-30 cm depth are used for calibration, leaving 2370 points (69%) remaining (the samples removed consisted of much shallower samples). In order to meet the methodology's depth requirements, soil carbon and bulk density must be measured to at least 30cm, and this project seeks to measure directly to 30cm depth. This step thus ensures some level of consistency in the sampling across the remaining samples. Finally, the terminology and units of all the data were found to be consistent and well reported⁹⁴. For the purposes of this work, all data were stored with geocoordinates in degrees latitude/longitude, sampling depths in centimeters, dates of sampling in the format YYYY-MM-DD, soil organic carbon weight percentages (wt%) and bulk densities in ton/m³. These 3 collective previous steps ensure a degree of data harmonization so that effective models may be built on top of the data.

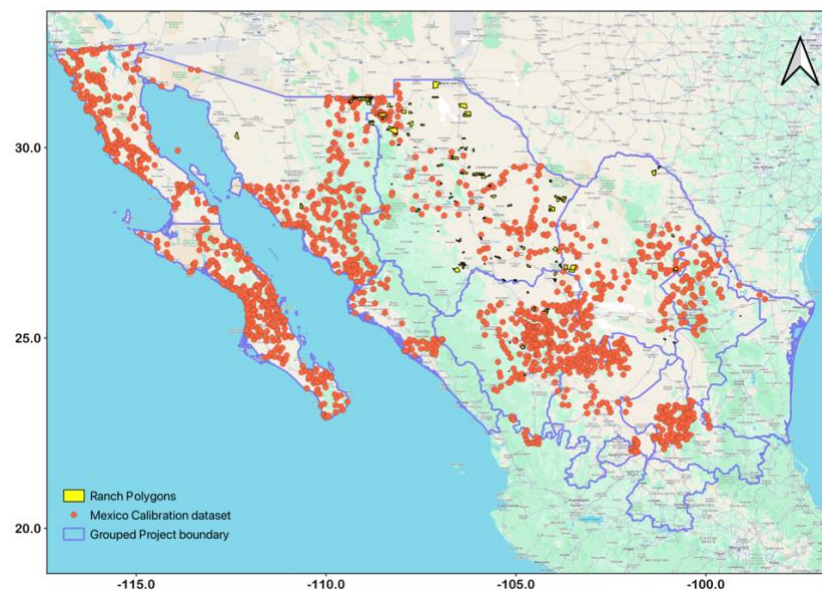
Further information on the nature of the calibration dataset is presented in Section 5.1 of the remote sensing report provided to the VVB at the time of validation. The remote sensing report also provides information on the theoretical basis and physics of the remote sensing algorithm used in this project that measures SOC and BD to 30cm depth, and specific details with respect to its calibration and validation for this project. Considering that the project's start date is in 2018, the calibration dataset was collected prior to this date. Given that unimproved grazing practices have been continuously carried out in the region for several decades as detailed in Section 3 in the baseline scenario, it is likely that the vast majority of the calibration dataset samples occur from areas under unimproved grazing. However, this dataset is not used directly to estimate baseline SOC, but rather only as a calibration set for the remote sensing algorithm, which then estimates the SOC used as input for the RothC in both the baseline and project scenarios. The remote sensing algorithm thus calibrated is applicable to both the baseline and project scenarios, because it uses the calibration dataset to learn how satellite data is related to the physical properties of soils in the region, as opposed to interpolating the calibration datasets outputs to produce an averaged soil map. In contrast, for example, interpolation is how the ISRIC Soilgrids, noted in Table 6 as a state-of-the-art peer reviewed soil map, works to create a static soil map. Further information on the physical properties of soil and their causal relationships with satellite data are available in the remote sensing report, and in Section 4.4.1 of the PD.

⁹³ Baritz, R., Erdogan, H., Fujii, K., Takata, Y., Nocita, M., Bussian, B., Batjes, N., Hempel, J., Wilson, P., and Vargas, R. (2014). Harmonization of methods, measurements and indicators for the sustainable management and protection of soil resources. Technical report, Global Soil Partnership, Food and Agriculture Organization of the United Nations. https://www.fao.org/fileadmin/user_upload/GSP/docs/ITPS_Pillars/annexV_pillar5.pdf

⁹⁴ INEGI (2011). "Diccionario de datos de erosión del suelo, Escala 1:250,000". Unpublished (Obtained from direct communication with INEGI)

Of the calibration dataset, 51 soil data points fall within the specific project areas of the first instance of the project, across 18 ranches. However, this does not preclude the rest of the data from being used for calibration purposes, as long as the dataset is representative of the conditions found throughout the project, since the data, as discussed above and Section 4.4.1, are not used directly or through interpolation but rather for building an understanding of the physical properties of soils in the region. The appropriateness and representativeness of the remote sensing calibration dataset with respect to the initial project instances is thus further studied, in terms of the following factors: general spatial coverage of the project location, representation of all climate zones present in the initial instances, representation of all the soil textures present in the initial instances, matching land cover type (only grasslands in this project), and an appropriate range of soil carbon and bulk density that is representative of typical grassland soil carbon ranges. This choice of factors is chosen based on the theoretical basis of the remote sensing technology used, which is described further in the remote sensing report.

The figure below shows the spatial extent of the calibration dataset, with respect to the grouped project boundary and initial project instances:



The table below shows the distributions of different soil texture classes (determined from ISRIC soil grids⁹⁵ and using the USDA soil texture formula⁹⁶) in the calibration dataset and initial project instances.

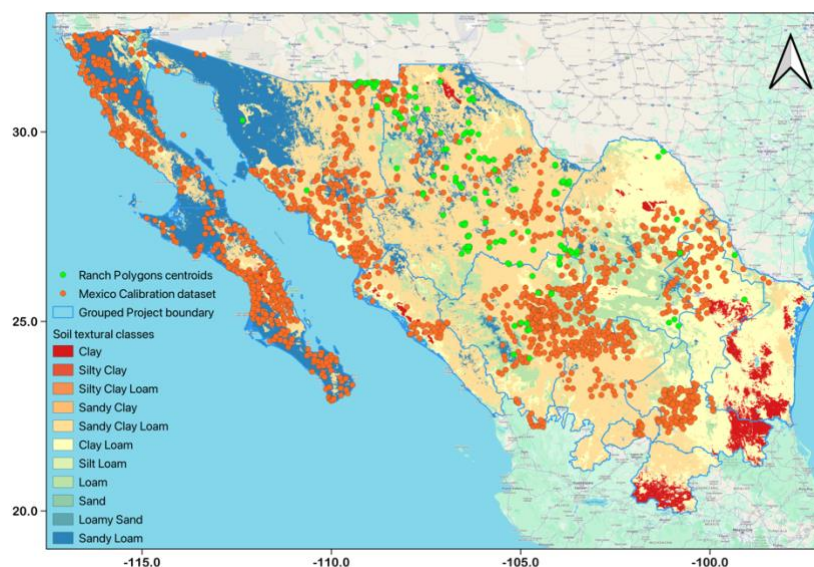
Soil Texture Class	% of Calibration Dataset	% of initial project polygons
Clay	1.90	0
Clay loam	17.96	12.41
Loam	9.56	1.45

⁹⁵ ISRIC World Soil Information. *Soilgrids - global gridded soil information*. www.isric.org. <https://www.isric.org/explore/soilgrids>

⁹⁶ The USDA Soil Texture Calculator https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_054167 is used to determine the soil texture class based on percent sand and clay content.

Soil Texture Class	% of Calibration Dataset	% of initial project polygons
Loamy sand	7.36	0
Sand	0.31	0
Sandy clay	0.06	0.73
Sandy clay loam	44.26	80.29
Sandy loam	18.33	5.11
Silty clay loam	0.12	0
Silty loam	0.12	0

The figure below shows the soil texture classes in the region, with calibration dataset and the initial sample units overlaid:

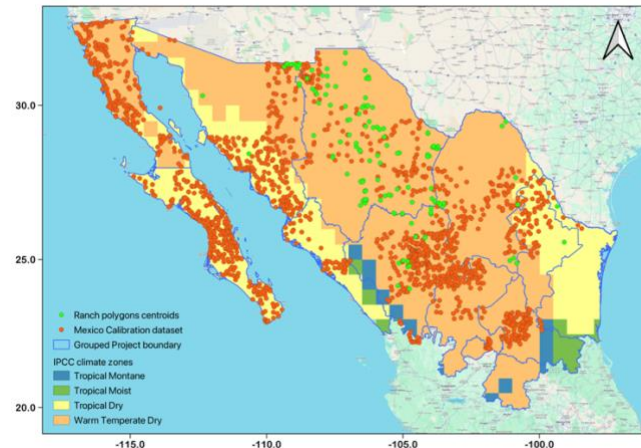


The table below shows the distributions of different climate zones (from the IPCC classification⁹⁷) in the calibration dataset and initial project instances.

IPCC Climate Zone	% of Calibration Dataset	% of initial project polygons
Tropical Dry	34.38	2.13
Tropical Moist	0.31	0
Tropical Montane	0.80	0
Warm Temperate Dry	64.46	97.87

The figure below shows the climate zones with the calibration data and initial sample unit locations overlaid:

⁹⁷ <https://www.ipcc-nggip.iges.or.jp/public/2019rf/corrigenda1.html>



The above tables and figures show that the calibration dataset is representative of the climate zones and soil textures found in the initial project instances and covers the grouped project location. There are certain spatial gaps in grouped project boundaries for the calibration dataset, and these gaps represent regions where data was not collected by INEGI that met all the aforementioned cleaning requirements (Eg. 0-30cm depth). As seen from the climate zone map and soil texture map, these areas are not substantially different from the other areas within the grouped project boundaries. Furthermore, we do a strict comparison with the climate zones and soil textures in the project polygons to ensure they are fully represented in the dataset, and the above two tables demonstrate that. The survey data from INEGI also confirm that all the calibration samples used are from grassland locations (as required since this is a grassland project), and there is a soil carbon range in the calibration dataset from 0 to 5%, which is representative of typical ranges of SOC independently measured and reported by other researchers for the same general region^{98,99,100}. Over the lifetime of the project, given that the project activities help to restore lands to an earlier state present centuries ago (as seen in Section 3), through the rotational grazing and water interventions, the soil carbon levels in the project scenario are unlikely to exceed the full natural ranges in SOC reported today for the region. Thus the calibration dataset has representation of soil carbon levels as they would be in the project and baseline scenarios, throughout the lifetime of the project. Additionally, the calibration data were limited to non-compacted soils (soils without unusually high bulk density, see ATBD for more details), as the ranches in this region all have stocking rates that would not lead to compaction in the project scenario, and would not have led to compaction in the baseline scenario (See Appendix 4, and this footnote¹⁰¹), so compacted soils would not be representative.

⁹⁸ Jurado-Guerra Pedro, Saucedo-Terán Ruben, Morales-Nieto Carlos, Juárez-Morales Martín, Sosa-Pérez Gabriel, Álvarez-Holguín Alan (2021) Soil carbon stocks of semi-arid grasslands in northern Mexico. *The Rangeland Journal* **43**, 247-255.

⁹⁹ Ayala-Niño, F. *et al.* (2020) 'Spatial distribution of soil carbon storage in desert shrubland ecosystems of northwest Mexico', *Journal of Arid Environments*, 183, p. 104251. doi:10.1016/j.jaridenv.2020.104251.

¹⁰⁰ Guevara, M., C.E. Arroyo-cruz, N. Brunsell, C.O. Cruz-gastardo, G.M. Domke, J. Equihua, J. Etchevers, D.J. Hayes, T. Hengl, A. Ibelles, K. Johnson, B. de Jong, Z. Libohova, R. Llamas, L. Nave, J.L. Ornelas, F. Paz, R. Ressler, A. Schwartz, S. Wills, and R. Vargas. 2020. Soil Organic Carbon Estimates for 30-cm Depth, Mexico and Conterminous USA, 1991-2011. ORNL DAAC, Oak Ridge, Tennessee, USA. <https://doi.org/10.3334/ORNLDAAAC/1737>

¹⁰¹ As per Appendix 4, the ranches have an average stocking rate of 17 ha per animal unit (eg. head of cattle) in the historical 3-yr look-back that is taken to be representative of the baseline scenario, and likewise 16 ha per animal unit in the first

All of the above attributes establish that the calibration dataset used fits the requirements of the initial project instances, for training the remote sensing technology to produce the soil organic carbon stock input for the RothC model. Furthermore, with the right representation and coverage of the domain of soil carbon and bulk density in grasslands, this dataset can represent different conditions across both the baseline and project scenarios of this project. In the future, for new project instances added to the project, it is required to check that the project instances fall within the grouped project boundaries, and that the project instances are also represented in terms of their climate zone and soil texture type within this calibration dataset. These are present as eligibility criteria for this grouped project. New project instances are not planned to utilize any additional calibration data beyond this calibration dataset available at the time of validation.

In addition to the primary dataset of soil data used for calibration, the remote sensing technology used in this project utilizes the following input data sources for producing soil carbon stock values for the project activity instances: ESA satellite data (Sentinel satellite bands), NASA satellite data (Landsat satellite bands, SMAP satellite bands), and ISRIC Soilgrids data (only for soil texture inputs to the bulk density calculation process, and with the same source and justification as the clay data in Table 6 below and in Table 8). During the calibration process, the satellite data sources are mined for the corresponding satellite pixels that are collocated spatially with the calibration soil data point locations, at the single closest available imaging time to the soil sample being collected. This results in a certain uncertainty due to satellite pixels covering more spatial area than the individual soil sample data points themselves, and thus experiencing more spatial variability than the sample points, which is discussed further in Section 4.4.1. The subsequent estimation process for the calculation of the soil carbon stock input for the RothC model are similar to the calibration process, with the satellite data sources similarly collected for every pixel in a pixel grid covering the sample unit of interest. Further details on the end to end process are available in the remote sensing report (ATBD) available to the VVB and Verra at the time of validation. The satellite data sources used have full planetary coverage, and thus also cover the entire grouped project boundaries, and additionally have long-duration mission support from ESA and NASA, so they will be usable for any additional project activity instances added in the future as well.

monitoring period. A study conducted by Echavarría et al within the grouped project boundaries suggests that even a moderate stocking rate of 1.29 ha per animal unit in a rotational grazing system did not lead to any appreciable change in soil compaction, and the bulk density remained nearly unchanged around 1.4 ton/m³, so it is unlikely that the stocking rates in the project will lead to compaction in either project or baseline scenarios. Furthermore, other literature in the region (Concostrina-Zubiri et al) suggests that 8ha per animal unit and above can be considered low intensity, so this project itself would be considered low intensity. A global meta-analysis of soil compaction as a function of grazing (Lai et al) suggests that low intensity grazing has not led to any observable compaction, whereas truly high intensities (eg. <1 ha per animal unit) lead to observable compaction. Overgrazing in the baseline scenario in Northern Mexico has more of an effect on desertification through resulting in the loss of vegetation cover through being eaten, rather than on compaction from hoof action.

Refer to: Echavarría, F. G., A. Serna, R. Bañuelos, M. J. Flores, R. Gutiérrez, and H. Salinas. "SOIL PHYSICAL DEGRADATION OF RANGELANDS UNDER CONTINUOUS GRAZING AT THE ZACATECAS, MEXICO HIGHLANDS." Concostrina-Zubiri, L., E. Huber-Sannwald, I. Martínez, JL Flores Flores, and A. Escudero. "Biological soil crusts greatly contribute to small-scale soil heterogeneity along a grazing gradient." Soil Biology and Biochemistry 64 (2013): 28-36. Lai, L.; Kumar, S. A global meta-analysis of livestock grazing impacts on soil properties. *PLoS ONE* 2020, 15, e0236638

The performance of the remote sensing technology itself is described further in Section 4.4.1 of this project description.

Other soil parameters for the RothC model are determined from published soil maps, with known uncertainty. Climate variables parameters are sourced from a synthetic weather station. The model prediction interval is monthly, so all parameters are collected and submitted to the model with month frequency. The following table outlines the model input parameters and their sourcing method.

Input Data	Source Used	Timing
Soil organic carbon stock at t=0 (tons C/ha)	Boomitra's remote sensing technology is used to determine soil organic carbon weight percentage and bulk density, with known uncertainty, at t=0, and the product of the two values followed by unit interconversion provides the soil organic carbon stock. The approach and its uncertainty are described further in Section 4.4.1. This data source meets the requirements of Table 6 in the methodology, which stipulates that SOC stock must be "Directly measured at t=0 or (back-) modeled to t=0 from measurements collected within +/-5 years of t =0, or determined for t=0 via emerging technologies (e.g., remote sensing)."	Ex-ante
Monthly rainfall (mm)	ERA5-Land weather data from the European Center for Medium Range Weather Forecasts (ECMWF), which has data from 1950 ¹⁰² . This data source meets the requirements of Table 6 in the methodology, which stipulates that climatic variables must follow that "Measurements are taken at the closest continuously monitored weather station, not exceeding 50 km of the sample field, or from a synthetic weather station". As described in the literature, ERA5 is a form of synthetic weather station and is state-of-the-art for providing accurate climatic variables ¹⁰³ .	Continuously Monitored Ex-ante
Monthly open pan evaporation (mm)	ERA5-Land weather data from the European Center for Medium Range Weather Forecasts (ECMWF), which has data from 1950 ^{102,104} . This data source meets the requirements of Table 6 in the methodology, which stipulates that climatic variables must follow that "Measurements are taken at the closest	Continuously Monitored Ex-ante

¹⁰² Copernicus Climate Data Store. Copernicus Climate Data Store. <https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-land-monthly-means?tab=overview>

¹⁰³ Muñoz-Sabater, J., Dutra, E., Agustí-Panareda, A., Albergel, C., Arduini, G., Balsamo, G., Boussetta, S., Choulga, M., Harrigan, S., Hersbach, H., Martens, B., Miralles, D. G., Piles, M., Rodríguez-Fernández, N. J., Zsoter, E., Buontempo, C., and Thépaut, J.-N.: ERA5-Land: a state-of-the-art global reanalysis dataset for land applications, Earth Syst. Sci. Data, 13, 4349–4383, <https://doi.org/10.5194/essd-13-4349-2021>, 2021.

¹⁰⁴ Copernicus Climate Data Store. Copernicus Climate Data Store. <https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-land-monthly-means?tab=overview>

Input Data	Source Used	Timing
	continuously-monitored weather station, not exceeding 50 km of the sample field, or from a synthetic weather station”. As described in the literature, ERA5 is a form of synthetic weather station and is state-of-the-art for providing accurate climatic variables ^{103,105} . This data source meets the requirements of Table 6 in the methodology, which stipulates that	
Average monthly mean air temperature (o C)	ERA5-Land weather data from the European Center for Medium Range Weather Forecasts (ECMWF), which has data from 1950 ¹⁰² . This data source meets the requirements of Table 6 in the methodology, which stipulates that climatic variables must follow that “Measurements are taken at the closest continuously-monitored weather station, not exceeding 50 km of the sample field, or from a synthetic weather station”. As described in the literature, ERA5 is a form of synthetic weather station and is state-of-the-art for providing accurate climatic variables ¹⁰³ .	Continuously Monitored Ex-ante
Clay content of the soil	Determined using peer-reviewed global soil maps from International Soil Reference and Information Center ¹⁰⁶ . This data source meets the requirements of Table 6 in the methodology, which stipulates that soil properties (other than soil carbon & bulk density) must be “Directly measured or determined from published soil maps, with known uncertainty”. ISRIC’s soil map is a published soil map that also has a known uncertainty layer for each parameter, including the clay content of soil.	Ex-ante
An estimate of the decomposability of the incoming plant material - the DPM/RPM ratio	Determined from the scientific literature, and substantiated in the Model Validation Report.	Ex-ante
Soil cover (Bare/Vegetated)	This project takes place on native grassland vegetation, and the vegetation cover exists throughout the year (vegetation is not uprooted as part of the project), so the soil cover is taken to be vegetated continuously.	Ex-ante
Monthly input of plant residues	Determined from calibrations per specific practice category and crop functional group, as given in the Model Validation Report.	Continuously Monitored Ex-ante

¹⁰⁵ Muñoz-Sabater, J., Dutra, E., Agustí-Panareda, A., Albergel, C., Arduini, G., Balsamo, G., Boussetta, S., Choulga, M., Harrigan, S., Hersbach, H., Martens, B., Miralles, D. G., Piles, M., Rodríguez-Fernández, N. J., Zsoter, E., Buontempo, C., and Thépaut, J.-N.: ERA5-Land: a state-of-the-art global reanalysis dataset for land applications, Earth Syst. Sci. Data, 13, 4349–4383, <https://doi.org/10.5194/essd-13-4349-2021>, 2021.

¹⁰⁶ ISRIC World Soil Information. *Soilgrids - global gridded soil information*. [www.isric.org](https://www.isric.org/explore/soilgrids). <https://www.isric.org/explore/soilgrids>

Input Data	Source Used	Timing
Monthly input of farmyard manure (FYM)	Determined from the reported count of livestock in each sample unit, and literature values for the production of manure per day for the given type of livestock ¹⁰⁷ .	Ex-ante
Depth of soil layer sampled	30cm, as required by the methodology.	Ex-ante

Table 6: Inputs to the models and their sources

For further details on the baseline emission calculation approach with RothC, a draft Model Validation Report (MVR) is provided to the VVB and VCS during validation and VCS project review.

The full baseline and project emissions calculation process is summarized in the schematic below:

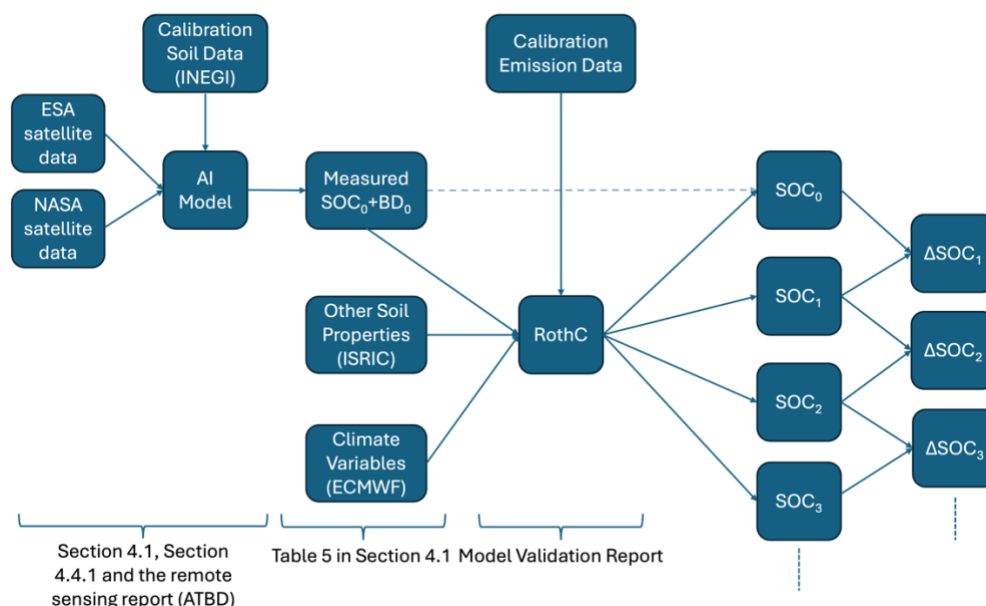
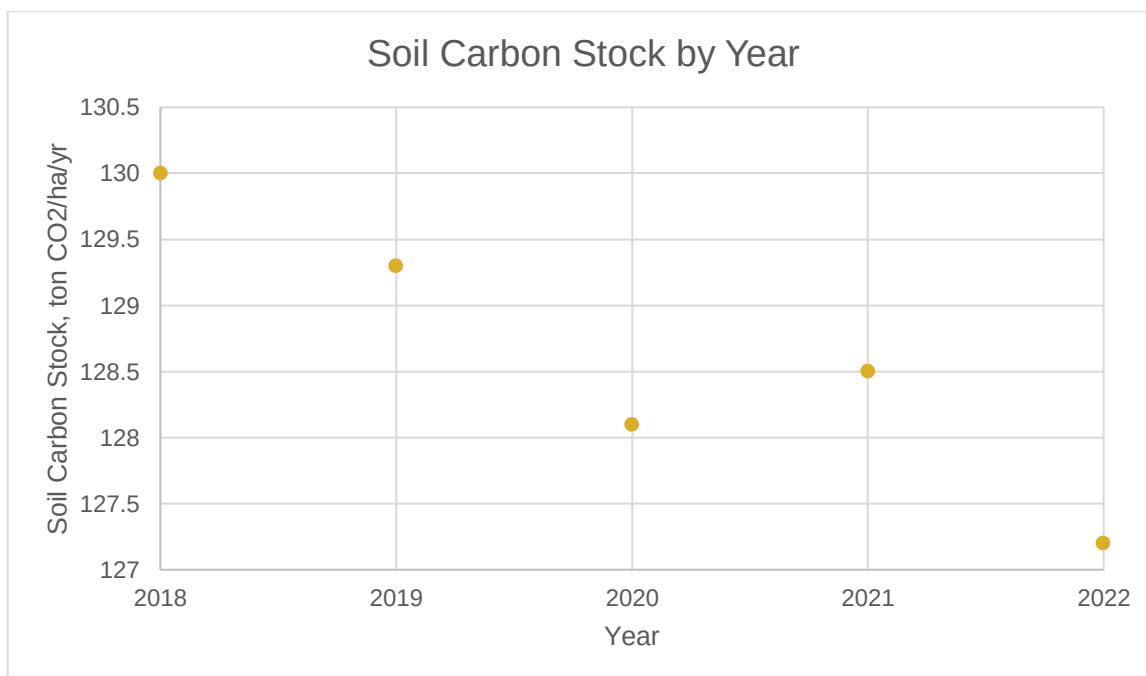


Figure 27. Baseline emission calculation process, integrating the remote sensing AI model to measure soil organic carbon and bulk density at t=0 and initializing the calibrated RothC model, which, along with the appropriate Table 5 inputs, to generate soil carbon stock levels for each year, as used in Equation 2 of the methodology.

Consider an example of one of the ranches in the project, where the average annual temperature is 18.9°C and the average rainfall is 330mm per year, with open pan evaporation about 150mm. The clay content is 23%. The Roth-C documentation gives 0.67 as a suitable value for DPM/RPM in unimproved grasslands, such as in this project. The soil is vegetated year-round with grass, and the soil is studied to a 30cm depth, and 0.2-ton C/ha/yr in plant residue input. The soil carbon stock is simulated to be:

¹⁰⁷ University of Massachusetts Amherst. (2020, April 13). *Manure inventory*. Center for Agriculture, Food, and the Environment. <https://ag.umass.edu/crops-dairy-livestock-equine/fact-sheets/manure-inventory>



In this example, the ranch would have lost 2.8 tonsCO₂/ha over the first monitoring period, in the baseline scenario.

These types of calculations, following the Fig 27 schematic, are carried out individually for every sample unit in the project.

Annual calculation results for the first instance for the first monitoring period and beyond are summarized in the 'estimated baseline emissions or removals' column of the table for instance 1 ERRs in Section 4.4.3. The values in that table for future monitoring periods are calculated based on the average results across the first monitoring period.

4.2 Project Emissions

As seen in Section 3.3, this project only includes Soil Organic Carbon stock change in the project boundary, which will be quantified with Quantification Approach 1 as given in VM0042. According to the methodology, Soil Organic Carbon stocks in the project scenario as described in section 4.1 where subscript *bsl* is substituted with *wp*. However, if any activity contributes or have emissions during project implementation and monitoring will be reported in the subsequent monitoring cycles.

Quantification Approach 1 is a 'measure and model' approach, and in this project, as noted in Section 4.1, the RothC model is used for the emission calculation. RothC model inputs for the project scenario are collected as per the guidance provided in the Table 7 of the methodology. All the model input are the same as the Table 5 mentioned in Section 4.1 of this document, which also provides more details on their sourcing. There is one more parameter (agriculture management activities) that is monitored ex post with survey methods. Information on management activities are collected via consultation with the landowner of the sample unit (ranch).

The following table outlines the model input parameters and their sourcing method.

Input Data	Source Used	Timing
Soil organic carbon stock	Boomitra's remote sensing technology is used to determine soil organic carbon weight percentage and bulk density, with known uncertainty, at t=0, and the product of the two values followed by unit interconversion provides the soil organic carbon stock. The approach and its uncertainty is described further in Section 4.4.1. This data source meets the requirements of Table 6 in the methodology, which stipulates that SOC stock must be "Directly measured at t=0 or (back-) modeled to t=0 from measurements collected within +/-5 years of t =0, or determined for t=0 via emerging technologies (e.g., remote sensing) with known uncertainty."	Determined at project start (re-measured every 5 years or less)
Monthly rainfall (mm)	ERA5-Land weather data from the European Center for Medium Range Weather Forecasts (ECMWF), which has data from 1950 ¹⁰⁸ . This data source meets the requirements of Table 6 in the methodology, which stipulates that climatic variables must follow that "Measurements are taken at the closest continuously-monitored weather station, not exceeding 50 km of the sample field, or from a synthetic weather station". As described in the literature, ERA5 is a form of synthetic weather station and is state-of-the-art for providing accurate climatic variables ¹⁰⁹ .	Continuously Monitored Ex-post
Monthly open pan evaporation (mm)	ERA5-Land weather data from the European Center for Medium Range Weather Forecasts (ECMWF), which has data from 1950 ¹⁰² . This data source meets the requirements of Table 6 in the methodology, which stipulates that climatic variables must follow that "Measurements are taken at the closest continuously-monitored weather station, not exceeding 50 km of the sample field, or from a synthetic weather station". As described in the literature, ERA5 is a form of synthetic weather station and is state-of-the-art for providing accurate climatic variables ¹⁰³ .	Continuously Monitored Ex-post
Average monthly mean air temperature (o C)	ERA5-Land weather data from the European Center for Medium Range Weather Forecasts (ECMWF), which has data from 1950 ¹⁰² . This	Continuously Monitored Ex-post

¹⁰⁸ Copernicus Climate Data Store. Copernicus Climate Data Store. <https://cds.climate.copernicus.eu/cdsapp#!/dataset/reanalysis-era5-land-monthly-means?tab=overview>

¹⁰⁹ Muñoz-Sabater, J., Dutra, E., Agustí-Panareda, A., Albergel, C., Arduini, G., Balsamo, G., Boussetta, S., Choulga, M., Harrigan, S., Hersbach, H., Martens, B., Miralles, D. G., Piles, M., Rodríguez-Fernández, N. J., Zsoter, E., Buontempo, C., and Thépaut, J.-N.: ERA5-Land: a state-of-the-art global reanalysis dataset for land applications, Earth Syst. Sci. Data, 13, 4349–4383, <https://doi.org/10.5194/essd-13-4349-2021>, 2021.

Input Data	Source Used	Timing
	data source meets the requirements of Table 6 in the methodology, which stipulates that climatic variables must follow that “Measurements are taken at the closest continuously-monitored weather station, not exceeding 50 km of the sample field, or from a synthetic weather station”. As described in the literature, ERA5 is a form of synthetic weather station and is state-of-the-art for providing accurate climatic variables ¹⁰³ .	
Clay content of the soil	Determined using peer-reviewed global soil maps from International Soil Reference and Information Center ¹¹⁰ . This data source meets the requirements of Table 6 in the methodology, which stipulates that soil properties (other than soil carbon & bulk density) must be “Directly measured or determined from published soil maps, with known uncertainty”. ISRIC’s soil map is a published soil map that also has a known uncertainty layer for each parameter, including the clay content of soil.	Ex-ante
An estimate of the decomposability of the incoming plant material - the DPM/RPM ratio	Determined from the scientific literature, and substantiated in the Model Validation Report.	Ex-ante
Soil cover (Bare/Vegetated)	This project takes place on native grassland vegetation, and the vegetation cover exists throughout the year (vegetation is not uprooted as part of the project), so the soil cover is taken to be vegetated continuously.	Ex-ante
Monthly input of plant residues	Determined from calibrations per specific practice category and crop functional group, as given in the Model Validation Report.	Continuously Monitored Ex-post
Monthly input of farmyard manure (FYM)	Determined from the reported count of livestock in each sample unit, and literature values for the production of manure per day for the given type of livestock ¹¹¹ .	Ex-post
Depth of soil layer sampled	30cm, as required by the methodology.	Ex-ante

Table 7: Inputs to the models and their sources

For further details on the project emission calculation approach with RothC, a draft Model Validation Report (MVR) is provided to the VVB and VCS during validation and VCS project review.

The full process used to calculate the project emissions follows the same steps as given in the schematic (Fig 27) in Section 4.1, with the difference that the RothC model used is the version calibrated for the project scenario.

¹¹⁰ ISRIC World Soil Information. *Soilgrids - global gridded soil information*. [www.isric.org. https://www.isric.org/explore/soilgrids](https://www.isric.org/explore/soilgrids)

¹¹¹ University of Massachusetts Amherst. (2020, April 13). *Manure inventory*. Center for Agriculture, Food, and the Environment. <https://ag.umass.edu/crops-dairy-livestock-equine/fact-sheets/manure-inventory>

The RothC model estimates for the project scenario will be routinely recalibrated and revalidated and ‘true-upped’ as soil organic carbon stock measurements will be done with the remote sensing system for each sample unit every 5 years or more frequently. The project also plans to have at least one new measurement in every monitoring period, so the model may be properly recalibrated and true-upped in every monitoring period, which will be at least as frequent as every 5 year, or more frequently.

In the case of the first monitoring period, the measured soil organic carbon stock on sample unit level is available twice - a few months prior to the project start and a few months prior to the end of the first monitoring period. These values are used to appropriately run the RothC model across the entire first monitoring period. The RothC model is thus used to produce an output soil carbon stock for the monitoring period’s start date, and likewise also an output stock for the monitoring period’s end date, and for each intervening year. The difference between these RothC model outputs by years of the monitoring period represents the project scenario SOC stock changes for each year, in accordance with Quantification Approach 1. When a given sample unit starts its first project activities after the monitoring period start date, the first RothC output is produced for its activity start date instead of the monitoring period start date.

The remote sensing system for measurement of soil organic carbon stock (as an input to the RothC) is the same system also described in Section 4.1, and is thus calibrated with the same primary dataset (the “INEGI data”) that is described in detail in Section 4.1. This primary dataset is not expected to be expanded over the course of the project crediting period – all the current sample units have been shown in Section 4.1 to be represented in the primary dataset. Any new project activity instances also have an eligibility criterion (Section 1.3) that requires them to be represented in the primary dataset’s climate zones and soil textures in order to be included (so geographical areas outside of these zones and textures are not included). Thus, all project instances will continue to be represented by the primary dataset for remote sensing calibration purposes. However, note that the primary dataset is distinct from the RothC recalibration data and the ongoing remote sensing validation data. As required by Quantification Approach 1, and reflected in the Modeling Plan (Section 5.3), stock measurements from the project sites obtained through remote sensing are available with a frequency greater than 5 years and will be used for routine recalibration and true-up of the RothC. Additionally, as reflected in Section 5.3, ongoing validation soil sampling in every monitoring period will ensure that the remote sensed soil carbon stock measurements remain accurate as time passes in the project.

Annual calculation results for the first instance for the first monitoring period and beyond are summarized in the ‘estimated project emissions or removals’ column of the table for instance 1 ERRs in Section 4.4.3. The values in that table for future monitoring periods are calculated based on the average results across the first monitoring period.

4.3 Leakage

There are no direct or indirect leakages expected from this project activity. The proposed activity is completely in-situ in nature, which does not contribute to indirect leakages or new emissions elsewhere. As clearly described in the project activity description section of the PD, the activity proposed is purely to

bring behavioral change in the practices followed in the baseline. The project scenario does not involve any such activity that leads to new emissions elsewhere.

The methodology also assumes no leakage if certain conditions are met:

- 1) No new application of manure from outside the project area (i.e., manure applied in the project from outside of the project area, that was not previously applied in the historical baseline period). The project activity does not involve any such application of manure from outside the project area.
- 2) No productivity declines. As noted in Section 2.5, productivity declines are not expected to occur, according to the academic literature. Regardless, as required by the methodology, productivity will be measured every ten years and changes in productivity will be quantified as per Eq 29 or Eq 30 in the methodology. Many studies suggest that rotational grazing will improve forage productivity^{112,113,114}. Hence, the project activities implemented do not decrease the productivity in the grasslands with respect to grass production. However, since this is a grassland project, a detailed productivity analysis with respect to forage availability and livestock product will be done every 10 years as described in section 8.4.3 of the methodology.
- 3) No displacement of livestock outside of the project boundary. The entire legal area of every ranch participating in the project is included in the project. The ranchers do not graze their livestock in any area outside of their ranch. Furthermore, as noted in Section 2.5, livestock numbers are not expected to decline with the project activity, according to the academic literature. Regardless of the possibility of any such declines, this project also does not claim credit for reductions in N₂O or CH₄ emission from reductions in enteric emission due to reduced livestock numbers. Thus, this leakage accounting is not required either. As per the baseline livestock stocking analysis, there has been no decrease in livestock counts over the years, and such a decrease is not expected in the project scenario compared to the baseline scenario. None of the project activities will result in the displacement of livestock from the project area. Project activities will increase forage availability, and, livestock will thereby have good-quality grass to eat. Only in the case of severe droughts ranchers are forced to sell their livestock to meet their financial requirements. Otherwise, livestock grazing is the primary occupation of the ranchers in the region.

Nevertheless, ranchers have the option to sell the cattle to the beef industry, where they are used as food, without causing any displacement of livestock from the project boundary. The drastic drop in the livestock stocking rates might happen when there is a severe drought/ lack of forage in the region. Hence, the livelihood of displacement of cattle from the project boundary is very mere.

¹¹² [Rotational vs. Continuous Grazing | Master Grazer \(uky.edu\)](#),

¹¹³ Sanderman J, Reseigh J, Wurst M, Young MA, Austin J. Impacts of Rotational Grazing on Soil Carbon in Native Grass-Based Pastures in Southern Australia. PLoS One. 2015 Aug 18;10(8):e0136157. doi: 10.1371/journal.pone.0136157. PMID: 26284658; PMCID: PMC4540585.

¹¹⁴ Matthew W. Jordon, Kathy J. Willis, Paul-Christian Bürkner, Gillian Petrokofsky, Rotational grazing and multispecies herbal leys increase productivity in temperate pastoral systems – A meta-analysis, Agriculture, Ecosystems & Environment, Volume 337, 2022, 108075, ISSN 0167-8809, <https://doi.org/10.1016/j.agee.2022.108075>.

The livestock stocking rates are monitored every year and will be reported in the monitoring report. If there is a considerable amount of decrease in livestock stocking rates, as per section 8.4.2 of the methodology, the CH₄ and N₂O emissions associated with livestock displacement will be counted in the project scenario using equations mentioned in the methodology (equations 5, 6, 7, 20, 21, 22, 23, 24 and 25)).

Hence, LE_t is set to zero.

4.4 Uncertainty Quantification

As per section 8.6 of methodology, total uncertainty deductions are quantified using equation 46 as shown below.

$$UNC_t = MIN \left(100\%, MAX \left(0, \frac{T \sqrt{\sum \cdot s_{\Delta \cdot t}^2}}{\overline{\Delta CO_2}_t + \overline{\Delta CH_4}_t + \overline{\Delta N_2O}_t} - 15\% \right) \right)$$

Where,

UNC _t	Uncertainty deduction in year t (expressed as the extent to which the half width of the 95% confidence interval, as a percentage of the mean, exceeds the threshold of 15%); unitless number between 0 and 1
Σ.	Sum over pools and gases CO ₂ _soil, CTREE, CSHRUB,24 CH ₄ _SOC, CH ₄ _ent, CH ₄ _md, and N ₂ O_soil, where Quantification Approaches 1 or 2 were employed.
s ² Δ•,t	Variance of the estimate of Δ • t. (Δ • t = mean emission reductions from gas and pool • at time t) (see); (t CO ₂ e/unit area)
$\overline{\Delta CO_2}_t$	Areal average carbon dioxide emission reductions in year t; t CO ₂ e/unit area
$\overline{\Delta CH_4}_t$	Areal average methane emission reductions in year t; t CO ₂ e/unit area
$\overline{\Delta N_2O}_t$	Areal average nitrous oxide emission reductions in year t; t CO ₂ e/unit area
T	Critical value of a student's t-distribution for significance level α = 0.05 (i.e., a 1 – α = 95% confidence interval) and the degrees of freedom df appropriate for the design used (e.g., df = n – 1 for a simple random sample of n sample units)
15%	Threshold beyond which there is an uncertainty deduction
.	Gas or Pool

This project uses quantification approach 1 in which key sources of uncertainty accounted for are sample error and, where models are applied (Quantification Approach 1), measurement error of model inputs and model prediction error. Uncertainty in area estimation is addressed via complete (and accurate) GIS boundaries of the project area, applying QA/QC procedures specified in the parameter table for Ai.

Since Quantification Approach 1, as applied in this project, utilizes RothC outputs for the determination of the project and baseline carbon stocks, the uncertainty must be propagated in an appropriate and conservative manner to the resultant combined uncertainty of the RothC output carbon stock. In this project, for the case of the soil carbon stock, given the project design and the requirements of the methodology, we must combine the error in the RothC inputs, after propagating through the RothC, and the inherent model prediction error in the RothC model itself as determined in VMD0053, to arrive at a combined error. The RothC input errors are discussed further in the ‘Model Input Measurement Error’ section below, and as presented there, the main error that must be propagated forward is the remote sensing measurement error for ongoing soil carbon stock measurement.

Model prediction error

If both the project emissions and baseline emissions fall under Case B, and paired modeled and direct-re-measured sites in an experimental sampling regime subject to control and treatment scenarios are available for quantification of the model prediction error, then, following VM0042 v1.0, the model prediction error may be given as:

$$S_{\text{struct},\Delta\bullet,t} = s\bullet\sqrt{2(1 - \rho\bullet)}$$

Where:

$S_{\text{struct},\Delta\bullet,t}$	(Approximate) standard error in $\Delta\bullet$ ($\Delta\bullet$ = emission reductions in gas and pool $\bullet$) due to model prediction error at time t ; t CO ₂ e/unit area
$s\bullet$	Standard deviation of the residuals ($\bullet_{\text{measured}} - \bullet_{\text{modeled}}$). $\bullet$ = modeled or measured emission or stock change in gas and pool $\bullet$ over a fixed interval); t CO ₂ e/unit area
$\rho\bullet$	Correlation coefficient of (i) model errors in the project scenario and (ii) model errors in the baseline scenario in gas and pool $\bullet$ over a fixed interval; dimensionless
$\bullet$	Gas or pool

This method, for this specific paired experimental sampling regime, allows for the total calculation of model error across both the project and baseline scenarios. It is assumed that the standard deviation $s\bullet$ of the residuals ($\bullet_{\text{measured}} - \bullet_{\text{modeled}}$) is the same in the control and treatment scenarios.

For other situations, when paired modelled and direct re-measured sites in an experimental sampling regime subject to control and treatment scenarios are not available, the model prediction error is just the appropriately calculated $S_{\text{struct},\Delta\bullet,t} = s\bullet$ for the respective baseline or project scenario.

The calculation of $s\bullet$ is detailed in the Model Validation Report for both the baseline and project scenarios. A draft Model Validation Report is provided to the VVB and VCS at the time of validation and project review. As per the draft Model Validation Report and calculation spreadsheets, $s\bullet = 0.9783$ tons C/ha=3.587 ton CO₂e/ha for the baseline scenario.

Data for quantifying model prediction error may be sourced from studies conducted external to the project area, and should be from the same datasets used to validate the model (as detailed in VMD0053 “Model Calibration and Validation Guidance for the Methodology for Improved Agricultural Land Management”). If the amount of data for quantifying model prediction error varies significantly among crops, soil texture, and climate zones then a model prediction error could be estimated for groups of similar sites. That way, a model prediction error can be assigned to each sample unit i : $s^2_{struct,\Delta^*,i,t}$. Then $s^2_{struct,\Delta^*,t}$ is the model error variance for the population, estimated from the $s^2_{struct,\Delta^*,i,t}$ with an areal averaging:

$$s^2_{struct,\Delta^*,t} = \sum_i \frac{A_i^2}{A^2} s^2_{struct,\Delta^*,i,t}$$

For this project, the biogeochemical model is run separately for each individual sample unit (ranch), but there is only one crop functional group – pasture – and one predominant practice category – grazing effects – so $s^2_{struct,\Delta^*,i,t}$ is a constant on a ranch level.

Model input measurement error

Measurement errors of model inputs are captured by a combination of the (1) model prediction error noted previously (for the case of the climate variables and the soil properties, other than soil carbon stock) and (2) the uncertainty associated with the remote sensed soil carbon stock on a sample unit level. As detailed in the Model Validation Report, the same model inputs (other than remote-sensed SOC) are used during calibration/validation as are during model propagation for the project’s sample units. For this reason, the model prediction error contains the elements of the model input errors of the climate variables and the soil properties. Beyond these steps, QA/QC procedures for model inputs ensure that model inputs are sufficiently accurate and that measurement errors are uncorrelated with each other, along with no other material errors being left unaccounted.

QA/QC procedures and data downscaling procedures (if any) for the model inputs are shared in the table below:

Input Data	QA/QC procedure
Soil organic carbon stock	The training data for the remote sensing-based Boomitra technology must be QA/QC’d for proper domain coverage as detailed in the accompanying remote sensing report and in Section 4.1 of this document. Furthermore, the whole system itself is QA/QC’d with new validation datasets on a regular basis as noted in the monitoring plan. The SOC is calculated on a field level already so no downscaling is necessary.
Monthly rainfall (mm)	As discussed in previous sections, ERA5 data is used for this parameter. It is extensively QA/QC’d by the ECMWF, the producer of the dataset ¹¹⁵ . ERA5 has uncertainty estimates for this parameter from a 10-member Ensemble of Data Assimilations (EDA) approach, which are also reviewed to ensure consistency ¹¹⁶ . ERA5 has a resolution of 31km. Given that the nearest calibrated physical

¹¹⁵ A presentation on ECMWF QA/QC protocols is available here: https://climate.copernicus.eu/sites/default/files/2022-09/S3_ChunxueYang_V2.pdf

¹¹⁶ The ERA5 uncertainty is documented here: <https://confluence.ecmwf.int/display/CKB/ERA5%3A+uncertainty+estimation>

Input Data	QA/QC procedure
	weather stations can often be much farther than 31km from the sample units, ERA5 still provides higher resolution data than physical weather stations available today in the project area. The value of the grid position that the sample unit falls within is directly used. There may be errors due to the lack of sufficient resolution to the sample unit level, but these errors are captured in the model prediction error as the same resolution weather data is used in the calibration and validation of the RothC model.
Monthly open pan evaporation (mm)	See above approach for ERA5, which is also used for this input
Average monthly mean air temperature (o C)	See above approach for ERA5, which is also used for this input
Clay content of the soil	The published uncertainty layer from ISRIC Soilgrids for the parameter is reviewed, ensuring that the error is less than 20% of the actual parameter value. The ISRIC data is calculated to a field resolution since ISRIC provides 30m resolution maps – ISRIC’s interpolation (downscaling) of soil data for arriving at field-level values is state-of-the-art and ensures the best possible accuracy in determining this parameter in the absence of field sampling.
An estimate of the decomposability of the incoming plant material - the DPM/RPM ratio	This is a literature constant and hence there is no QA/QC necessary
Soil cover (Bare/Vegetated)	This is a project-level constant and hence there is no QA/QC necessary
Monthly input of plant residues	The calibration/validation procedures in the model validation report provide for the QA/QC. This data is calculated to a field resolution through the procedure in the model validation report.
Monthly input of farmyard manure (FYM)	The QA/QC procedure for livestock numbers, detailed in the monitoring plan, is the main QA/QC in determining this parameter. This data is calculated to a field resolution.
Depth of soil layer sampled	This is a project-level constant. However, depths may be indirectly affected in the soil carbon stock inputs, if the soil in the sample unit were to have high compaction levels (the remote sensing would underestimate depth), or if similarly, the soil carbon stock inputs are from a remote sensing system trained on a calibration dataset that has a skew in compaction (the system would overestimate depth). Given the observed livestock counts in Appendix 4, none of the present sample units are likely to be compacted due to overgrazing or other stocking rate related effects (as the stocking rates are very low). Refer to this footnote for an in-depth explanation¹⁰¹. On the other hand, the calibration dataset could have highly compacted locations, which would then not be representative of the project and could lead to skewed results that indirectly represent a wrong depth level. Thus, compacted locations (high bulk density levels) are removed from the calibration dataset as part of the data pre-processing procedures further described in the ATBD and in Section 4.1. Finally, the soil carbon remote sensing system’s calibration data is itself built for 0-30cm depth, ensuring consistent depths are used in

Input Data	QA/QC procedure
	the remote sensing soil carbon input to RothC, this particular parameter, the propagation of the RothC itself, and the entire project.

Table 8. QA/QC of the model inputs

Further details on the quantification of remote sensed soil carbon stock measurement error on a sample unit (field/ranch) level for a given measurement time, $S_{meas,SOC,t,i}^2$, are provided in Section 4.4.1 and accompanying documentation for the VVB and VCS Team. This measurement error must be further propagated through the RothC as described in the Combined Error subsection below.

Sample error

There is no *sampling* error in this project, because the full population distribution of soil carbon levels across the ranches is measured through remote sensing on a pixel level, for every pixel across the project area. There may be sample errors inherent in the creation of the remote sensing algorithms used for determination of SOC stock, particularly in the accuracy of the calibration dataset used and any spatialization pre-processing used to match point sampling data with satellite data, and these are separately covered in Section 4.4.1 and the measurement error determination.

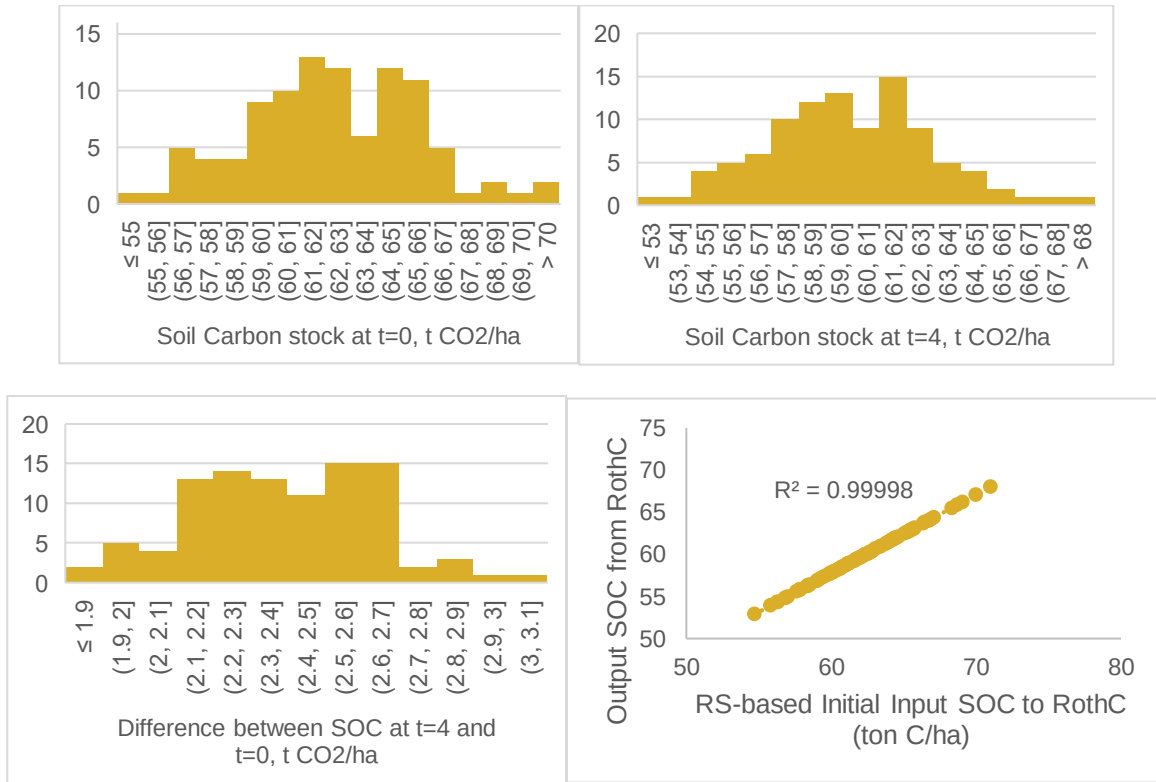
Combined error

The combined error must include both the remote sensing soil carbon uncertainty and RothC model prediction uncertainty, with the remote sensing uncertainty propagated through the RothC model as well, since the remote sensing soil carbon is an input to the RothC, and the RothC output is ultimately used for the GHG ERR calculations, under Quantification Approach 1.

The SOC measurement input error must be included and propagated through the RothC model through the use of Bayesian Monte Carlo methods (as specified in the guidance in VM0042 v2.0 Section 8.6.1.2.2).

Bayesian Monte Carlo (MC) simulations of the input remote-sensed soil organic carbon measurements following a distribution as per their established uncertainty (Section 4.4.1) are fed into the RothC model, with the resultant output distributions of SOC stock for the start of the monitoring period and each ensuing year collected. The difference in these distributions is the simulated stock change distribution with fixed RothC model parameters, and taking the standard deviation of this difference distribution provides the uncertainty contribution from the error in the input. This resultant uncertainty added to the RothC model prediction error determined as per the requirements of VMD0053.

Consider an example of an individual sample unit in the first instance in this project. The distribution of initial soil carbon is sampled with 100 MC simulations (refer to the distribution derived in Section 4.4.1.3) and fed into the RothC model to produce a simulated output distribution after 4 years of forward propagation (the length of monitoring period 1):



The top left histogram is the distribution at $t=0$, and the top right the distribution after 4 years of RothC forward propagation, with the bottom left histogram the difference between the two, and the bottom right a scatterplot of the initial and final distributions. The two distributions are highly correlated with a correlation of 99.998% and a covariance of 9.98, which also leads the difference distribution to have a small standard deviation of just 0.241 tCO₂/ha. It can be observed that this variance is small compared to the variance due to the baseline scenario model prediction error. As seen in the draft Model Validation Report, the model prediction error in 3.587 tCO₂/ha so the final standard error for the baseline emissions of this ranch would be, analytically, the sum of the squares of the variances, or $\sqrt{3.587^2 + 0.241^2} = 3.595 \text{ ton CO}_2/\text{ha}$. This type of analysis may be repeated across every single sample unit in the project, by propagating the input uncertainty distribution through RothC and observing the difference in outputs. For the sake of notation, we refer to this propagated uncertainty contribution as $s_{RS-BSL-MC,i,t}$, denoting the uncertainty of the remote sensing input propagated through the baseline RothC model run via MC simulations.

Hence, in the first monitoring period, for the baseline scenario:

$$s_{\Delta,i,t,BSL}^2 = s_{RS-BSL-MC,i,t}^2 + s_{STRUCT,\Delta,i,t}^2 = s_{RS-BSL-MC,i,t}^2 + s_{BSL}^2 \bullet$$

For the project scenario, a similar uncertainty propagation must be carried out, but with the RothC model run of the project scenario, resulting in a term $s_{RS-PROJ-MC,i,t}$.

$$s_{\Delta,i,t,proj}^2 = s_{RS-proj-MC,i,t}^2 + s_{struct,\Delta,i,t}^2 = s_{RS-proj-MC,i,t}^2 + s^2 \bullet_{proj}$$

Note that the $s_{RS-proj-MC,i,t}^2$ may be distinct from $s_{RS-bsl-MC,i,t}^2$ because the RothC model is run differently between the project and baseline scenarios. Additionally, with the regular recalibration and true-up of the project scenario RothC model, the term $s_{RS-bsl-MC,i,t}^2$ will also acquire some of the errors arising from the recalibration process itself, which are not present in the $s_{RS-proj-MC,i,t}^2$. For example, the repeat measurements of remote-sensed soil organic carbon stock have their own uncertainty associated with them (as shown in Section 4.4.1), and these become absorbed into the way that the outputs in the RothC are generated, when the MC simulation is generated. With recalibration and true-up, the project-level RothC MC simulation of the SOC stock will be less correlated (lower covariance) from year to year than it is in the baseline scenario. This contributes to a distinct and potentially higher $s_{RS-proj-MC,i,t}^2$ than $s_{RS-bsl-MC,i,t}^2$, as this additional error is properly incorporated through the MC simulation. The final combined uncertainty for a given sample unit is the summation of the variances of the baseline and project scenarios for that sample unit:

$$s_{\Delta,i,t}^2 = s_{\Delta,i,t,proj}^2 + s_{\Delta,i,t,bsl}^2$$

This equation may be expanded to:

$$s_{\Delta,i,t}^2 = s_{\Delta,i,t,proj}^2 + s_{\Delta,i,t,bsl}^2 = s_{RS-proj-MC,i,t}^2 + s^2 \bullet_{proj} + s_{RS-bsl-MC,i,t}^2 + s^2 \bullet_{bsl}$$

Observe that there are 2 MC simulation terms, one for baseline and project scenario respectively. They may also be combined together if the MC simulations are extended one step further beyond just the individual baseline or project scenario to the net carbon stock change calculation (eg. Eq 33 in VM42 v1.0). In that case, the variance of the net stock change distribution can be called $s_{RS-MC,i,t}^2$ and the combined uncertainty for a sample unit may be written as:

$$s_{\Delta,i,t}^2 = s_{RS-MC,i,t}^2 + s^2 \bullet_{proj} + s^2 \bullet_{bsl}$$

Finally, to obtain the total combined error across the project, we assume the independence of sample units, since they are independent ranches/fields managed independently in this project as defined in Section 5.3.11. Thus the errors are combined together to a project level:

$$s_{\Delta,t}^2 = \frac{1}{n^2} \sum_i s_{\Delta,i,t}^2$$

Where, n is the number of sample units. $s_{\Delta,t}^2$ is then used in Equation 46 of the methodology to compute the uncertainty deduction, as provided at the beginning of this Section 4.4.

4.4.1 Boomitra Technology to determine Soil Organic Carbon Stock with Remote Sensing

Boomitra has developed a technology to determine SOC weight percentage and bulk density levels using emerging technologies such as remote sensing. Satellite remote sensing offers low-cost measurement

technological capability by allowing measurements on a field level to be taken at a very low cost (if using public, freely available satellite data), and multiple measurements to be taken from a given field at regular intervals. High resolutions satellites today are able to measure every land area on earth to 3-30m resolution and nearly every 2 weeks or more frequently. This quantity of data presents a great opportunity for frequent and accurate measurements to be made.

Boomitra's remote sensing SOC and bulk density measurement technology can be interpreted as a further extension of recent work in the SOC remote sensing field, utilizing data across many different sources. It also contributes a new scientific outlook to the field with an approach that enables the ability to sense information at appreciable depths throughout the top 30cm or more of the soil, as required by the chosen VCS methodology. Utilizing certain data and satellite bands under Boomitra's scientific framework enables direct observation and measurement of soil organic carbon, at the level of a satellite pixel. The framework utilizes soil physical properties that are directly measurable at reasonable depths into the soil with certain satellite data. In turn, the soil carbon levels and bulk density are known to have a causal relationship with these properties (ie. change in soil carbon causes change in these physical properties) , which has also been empirically verified across other studies. Thus, soil carbon and bulk density are able to be established through certain satellite measurements. The technology is analogous to a classic mercury thermometer. A mercury thermometer measures temperature through the thermal expansion of a column of mercury, which is driven by the temperature. The thermal expansion of mercury with temperature is a well-known causal physical phenomenon and an empirically derived coefficient of thermal expansion relates temperature directly to thermal expansion. The reading of the length of the mercury column by a user looking at the markers on the thermometer is analogous to certain satellites measuring specific soil physical properties at reasonable depth. Likewise, the causality between temperature and the length of the column is analogous to that between soil carbon and the soil physical property. Thus, just as a mercury thermometer measures temperature via the measurable length of mercury, this technology measures soil carbon through directly measurable soil physical properties. For a given geometry of the mercury thermometer, regardless of when the thermometer is used, the length of the column of mercury and its relationship with temperature is the same. Likewise, for a given set of physical conditions and fixed satellite used, the relationship between the satellite measurement and the soil carbon level is the same, regardless of when the technology is used. Thus, just as a thermometer may monitor temperature dynamically, this technology monitors carbon dynamically. Note that the framework of the technology is thus different from typical data-driven soil mapping exercises wherein a large number of environmental covariates are used to fit the best possible ML model that optimizes for accuracy but may not have any causal relationships demonstrated, and may not directly be used dynamically (Eg. ISRIC Soilgrids, the state-of-the-art soil map used for clay inputs to RothC in this project, uses over 400 covariates in such a data driven model, and is a static soil map¹⁰⁶). The remote sensing report provided to the VVB and Verra outlines these theoretical framework steps and the associated assumptions, along with data-driven justifications of these assumptions in the context of this project.

In practice, real world conditions result in signal noise caused by: imaging nuances specific to the cameras on a given satellite; any above-ground biomass and its associated seasonality; and lastly, unrelated fluctuations in the soil itself, such as moisture levels, which are strongly affected by rain or the absence of it. Mercury thermometers also have variation caused by the geometry of the device. Thus,

just as a given mercury thermometer has empirically calibrated temperature markings to produce accurate readings, a combination of data across many satellites, followed by machine learning techniques training on a diverse set of calibration data, help to reduce noise in the calculations, improving the accuracy of measuring soil organic carbon stock. These machine learning systems need to be trained and calibrated for each geographical region – the aforementioned underlying theoretical assumptions and controlling the noise usually only hold in a demonstrable manner within a given defined region. This includes a soil data processing workflow from data collection to calibrating and validating the satellite-based soil carbon measurement. Ground data such as real soil test data from different credible sources are collected for each geography, such as the INEGI dataset described in detail in Section 4.1. With the help of this data, machine learning systems are calibrated and trained to minimize errors while estimating absolute SOC levels and their resulting changes over time. This processing workflow is detailed further in the remote sensing report provided to the VVB and VCS. Any calibration dataset is collected over a certain timeline – in the case of the INEGI dataset, as mentioned in Section 4.1, this timeline is from 2005 to 2012, prior to the start date of the project. However, given the underlying physics framework of the technology used, the validation of the associated assumptions for Northern Mexico, and the representativeness of the calibration dataset across all project areas and the likely ranges in soil carbon across the lifetime of a project, the ML system created with the calibration is theoretically applicable throughout the baseline and project scenarios of the project, just as a mercury thermometer once calibrated is applicable whenever it is used within the range of calibration. See the remote sensing report for further justification on this applicability. This applicability is regularly checked empirically during each verification (eg. ongoing validation sampling), and the uncertainties present in each monitoring period are fully quantified, as seen in the subsections below.

4.4.1.1 Sources of Uncertainty

The methodology requires emerging technologies such as remote sensing to have a ‘known uncertainty’ when being used in the project for soil carbon stock quantifications. Remote sensing has different sources of uncertainty than SOC stock estimates from conventional soil sampling measurements. Assuming effective field sampling followed by dry combustion lab testing, individual soil samples themselves may have SOC wt% uncertainties of 0.02wt%¹¹⁷. However, when it comes to estimating SOC stocks across sample units, uncertainty becomes much higher due to sampling error – the uncertainty generated by measuring only specific areas within the much larger project through conventional soil sampling. For example, typically, physical soil sample testing may only be done once every 40 acres according to precision ranching literature¹¹⁸, however the actual SOC variation in large grassland fields can be 0.10wt% or higher¹¹⁹. Getting to an observability of 0.01wt% changes, with dry combustion testing, would require 100 samples or more, using the conventional sampling error guidance in Section 8.6.1 of VM0042v1. On the other hand, remote sensing, which measures every 30mx30m pixel in the project area, does not experience this particular form of sampling error, but rather experiences greater errors in point-level measurements of the SOC. The subsequent paragraphs provide methods and sample results

¹¹⁷ <https://anlab.ucdavis.edu/analysis/Soils/322>

¹¹⁸ <https://cropwatch.unl.edu/2021/pasture-and-forage-minute-grazing-stockpiled-grass-alfalfa-soil-sampling>

¹¹⁹ This has directly been measured in the project from soil sampling on real participating ranches. In one particularly ranch with 77 samples taken, the standard deviation in SOC% was 0.9wt%.

on quantifying these uncertainties, and a comparison to conventional soil sampling and testing strategies.

The total uncertainty of the remote sensing may be quantified by fully listing the different sources of uncertainty and carrying out various methods to both minimize and quantify the resultant uncertainty in the measured SOC and bulk density values.

Machine learning models, such as the one utilized in the context of the Boomitra remote sensing technology, have three sources of uncertainty:

1. Noise in input data: If the inputs to the machine learning model have inherent noise to them, then the outputs will also have a carry-through effect. In the case of the models in this document, this refers to satellite sensor measurement noise. Given the levels of calibration of the public satellites used in this work, this noise can generally be assumed to be random error from the sensors, as noted in the remote sensing report. Ultimately this source of error is accounted in the different uncertainty calculation techniques using the analysis of model outputs (which implicitly incorporate this error), as seen in subsequent subsections.
2. Incomplete coverage of the domain: If the training data used to calibrate the model is not sufficiently representative of the domain for which the model is to make predictions, these kinds of uncertainties can occur. In the case of this work, a source of this uncertainty is from calibration soil samples not being fully representative of the region of interest for which the model is to be applied. This uncertainty is to be minimize through choosing the right underlying training datasets to calibrate the model and can be substantiated through analysis of the training datasets themselves to see if they cover the necessary ranges in soil carbon, soil textures, cropping types and climate zones found in the region of interest. Typically, large governmental or private soil surveys of an entire region tend to approximate the coverage of the domain reasonably well and can minimize this source of uncertainty. In this work, as detailed in Section 5 of the accompanying remote sensing report and Section 4.1 of this document, the primary training data source used spans across the entire geographical region and was collected by the Mexican government as part of a systematic large scale study of soil conditions across the country, suggesting that the dataset does cover the full range of the domain of interest, including the full extent of carbon levels in the baseline and project scenarios. Further justifications on domain coverage are provided in Section 5 of the accompanying remote sensing report and in Section 4.1 of this document. Another related source of incomplete coverage of the domain may arise from model drift, causing the correct domain of the model itself to shift with time. Model drift in machine

learning systems may be caused by: input covariate drift, concept drift or label drift¹²⁰. Given that the calibration soil survey data is QA/QC'd to be representative of the full range of anticipated conditions in carbon, label drift, or representation of the soil carbon levels in the calibration dataset, is not likely to occur. As noted in Section 4.1 and in the remote sensing report, the full quantification of soil carbon and bulk density uses NASA & ESA satellite band data and soil texture data (only for bulk density) as covariates. Soil textures are unlikely to change over human lifetimes¹²¹. However, satellites can surely change in their imaging due to changes in orbits and changes in the onboard measurement devices. For this reason, it is important to always use properly normalized data produced by NASA & ESA for each satellite and each band that accounts for these changes to the satellites, and is known to be intercomparable across different times of imaging. This work uses the properly normalized data, as noted in the remote sensing report. Finally, concept drift could occur if the relationship originally learned by the machine learning model itself changes with time. Specifically in this work, as noted earlier, the relationship being learned is between a directly satellite-measurable soil physical property and the soil carbon. Concept drift can thus occur if there are changes to the soil structure and composition over time that are not already connected to the learned relationship to soil carbon and the original domain represented by the calibration set. Thus sources of concept drift may include (1) systemic changes over time that are unrelated to the project itself, and (2) the project activities themselves, which are the key change in the project areas from the baseline scenario. The primary systemic change unrelated to the project may be climate change. Soils in the grasslands of the region have reached their current state over several millenia of evolution, including the presence of livestock ranching for the last several hundred years. However, climate change could potentially enhance or hurt vegetation growth, lead to higher or lower levels of average yearly precipitation, higher or lower average temperatures and so on. These effects will directly affect soil carbon, but may not affect other aspects of soil structure and composition in an unrelated way in the term of the project, with the exception of average moisture levels. Moisture is a large component of soil composition and will surely fluctuate over time with climate change. For this reason, the technology includes an approach to minimize the effects of moisture through carefully choosing specific times of the year for repeatable measurement, as discussed further in the remote sensing report. Thus, the effects of systemic changes over time are minimized through careful choices for the process steps in the measurement. On the other hand, project activities of transitioning to improved grazing

¹²⁰ Y. Xu and D. Klabjan, "Concept Drift and Covariate Shift Detection Ensemble with Lagged Labels," in 2021 IEEE International Conference on Big Data (Big Data), Orlando, FL, USA, 2021 pp. 1504-1513.

¹²¹ <https://ohioline.osu.edu/factsheet/anr-0136>

may have unexpected effects on soil structure and composition. The key effect may be from the localized increase in stocking density that rotational grazing creates in a given paddock, leading to potentially greater soil compaction within that paddock due to livestock hoof action. This soil compaction is completely separate from the soil carbon change, but would be a key form of concept drift for the technology when a practice shift to rotational grazing is happening. However, this source of drift is not applicable to this specific project region due to the very low stocking rates present relative to what is needed to cause compaction (stocking rates are high enough to cause overgrazing, but an order of magnitude too low to cause soil compaction from animal hooves). Refer to this previous footnote for a deeper discussion and justification¹⁰¹. Thus, through proper QA/QC and controls, errors due to incomplete coverage of the domain are minimized.

3. Imperfect models: Last but not least, the model itself may be imperfect due to being unable to fully capture the variations in its training data. This is an element of any model that is a reduction of a more complicated underlying system. In this work, imperfect models can be due to an underlying nature of the machine learning architecture and training process used itself (eg. linear models, decision tree algorithms, neural networks with gradient descent, etc.), or even from the targets in the training data (eg. SOC of soil samples trained on) or from the associated pre-processing steps. The INEGI soil samples used for training in this work have gone through the same analytical lab technique, dry combustion, which may result in a 0.02wt% error¹¹⁷ in the samples' carbon levels. There may also be errors introduced from the potential (unknown) slight variations in sample collection procedures carried out by different individual technicians that undertook the soil survey, that result in random errors in the data points. Similarly, one specific pre-processing step that leads to imperfect models is the spatialization approach taken to match point measurement data of soils that are used for calibrating the satellite models to the pixels extracted from satellite data, since the satellite pixels do not directly match to points but rather to areas corresponding to the pixel size. As discussed further in the accompanying remote sensing report's Section 5, this work matches satellite data to the INEGI data for training by identifying the collocated satellite pixels, which represent an area larger than the point locations sampled, and thus the exact spatial variability seen by the pixels is ultimately not represented in the sample point data, which also leads to an imperfect model. Given that nearby soils are correlated, the effect is not expected to be large, but this pre-processing step is certainly an error source. Ultimately this general source of error (imperfect models) is accounted in the different uncertainty techniques using the analysis of model outputs (which implicitly incorporate this error, in frequentist and Bayesian approaches), as seen in subsequent subsections.

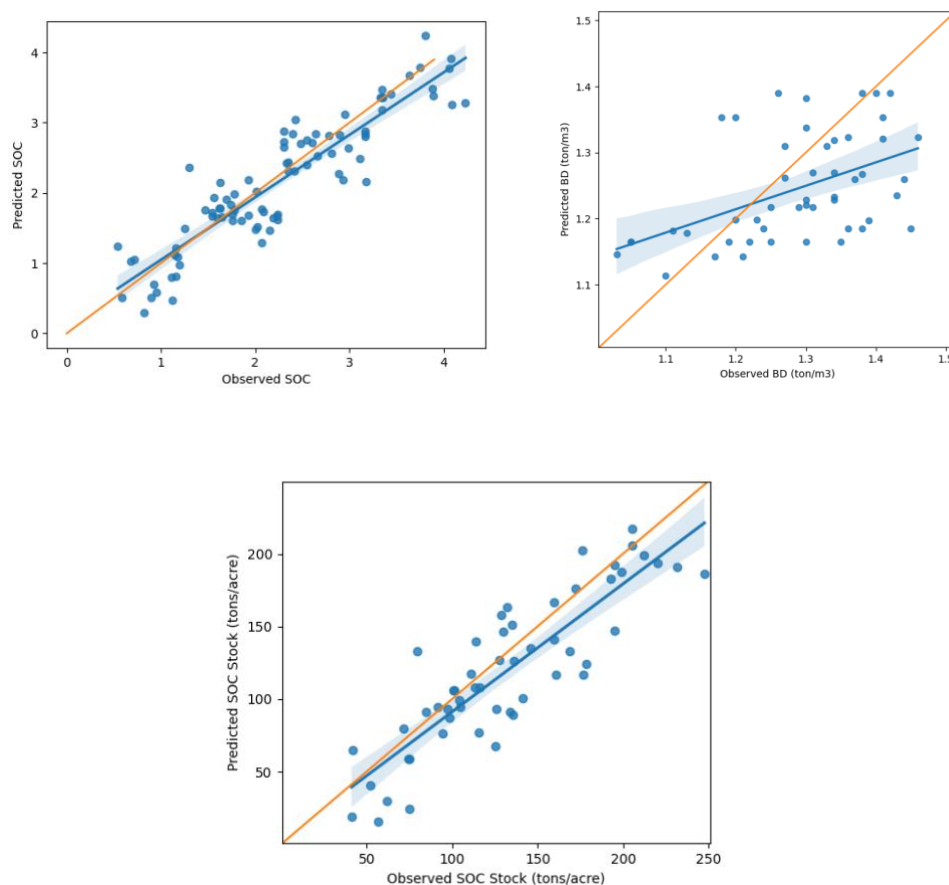
There are two approaches to computing uncertainty across these sources 1 and 3 above in a conservative manner: the frequentist approach and the Bayesian approach.

4.4.1.2 Frequentist Approach

The frequentist approach allows for a direct comparison of observations and predictions on validation data to propagate a result uncertainty that encompasses both noise in input data and imperfect models. Uncertainty may be computed systematically across every soil organic carbon stock value generated on a field level (every chosen farm boundary). During the validation of the model, a mean squared error (MSE) is calculated with respect to the validation data, and it represents a pixel-level uncertainty in the calculation, since the pixel is the smallest unit of calculation of the remote sensing system (there is no added upsampling), and each validation data point is compared to a specific pixel. Thus, for the remote sensing, the point measurement is the pixel measurement, and the point-level uncertainty is the pixel-level uncertainty. Mean Square Error (MSE) is also a liberal estimator of the standard error (it overestimates the standard error) because it accounts for both bias and variance in the data predictions, whereas the standard error accounts for only the variance. Once the MSE for calculations on sample point-data is known, it may be used as a pixel-level uncertainty. If this frequentist uncertainty is used, then the pixel-level MSE may be scaled up to a sample unit (ranch) level by scaling the MSE by the number of *decorrelated pixels* that exist within the sample unit. Since adjacent areas may have correlated soil carbon levels or satellite data signatures, it is not possible to simply divide the MSE by the number of pixels to arrive at the ranch-level MSE. Further details on decorrelation lengths are provided in the accompanying remote sensing report.

The monitoring plan of this project provides for the ongoing collection of validation datasets with conventional methods (eg. Ground soil sampling and testing) to continually validate the remote sensing technology prior to each verification of the project. The uncertainty of this remote sensing technology may then be derived from the results on the validation datasets at each verification. The following paragraphs detail the results from this undertaking for the first monitoring period.

In 2022, nearly 100 soil samples were collected by a third-party group of trained soil researchers and tested with dry combustion across the project areas, following protocols further detailed in the Monitoring Plan and in Section 5.1.2 of the remote sensing report. Below are summarized results, based on calculating remote sensed measurements at the pixel level for SOC wt% and bulk density, and comparisons to the conventionally measured value from dry combustion:



The above figures present a comparison of the 2022 validation samples' soil organic carbon (wt%) (top-left), bulk density (tons/m³) (top-right) and resultant SOC stock (tons CO₂e/acre) (bottom) with regression line (blue) and 95% confidence interval (shaded blue) drawn, along with a 1:1 line (orange) for guidance. Based on analytical uncertainties, the standard deviation of the datapoints in the x-axis (the soil sample measurements), is believed to be 0.02wt% or less.

Note that the pixel is the smallest unit of calculation and used for the comparisons above directly, so these comparisons to the validation data points represent pixel-level uncertainty.

The table below presents pixel-level **uncertainty** of the remote sensing, based on this 2022 soil sampling validation.

Value	Root Mean Squared Error
Soil Organic Carbon, wt%	0.3970wt%
Bulk Density, tons/m ³	0.1420 tons/m ³
Soil Organic Carbon Stock, tons CO ₂ e/acre	28.99 tons CO ₂ e/acre

Note that since these are pixel-level values, the errors will improve upon aggregation of more pixels, similar to how taking additional soil samples from an area would improve accuracy of the estimate for the area.

For a comparison to conventional soil sampling-based determination of SOC, first we assume, as mentioned in the section 4.4.1.1, that 100 soil samples must be taken to reach observability of 0.01wt% changes when the overall variation in the grassland is 0.1wt%. Secondly, assume as mentioned in Section 4.4.1.1 that samples are only taken every 40 acres. Then, 100 samples are taken over 4000 acres. For our model with 0.3970wt% uncertainty to reach a similar accuracy, it would need to have at least $(0.3970\text{wt}\%/0.01\text{wt}\%)^2 = 1580$ ‘independent’ measurements. Note again that, as mentioned before, this does not mean just 1580 pixels are necessary, due to spatial correlations between pixels. A decorrelation length scale must be carefully developed and this is addressed in further depth in Section 4.2.4.1 of the remote sensing report provided to VVB and Verra. There is naturally a significant amount of spatial variation in the grassland areas in this project because they are a native ecosystem that is not manually cropped/tilled/harvested etc. However, we can make a very conservative assumption of the decorrelation length of at most 100m, as presented in Fig 9 of Section 4.2.4.1 of the remote sensing report provided to VVB and Verra. Then, observe that:

$$\frac{0.3970\text{wt}\%}{\sqrt{4000 \text{ acres} * \frac{4046 \frac{\text{m}^2}{\text{acre}}}{100\text{m} * 100\text{m}}}} = 0.0099\text{wt}\%$$

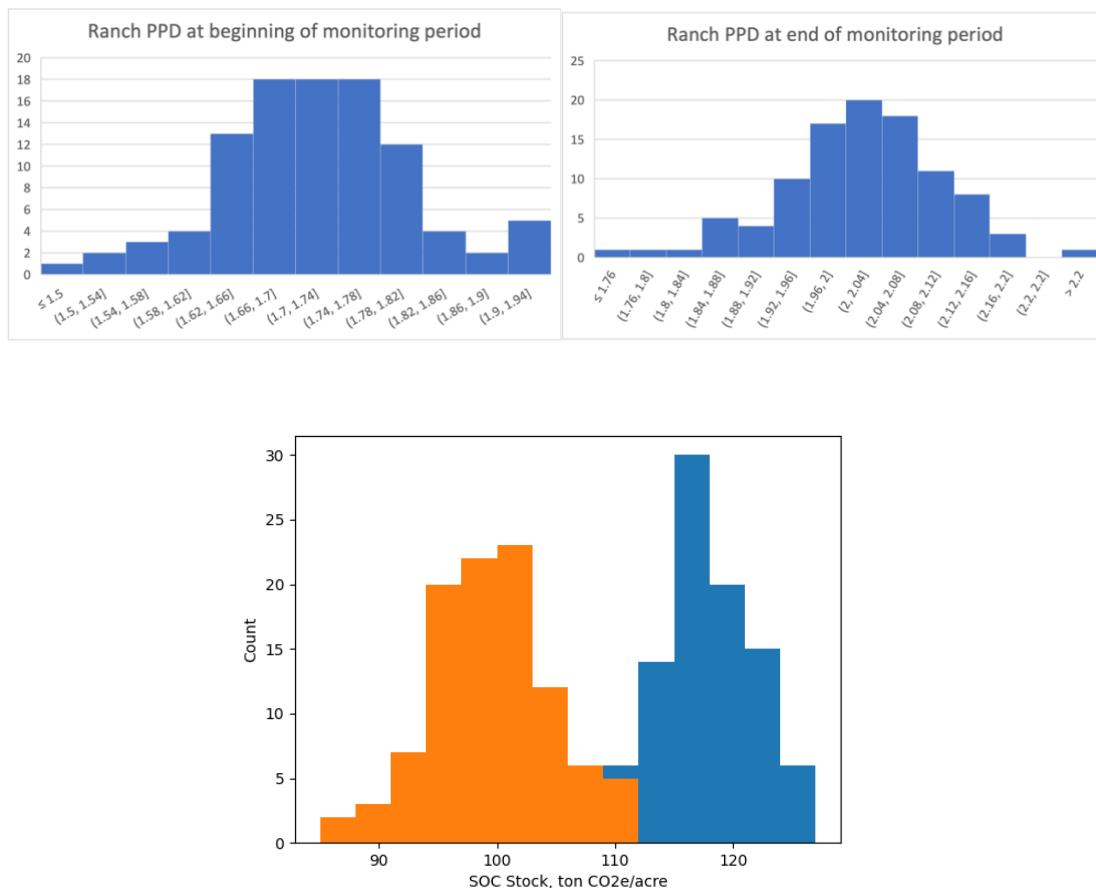
This suggests the remote sensing could be on par with the dry combustion analysis. Furthermore, note that the soil sampling and testing costs for 100 samples will be on the order of \$20,000 (this cost is based on the real cost incurred in this soil sampling & testing exercise, about \$200 per sample & test). The remote sensing analysis occurs at a fraction of this cost once the machine learning model is trained, while providing similar results at the sample unit level.

4.4.1.3 Bayesian Approach

An alternative, but more accurate calculation of variance of soil carbon measurements resulting from noise in input data and from model imperfection can be obtained through a Bayesian approach involving several Monte Carlo simulations of the output of the machine learning model. In this approach, for each ‘simulation’, the model is repeatedly trained with subsets of the training data and made to perform predictions of individual pixels in the underlying field that is being studied. The repeated training of the model essentially creates a posterior distribution of the model’s internal parameters that accounts for the modeling error and elements of the input data noise. Then, using the posterior distributions of the models alongside the inputs of the validation dataset, a predictive posterior distribution of the validation predictions is produced. Thus, for each predicted value, we may compute a variance of its predictive posterior distribution to determine the uncertainty of that specific value. The individual predictive posterior distributions can also be averaged together across a series of pixels found in a given sample unit of interest to arrive at the predictive posterior distribution of the mean soil carbon of that sample

unit. Taking the variance of this distribution provides an accurate calculation of the uncertainty in the SOC stock and may be used directly as the uncertainty of SOC stock for the sample unit.

In Section 5.1.4 of the remote sensing report provided to the VVB and VCS, there is an example presented of the Bayesian approach with 100 Monte Carlo simulations for one of the project sample units (ranch) across the first monitoring period (4 years), the results of which are summarized here, generating the following Predictive Posterior Distributions¹²² of SOC:



In the above figures, the top two represent the SOC wt% PPDs at the beginning and end of the first monitoring period. The bottom figure represents the overlaid PPDs once they are converted to SOC Stock levels from wt% after the incorporation of similar bulk density PPD simulations as well. The orange distribution is from the start of the monitoring period and the blue from the end of the monitoring period.

Observe that the distributions are separated from one another, in terms of their respective centers and variance. The SOC wt% PPD at the beginning of the monitoring period has a standard deviation of 0.088wt% and the PPD at the end has a standard deviation of 0.087wt%. Furthermore, the two distributions have a significant degree of correlation, with a covariance of 0.005269 wt%². When the

¹²² In Bayesian Statistics, the Predictive Posterior Distribution is the distribution of output values (here, SOC), conditional on the distribution of the input values. See "[Posterior Predictive Distribution](#)". SAS. Retrieved 19 July 2014.

covariance is factored in, the standard deviation for the difference of the two distributions reduces to 0.069wt%.

Similarly, the SOC stock (tons CO₂e/acre) PPDs at start and end have standard deviations of 4.7 ton CO₂e/acre. Then 4.7 ton CO₂e/acre is the uncertainty in the SOC stock determined from the remote sensing. When this analysis is carried out, the uncertainty of both the bulk density and SOC wt% are directly incorporated during the calculation of the PPD for SOC stock in tons CO₂e/acre. This 4.7 ton/acre value can then be used as the ranch-level error in subsequent uncertainty propagation calculations where this ranch's data incorporated, to calculate final ERRs. Furthermore, the covariance of the distributions (15.30 ton²/acre²) may be considered, resulting in a final standard deviation of the increase in SOC stock (difference of the stock distributions) of 3.6 ton CO₂e/acre, lower than the individual distributions' standard deviations. At the 5% significance level, the width of the one-sided prediction interval for the ranch-level increase in SOC stock is $3.62 * t_{0.95} = 6.01$ tons CO₂e/acre, which is the minimum detection limit for the remote sensing system, on the level of this individual ranch. This type of analysis can be done on every ranch level using Bayesian methods. Experimental studies with intensive conventional soil sampling on field level report anywhere from 2 ton CO₂e/acre to 8 ton CO₂e/acre standard errors in SOC stock increase measured^{123,124,125,126}. The remote sensing system places within this range as well.

Consider a comparison on a project-level to conventional approaches (soil sampling and testing), involving one soil test every 40 acres (16ha) as noted earlier in the section. For the remote sensing approach, with 140 distinct sample units (ranches) in the project at the current time, the uncertainty in SOC percentage at the project level can be estimated to come to $0.088\text{wt\%}/\sqrt{140} = 0.0074\text{wt\%}$. This level of sensitivity is well within the requirements on a project level – in the first monitoring period, for example, the average SOC% increase across all ranches is 0.0604wt%, almost an order of magnitude higher. The average ranch is 4200 ha in size, so approximately 260 soil tests would have been done with 40 acre frequency in the conventional soil sampling. Across the region's soils, the variability in soil carbon is at least as large as 3wt%, as presented in the remote sensing report. On individual ranches, the variation is nearly 1wt%¹¹⁹. Then, each ranch is measured to 0.062wt%, and the project as a whole across the 140 ranches achieves 0.0052wt%. This is only slightly better than the remote sensing for overall observability, and only achieved after $140 * 260 = 36,400$ samples are taken. As noted earlier, the work in this project incurred \$200 in cost per soil sample and test, so the conventional soil sampling expense would be \$7.2M. It may typically not be feasible to take that many soil samples – other grassland soil carbon sequestration projects of similar size undertaking conventional soil sampling have taken much fewer samples¹²⁷. Taking fewer soil samples will increase uncertainty for the conventional approach

¹²³ Deluz Cédric, Nussbaum Madlene, Sauzet Ophélie, Gondret Karine, Boivin Pascal. (2020). Evaluation of the Potential for Soil Organic Carbon Content Monitoring With Farmers. *Frontiers in Environmental Science*, 8. <https://doi.org/10.3389/fenvs.2020.00113>

¹²⁴ Goidts, E., Van Wesemael, B., and Crucifix, M. (2009). Magnitude and sources of uncertainties in soil organic carbon (SOC) stock assessments at various scales. *European Journal of Soil Science*, 60, 723-739. <https://doi.org/10.1111/j.1365-2389.2009.01157.x>

¹²⁵ S. R. Sherpa, D. W. Wolfe, H. M. van Es, Sampling and data analysis optimization for estimating soil organic carbon stocks in Agroecosystems. *Soil Science Society of America Journal*. 80, 1377–1392 (2016).

¹²⁶ Intensive soil sampling has been conducted in a few of the ranches in this project as well. A ranch that had 77 soil samples taken with stratification has a sampling error of 0.11wt% and a corresponding standard error in stock of 6 tons CO₂e/acre

¹²⁷ <https://registry.terra.org/app/projectDetail/VCS/1468>

beyond that of the remote sensing. Deploying this project with conventional soil sampling and testing would end up substantially reducing the amount of project income that can be sent back to the ranchers and local communities, and furthermore reduce the financial viability of the project. The remote sensing, as demonstrated here, achieves a similar outcome at a much lower cost.

Further descriptions, methods and calculations for both frequentist and Bayesian approaches are given in Section 4.2.4 and Sections 5.1.2-4 of the remote sensing report provided to the VVB and VCS teams. Once aggregated to the sample unit (ranch) level, either approach, based on conservativeness, may be employed for the calculation of the uncertainty in the final ERRs in subsequent Monitoring Reports.

4.5 Net GHG Emission Reductions and Removals

Estimated net gross removals are quantified using Equation 31 of VM0042, version 1.0:

$$ER_t = (A_o \times (\overline{\Delta CO_2 Soil_t} + \overline{\Delta C_{CH_4 t}} + \overline{\Delta C_{N_2O, t}}) - LE_t) \times (1 - UNC_t)$$

Where:

ER_t	Estimated net GHG emissions reductions and removals in year t; t CO _{2e}
A_o	Project Area, Unit Area
$\overline{\Delta CO_2 Soil_t}$	Areal average carbon dioxide emission reductions from soil organic carbon pool in year t; t CO _{2e} /unit area
$\overline{\Delta C_{CH_4 t}}$	Areal average methane emission reductions in year t; t CO _{2e} /unit area
$\overline{\Delta C_{N_2O, t}}$	Areal average nitrous oxide emission reductions in year t; t CO _{2e} /unit area
LE_t	Leakage in year t, equal to zero; t CO _{2e}
UNC_t	Uncertainty deduction in year t; fraction between 0 and 1

This project only accounts for soil organic carbon stock changes. Hence the areal average carbon dioxide emission removals from CH₄ and N₂O **are zero**.

Carbon dioxide emission reductions are quantified as per equation 32 of methodology as shown below.

$$\overline{\Delta CO_2}_t = \overline{\Delta CO_2 soil_t} + \overline{\Delta CO_2 ff_t} + \overline{\Delta C_{TREE, t}} + \overline{\Delta C_{SHRUB, t}}$$

Where,

$\overline{\Delta CO_2}_t$	Areal average carbon dioxide emission reductions in year t; t CO _{2e} /unit area
----------------------------	---

$\overline{\Delta CO_2 soil_t}$	Areal average carbon dioxide emission reductions from soil organic carbon pool in year CO ₂ ^e /unit area
$\overline{\Delta CO_2 ff_t}$	Areal average carbon dioxide emission reductions from fossil fuel combustion in year CO ₂ ^e /unit area
$\overline{\Delta C_{TREE,t}}$	Areal average carbon dioxide emission reductions from tree biomass in year CO ₂ ^e /unit area
$\overline{\Delta C_{SHRUB,t}}$	Areal average carbon dioxide emission reductions from shrub biomass in year CO ₂ ^e /unit area

This project only accounts for soil organic carbon stock changes. Hence the areal average carbon dioxide emission removals from increasing **tree biomass, shrub biomass and fossil fuel combustions are zero.**

Carbon dioxide emission reductions from the soil organic carbon pool for sample unit i in year t are quantified for Quantification Approach 1 as mentioned equation 33.

$$\Delta CO_2 Soil_{i,t} = (SOC_{wp,i,t} - SOC_{wp,i,t-1}) - (SOC_{bsl,i,t} - SOC_{bsl,i,t-1})$$

Where,

$\Delta CO_2 Soil_{i,t}$	Carbon dioxide emission reductions from soil organic carbon pool for sample unit i in year t; t CO _{2e} /unit area
$SOC_{wp,i,t}$	Carbon stocks in the soil organic carbon pool in the project scenario for sample field i at the end of year t; t CO _{2e} /unit area
$SOC_{wp,i,t-1}$	Carbon stocks in the soil organic carbon pool in the project scenario for sample field i at the end of year t-1; t CO _{2e} /unit area
$SOC_{bsl,i,t}$	Carbon stocks in the soil organic carbon pool in the baseline scenario for sample field i at the end of year t; t CO _{2e} /unit area
$SOC_{bsl,i,t-1}$	Carbon stocks in the soil organic carbon pool in the baseline scenario for sample field i at the end of year t-1; t CO _{2e} /unit area
i	Sample unit

The initial SOC is the same in both the baseline and project scenarios at the outset of the project ($SOC_{wp,i,0} = SOC_{bsl,i,0}$) as a result, the above equation simplifies to

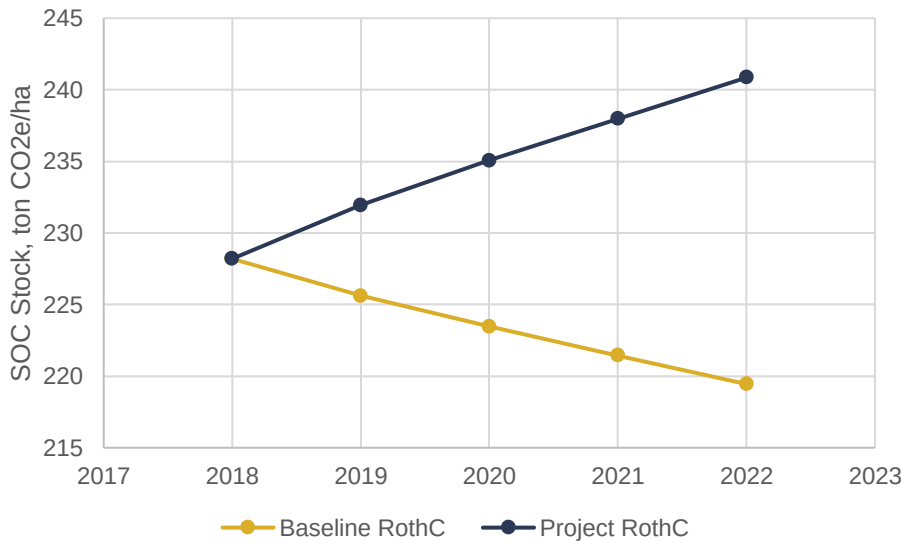
$$\Delta CO_2 Soil_{i,t} = SOC_{wp,i,t} - SOC_{bsl,i,t}$$

$\overline{\Delta CO_2 soil_t}$ is determined by taking an areal average of the independently calculated $\Delta CO_2 Soil_{i,t}$ for each sample unit in the project,

4.5.1 Example Calculation for a single field

A full example calculation spreadsheet is available for the VVB and VCS that carries the calculations starting from satellite data and other inputs, to the final Emission Reductions/Removals for a given sample unit, including 100 Bayesian Monte Carlo simulations and full uncertainty accounting, including in-depth calculation of model prediction error and remote sensing errors. Here, the same data and calculations summarized for general reference. The sample unit has an area of 2054.4 ha and an initial

measured soil carbon stock of 228.20 ton CO₂e/ha at the start of the project. The RothC model estimates the following for the baseline and project scenarios:



Here, we give calculations only for t=2022, but the same rules apply to all years, as can be seen in the more detailed spreadsheet, starting with Eq. 33 of the methodology:

$$\begin{aligned}\overline{\Delta CO_2}_{2022} &= \Delta CO_2 Soil_{i,2022} = (SOC_{wp,i,2022} - SOC_{wp,i,2021}) - (SOC_{bsl,i,2022} - SOC_{bsl,i,2021}) \\ &= (240.85 - 237.97) - (219.45 - 221.44) = 4.87 \text{ ton CO}_2\text{e/ha}\end{aligned}$$

For the combined error:

$$s_{\Delta,i,t}^2 = s_{RS-MC,i,t}^2 + s^2_{proj} + s^2_{bsl}$$

The project and baseline RothC models have model prediction errors of 2.907E-13 ton CO₂e/ha and 3.587 ton CO₂e/ha respectively, as shown in the spreadsheet. Likewise, as shown in the spreadsheet, the MC simulations for 2022 lead to a RothC-propagated remote sensing SOC uncertainty of 2.071 ton CO₂e/ha: $s_{\Delta,i,2022}^2 = (2.907 \times 10^{-13})^2 + (3.587)^2 + (2.071)^2 =$

$$s_{\Delta,i,2022}^2 = (2.907 \times 10^{-13})^2 + (3.587)^2 + (2.071)^2 = 17.16 \left(\frac{\text{ton CO}_2\text{e}}{\text{ha}} \right)^2$$

This is only a calculation for 1 sample unit, but for the purposes of the ensuing equations, to ensure that the equations themselves are meaningful, for just this example calculation, we generalize the same results to 141 sample units, which is the number of sample units in instance 1 of this project. In the real calculations for each monitoring period the appropriate SOC stock change and uncertainty results are derived for each sample unit:

$$s_{\Delta,2022}^2 = \frac{1}{n^2} \sum_i s_{\Delta,i,t}^2 = \frac{1}{141^2} * \sum_i 17.16 = 0.1217 \left(\frac{\text{ton CO}_2\text{e}}{\text{ha}} \right)^2$$

$$UNC_{2022} = MIN \left(100\%, MAX \left(0, T * \frac{\sqrt{0.1217}}{4.87} - 15\% \right) \right) = 0\%$$

T denotes the critical value of a student's t-distribution for significance level $\alpha = 0.05$ (i.e., a $1 - \alpha = 95\%$ confidence interval) and the degrees of freedom $n-1$ where n is the number of sample units (ranches). Typically, for an example with one ranch, the t distribution would be undefined with 0 degrees of freedom. In the example calculation above, we used the t distribution with 140 degrees of freedom given the 141 sample units in the first monitoring period, to get $T = 1.977$.

Since we have $LEt = 0$ according to the methodology's requirements, and the quantification only includes carbon emissions reduction from SOC stock change, and taking a 2054ha ranch area (Ao):

$$ER_{2022} = (Ao \times (\overline{\Delta CO_2 Soil_{2022}} + \overline{\Delta C_{CH4,2022}} + \overline{\Delta C_{N2O,2022}}) - LE_{2022}) \times (1 - UNC_{2022}) = 10000 \text{ ton CO}_2e \text{ (to 3 significant figures)}$$

The full calculation and background work associated with the example shown above is available in a supplementary spreadsheet for review. General calculations across all sample units and the entire first monitoring period are also available in the supplementary ERR spreadsheet.

During VCS Review Round 3, VCS requested that the project proponent (PP) demonstrate and provide evidence that areas with woody vegetation are used for grazing across all parts of the ranch. If grazing occurs in all areas (including those with dense vegetation, semi-arid land with sparse vegetation, and areas with tree cover), the PP must ensure that relevant stratification and monitoring plans (e.g., by vegetation type, grassland/non-grassland, shrubland/trees) are in place for SOC (Soil Organic Carbon) estimation in both the baseline and project scenarios. In response, the PP has added Appendix 05 to the project description (PD), documenting soil carbon sequestration across different vegetation types in Northern Mexico ranches and exploring potential differences across these types. Please refer to Appendix 05 for more details.

4.6 Estimated Reductions and Removals

An accompany spreadsheet is available providing details on the calculation of the values present in the below table. The values for years constituting the first monitoring period of this project are based on the monitored data and full execution of the processes outlined in the previous sections.

Year	Estimated baseline emissions or removals (tCO ₂ e)	Estimated project emissions or removals (tCO ₂ e)	Estimated leakage emissions (tCO ₂ e)	Estimated net GHG emission reductions or removals (tCO ₂ e)
Year 2018	0	0	0	0
Year 2019	1,187,412.36	1,187,412.36	0	1,275,037

Year	Estimated baseline emissions or removals (tCO ₂ e)	Estimated project emissions or removals (tCO ₂ e)	Estimated leakage emissions (tCO ₂ e)	Estimated net GHG emission reductions or removals (tCO ₂ e)
Year 2020	1,117,991.39	1,117,991.39	0	999,661
Year 2021	1,531,796.28	1,531,796.28	0	1,398,426
Year 2022	1,400,628.14	1,400,628.14	0	1,270,186
Year 2023	1,309,457.04	1,309,457.04	0	1,232,893
Year 2024	1,309,457.04	1,309,457.04	0	1,232,893
Year 2025	1,309,457.04	1,309,457.04	0	1,232,893
Year 2026	1,309,457.04	1,309,457.04	0	1,232,893
Year 2027	1,309,457.04	1,309,457.04	0	1,232,893
Year 2028	1,309,457.04	1,309,457.04	0	1,232,893
Year 2029	1,309,457.04	1,309,457.04	0	1,232,893
Year 2030	1,309,457.04	1,309,457.04	0	1,232,893
Year 2031	1,309,457.04	1,309,457.04	0	1,232,893
Year 2032	1,309,457.04	1,309,457.04	0	1,232,893
Year 2033	1,309,457.04	1,309,457.04	0	1,232,893
Year 2034	1,309,457.04	1,309,457.04	0	1,232,893
Year 2035	1,309,457.04	1,309,457.04	0	1,232,893
Year 2036	1,309,457.04	1,309,457.04	0	1,232,893
Year 2037	1,309,457.04	1,309,457.04	0	1,232,893
Year 2038	1,309,457.04	1,309,457.04	0	1,232,893
Total	26,189,140.81	26,189,140.81	0	24,669,598

(Note: the above table numbers (Estimated net GHG emission reductions or removals (tCO₂e)) are after deducting buffer credits of 11 %. Please see final ER projection sheet for complete information.)

In order to calculate the number of Verified Carbon Units (VCU) that may be issued, the buffer credits are estimated using VCS non permanence tool. The number of buffer credits identified at the time of validation is 11%.

The number of that may be issued in year t is calculated as per equation shown below.

$$VCU_t = ER_t - Buffer_t$$

Where,

VCU_t	Number of VCU in year t ; t CO ₂ e
ER_t	Estimated net GHG emissions reductions and removals in year t ; t CO ₂ e
$Buffer_t$	Number of buffer credits to be contributed to the AFOLU pooled buffer account in year t ; t CO ₂ e

5 MONITORING

5.1 Data and Parameters Available at Validation

Data / Parameter	AR										
Data unit	Percent										
Description	Weighted average adoption rate										
Source of data	Attested statement from an expert in the region										
Value applied	<table border="1"> <thead> <tr> <th>Activity Name</th><th>% of adoption rate</th></tr> </thead> <tbody> <tr> <td>Rotational grazing</td><td>5%</td></tr> <tr> <td>Keylines</td><td>1%</td></tr> <tr> <td>Gabions</td><td>5%</td></tr> <tr> <td>Ponds and Microbasin</td><td>5%</td></tr> </tbody> </table>	Activity Name	% of adoption rate	Rotational grazing	5%	Keylines	1%	Gabions	5%	Ponds and Microbasin	5%
Activity Name	% of adoption rate										
Rotational grazing	5%										
Keylines	1%										
Gabions	5%										
Ponds and Microbasin	5%										
Justification of choice of data or description of measurement methods and procedures applied	As per Section 7 of the methodology, when evidence is not available on a single proposed activity in the region from any of the indicated sources, the project proponent can seek the opinion of an expert. An expert has provided his opinion with signed and dated attestation on the practices. Details of the expert will be provided to the VVB during validation.										
Purpose of Data	Common practice assessment										
Comments	NA										

Data / Parameter	$Area_{an}$				
Data unit	Hectare				
Description	Area of proposed project-level adoption of each activity				
Source of data	Management plans, Rancher records, project activity commitments and carbon agreements with participating ranchers				
Value applied	At the time of validation, 553,486.55 ha of land has been included (which is 95% of the total land included in the 1st Instance). The below table represents the total area under activity for the 1st Instance which will be fixed at the verification event. <table border="1"> <thead> <tr> <th>Activity</th><th>Ranch Area (ha) at 1st Instance</th></tr> </thead> <tbody> <tr> <td>Rotational Grazing</td><td>625,000</td></tr> </tbody> </table>	Activity	Ranch Area (ha) at 1 st Instance	Rotational Grazing	625,000
Activity	Ranch Area (ha) at 1 st Instance				
Rotational Grazing	625,000				
Justification of choice of data or description of measurement methods and procedures applied	As per section 7 of the methodology, when evidence is not available on a single proposed activity in the region from any of the sources listed in the methodology, the Project Proponent can seek the opinion of an expert on the subject. An expert has provided his opinion with signed and dated attestation statement on the practices. Details of the expert will be provided to the VVB during validation. The complete area of each participating ranch is included				
Purpose of Data	Common practice assessment				
Comments	The project intends to adopt rotational grazing all over the project location.				

Data / Parameter	EA_{an}
Data unit	Percent
Description	Adoption rate of the n largest most common proposed project activity in the region
Source of data	Attested statement from an expert in the region
Value applied	5%
Justification of choice of data or description of	As per Section 7 of the methodology, when evidence is not available on a single proposed activity in the region from any of

measurement methods and procedures applied	the indicated sources, the project proponent can seek the opinion of an expert. An expert has provided his opinion with signed and dated attestation on the practices. Details of the expert will be provided to the VVB during validation.
Purpose of Data	Common practice assessment
Comments	NA

Data / Parameter	A_0
Data unit	Hectares
Description	Project area
Source of data	Measured in project area
Value applied	At the time of validation, ~ 575,515.16 ha of land has been included (which is 95% of the total land included in the 1 st Instance)
Justification of choice of data or description of measurement methods and procedures applied	Using geospatial techniques such as GIS coverage, ground survey data and remote imagery data with clear landmarks and other intersection points will be marked. The cumulative area of the ranches under this project is calculated using the appropriate method. Separate KML files are available at both validation and verification for the VVB.
Purpose of Data	Calculation of baseline and project emissions
Comments	The value mentioned in this table is overall project area which can be included in the project. This table will be updated when new instances are added to the grouped project (instance wise).

Data / Parameter	$P_{bsl,i,t}$
Data unit	Head
Description	Population of grazing livestock in the baseline scenario of type I in sample unit i in year t

Source of data	Rancher data
Value applied	Varies from ranch to ranch. See accompanying spreadsheet of list of ranches for a list of values and analysis for Instance 01. (Please refer Appendix 4 for the respective livestock population of each participating ranch)
Justification of choice of data or description of measurement methods and procedures applied	Data collected using rancher attestation forms and management plans. A spreadsheet is provided to the VVB whenever new ranches are added during the incorporation of a new project instance at the time of verification.
Purpose of Data	Calculation of baseline emissions. However, it is not used for any calculations in this project, since this project only involves carbon removals i.e., SOC stock change.
Comments	This value is used to check if there is any drastic reduction in the livestock stocking rates in the project scenario as compared to the baseline scenario.

Data / Parameter	$Days_{bsl,i,t}$
Data unit	Days
Description	Average grazing days per head in the baseline scenario inside sample unit i for each livestock type l in year t .
Source of data	Rancher field data
Value applied	365.25
Justification of choice of data or description of measurement methods and procedures applied	Entire ranches are individually enrolled, and ranchers attest that they are enrolling a complete ranch. The prevailing practice in the region is for all livestock owned by a given rancher to graze solely on an individual ranch. Thus, the average grazing days per head in a given year is 100% of the days in a year – 365.25 days.
Purpose of Data	Calculation of baseline emissions. However, it is not used for any calculation in this project, since this project only involves carbon removals i.e., SOC stock change.

Comments	This value is used to check if there is any drastic reduction in the livestock stoking rates in the project scenario as compared to baseline scenario.
----------	--

Data / Parameter	DPM/RPM
Data unit	fraction
Description	An estimate of the decomposability of the incoming plant material
Source of data	RothC model default value https://www.rothamsted.ac.uk/sites/default/files/RothC_guide_WIN.pdf
Value applied	0.67
Justification of choice of data or description of measurement methods and procedures applied	Recommendation given in the official RothC model documentation for an unimproved native grassland.
Purpose of Data	<i>To estimate baseline emissions</i>
Comments	Default value provided by the model

Data / Parameter	OD
Data unit	cm
Description	Depth of Soil layer sampled
Source of data	Methodology
Value applied	30 cm
Justification of choice of data or description of measurement methods and procedures applied	As per methodology requirement this parameter is fixed to 30 cm
Purpose of Data	<i>To estimate baseline emissions</i>
Comments	NA

5.2 Data and Parameters Monitored

Data / Parameter	AR
Data unit	Percent
Description	Weighted average adoption rate
Source of data	Filed Monitoring data
Description of measurement methods and procedures to be applied	Publicly accessible data from peer-reviewed scientific publications, industry associations' reports and assessments, agricultural censuses and other government data (such as surveys), etc. If all of the above sources are unavailable, signed and date attestation statement from a qualified independent local expert.
Frequency of monitoring/recording	Whenever new instances are added
Value applied	Ex post (less than 20%)
Monitoring equipment	No monitoring equipment is required to monitor this parameter.
QA/QC procedures to be applied	Internal audit of the data collected yearly. See monitoring plan section. The highest-quality publicly available evidence source appropriate to the project will be used. If supporting evidence is not available at the state/provincial level aggregated data or evidence at a regional level may be used, with justification.
Purpose of data	Common practice assessment
Calculation method	Measurement
Comments	Na

Data / Parameter	$Area_{an}$
Data unit	Hectares
Description	Area of proposed project-level adoption of each activity

Source of data	Rancher records and project activity commitments
Description of measurement methods and procedures to be applied	The area is estimated prior to verification
Frequency of monitoring/recording	Whenever a new instance is added
Value applied	Ex post
Monitoring equipment	No monitoring equipment is required to monitor this parameter. However, geospatial techniques will be used to estimate this parameter.
QA/QC procedures to be applied	Delineation of the sample unit area may use a combination of GIS coverages, ground survey data, remote imagery (satellite or aerial photographs), or other appropriate data. Any imagery or GIS datasets used must be geo-registered referencing corner points, clear landmarks or other intersection points. Internal audit of the data collected every year once See monitoring plan section.
Purpose of data	Common practice assessment
Calculation method	Measured
Comments	NA

Data / Parameter	EA_{an}
Data unit	Percent
Description	Adoption rate of the n largest most common proposed project activity in the region
Source of data	Field data collected
Description of measurement methods and procedures to be applied	Publicly accessible data from peer-reviewed scientific publications, industry associations' reports and assessments, agricultural censuses and other government data (such as surveys), etc. If all of the above sources are unavailable, signed

	and date attestation statement from a qualified independent local expert.
Frequency of monitoring/recording	Whenever a new instance is added
Value applied	Ex post
Monitoring equipment	Not applicable
QA/QC procedures to be applied	The highest-quality publicly available evidence source appropriate to the project will be used. If supporting evidence is not available at the state/provincial level aggregated data or evidence at a regional level may be used, with justification. If the above sources are unavailable, signed and date attestation statement from a qualified independent local expert.
Purpose of data	Common practice assessment
Calculation method	Not applicable
Comments	NA

Data / Parameter	A_i
Data unit	Unit Area
Description	Area of sample unit i
Source of data	Determined in project area
Description of measurement methods and procedures to be applied	The sample unit area is measured prior to verification
Frequency of monitoring/recording	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years.
Value applied	Ex post
Monitoring equipment	There is no monitoring equipment
QA/QC procedures to be applied	Delineation of the sample unit area may use a combination of GIS coverages, ground survey data, remote imagery (satellite or aerial photographs), or other appropriate data. Any imagery or GIS

	datasets used must be geo-registered referencing corner points, clear landmarks or other intersection points. Internal audit of the data collected every year once See monitoring plan section.
Purpose of data	Calculation of baseline and project emissions
Calculation method	Not applicable
Comments	NA

Data / Parameter	<i>i</i>
Data unit	Dimensionless
Description	Sample unit: defined area that is selected for measurement and monitoring, such as a field
Source of data	Determined in project area
Description of measurement methods and procedures to be applied	The sample unit is determined prior to verification.
Frequency of monitoring/recording	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
Value applied	Ex post
Monitoring equipment	Not applicable
QA/QC procedures to be applied	Delineation of the sample unit area may use a combination of GIS coverages, ground survey data, remote imagery (satellite or aerial photographs), or other appropriate data. Any imagery or GIS datasets used must be geo-registered referencing corner points, clear landmarks or other intersection points. Internal audit of the data collected once every year. See monitoring plan section.
Purpose of data	Calculation of baseline and project emissions
Calculation method	NA

Comments	NA
Data / Parameter	<i>L</i>
Data unit	Dimensionless
Description	Type of livestock
Source of data	Determined in sample unit <i>i</i>
Description of measurement methods and procedures to be applied	Rancher data collection.
Frequency of monitoring/recording	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
Value applied	Ex post
Monitoring equipment	NA
QA/QC procedures to be applied	Surveys will be conducted and validated by the project manager before reporting for verification.
Purpose of data	This parameter is not used for any calculation. However, it is monitored to see any drastic reduction in the livestock stocking rate to estimate leakage in the project scenario.
Calculation method	NA
Comments	NA

Data / Parameter	•
Data unit	Dimensionless
Description	Gas or pool
Source of data	Determined in sample unit <i>i</i>
Description of measurement methods and procedures to be applied	NA

Frequency of monitoring/recording	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
Value applied	Ex post
Monitoring equipment	NA
QA/QC procedures to be applied	NA
Purpose of data	Calculation of baseline and project emissions
Calculation method	
Comments	NA

Data / Parameter	$fSOC_{bsl,i,t}$								
Data unit	t CO _{2e} /unit area								
Description	Modeled soil organic carbon stocks pool in the baseline scenario for sample unit i at time t								
Source of data	Modeled in the project area								
Description of measurement methods and procedures to be applied	Remote sensing and/or with RothC model simulation (Calculation method noted in the CarbonFocus Algorithm Theoretical Basis Document) $SOC_{bsl,i,t} = f_{soc} (Var A_{bsl,i,t}, Var B_{bsl,i,t}, ...)$ Where, <table> <tr> <td>$SOC_{bsl,i,t}$</td><td>Modeled soil organic carbon stocks pool in the baseline scenario for sample unit i at time t (t CO_{2e}/unit area)</td></tr> <tr> <td>f_{soc}</td><td>Model predicting carbon dioxide emissions from the soil organic carbon pool (t CO_{2e}/unit area)</td></tr> <tr> <td>$Var A_{bsl,i,t}$</td><td>Value of model input variable A in the project scenario for sample unit i at time t (units unspecified)</td></tr> <tr> <td>$Var B_{bsl,i,t}$</td><td>Value of model input variable B in the project scenario for sample unit i at time t (units unspecified)</td></tr> </table>	$SOC_{bsl,i,t}$	Modeled soil organic carbon stocks pool in the baseline scenario for sample unit i at time t (t CO _{2e} /unit area)	f_{soc}	Model predicting carbon dioxide emissions from the soil organic carbon pool (t CO _{2e} /unit area)	$Var A_{bsl,i,t}$	Value of model input variable A in the project scenario for sample unit i at time t (units unspecified)	$Var B_{bsl,i,t}$	Value of model input variable B in the project scenario for sample unit i at time t (units unspecified)
$SOC_{bsl,i,t}$	Modeled soil organic carbon stocks pool in the baseline scenario for sample unit i at time t (t CO _{2e} /unit area)								
f_{soc}	Model predicting carbon dioxide emissions from the soil organic carbon pool (t CO _{2e} /unit area)								
$Var A_{bsl,i,t}$	Value of model input variable A in the project scenario for sample unit i at time t (units unspecified)								
$Var B_{bsl,i,t}$	Value of model input variable B in the project scenario for sample unit i at time t (units unspecified)								

	See Table 5: Inputs to the models and their sources for variable sources in the PDD.
Frequency of monitoring/recording	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
Value applied	Ex post
Monitoring equipment	Remote sensing and/or RothC model
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/QCs available from published handbooks, such as those published by FAO and available on the FAO Soils Portal ¹²⁸ , or from the IPCC GPG LULUCF 2003 is recommended.
Purpose of data	Calculation of baseline emissions
Calculation method	NA
Comments	The soil organic carbon stocks at time $t=0$ are calculated based on directly measured soil organic carbon content and bulk density at $t=0$ or (back-) modeled to $t=0$ from measurements collected within ± 5 years of $t=0$, or determined for $t=0$ via emerging technologies (remote sensing ¹²⁹) with known uncertainty and must be used in both the baseline and with-project scenario for the length of the project. Soil organic carbon stocks in the baseline scenario for sample unit i must be reported every 5 years or less.

Data / Parameter	$SOC_{bsl,i,t}$
Data unit	t CO _{2e} /unit area
Description	Areal-average soil organic carbon stocks in the baseline scenario for sample unit i in year t

¹²⁸ Food and Agriculture Organization of the United Nations. *Fao.org*. Sampling and laboratory techniques | FAO SOILS PORTAL | Food and Agriculture Organization of the United Nations. <http://www.fao.org/soils-portal/soil-survey/sampling-and-laboratory-techniques/en/>

¹²⁹ Calculation method noted in Boomitra CarbonFocus Algorithm Theoretical Basis Document

Source of data	Remote sensing and /or RothC model								
Description of measurement methods and procedures to be applied	Remote sensing along with RothC model (Calculation method noted in the CarbonFocus Algorithm Theoretical Basis Document) $SOC_{bsl,i,t} = f_{soc} (Var A_{bsl,i,t}, Var B_{bsl,i,t}, ...)$ Where, <table> <tr> <td>$SOC_{bsl,i,t}$</td><td>Modeled soil organic carbon stocks pool in the baseline scenario for sample unit i at time t (t CO2e/unit area)</td></tr> <tr> <td>f_{soc}</td><td>Model predicting carbon dioxide emissions from the soil organic carbon pool (t CO2e/unit area)</td></tr> <tr> <td>$Var A_{bsl,i,t}$</td><td>Value of model input variable A in the project scenario for sample unit i at time t (units unspecified)</td></tr> <tr> <td>$Var B_{bsl,i,t}$</td><td>Value of model input variable B in the project scenario for sample unit i at time t (units unspecified)</td></tr> </table> See Table 5: Inputs to the models and their sources for variable sources.	$SOC_{bsl,i,t}$	Modeled soil organic carbon stocks pool in the baseline scenario for sample unit i at time t (t CO2e/unit area)	f_{soc}	Model predicting carbon dioxide emissions from the soil organic carbon pool (t CO2e/unit area)	$Var A_{bsl,i,t}$	Value of model input variable A in the project scenario for sample unit i at time t (units unspecified)	$Var B_{bsl,i,t}$	Value of model input variable B in the project scenario for sample unit i at time t (units unspecified)
$SOC_{bsl,i,t}$	Modeled soil organic carbon stocks pool in the baseline scenario for sample unit i at time t (t CO2e/unit area)								
f_{soc}	Model predicting carbon dioxide emissions from the soil organic carbon pool (t CO2e/unit area)								
$Var A_{bsl,i,t}$	Value of model input variable A in the project scenario for sample unit i at time t (units unspecified)								
$Var B_{bsl,i,t}$	Value of model input variable B in the project scenario for sample unit i at time t (units unspecified)								
Frequency of monitoring/recording	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years								
Value applied	See the table below								
Monitoring equipment	Remote sensing and RothC model								
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/QCs available from published handbooks, such as those published by FAO and available on the FAO Soils Portal¹³⁰, or from the IPCC GPG LULUCF 2003 is recommended.								

¹³⁰ Food and Agriculture Organization of the United Nations. *Fao.org*. Sampling and laboratory techniques | FAO SOILS PORTAL | Food and Agriculture Organization of the United Nations. <http://www.fao.org/soils-portal/soil-survey/sampling-and-laboratory-techniques/en/>

Purpose of data	Calculation of baseline emissions
Calculation method	NA
Comments	The soil organic carbon stocks at time $t=0$ are calculated based on directly measured soil organic carbon content and bulk density at $t=0$ or (back-) modeled to $t=0$ from measurements collected within ± 5 years of $t=0$, or determined for $t=0$ via emerging technologies (remote sensing ¹³¹) with known uncertainty and must be used in both the baseline and with-project scenario for the length of the project. Soil organic carbon stocks in the baseline scenario for sample unit i must be reported every 5 years or less.

RothC model simulations are run to estimate areal-average soil organic carbon stocks in the baseline scenario for sample unit i in year t and the values are given below.

¹³¹ Calculation method noted in Boomitra CarbonFocus Algorithm Theoretical Basis Document

SL No	Ranch ID	Area (in Ha)	baseline_carbon_tons / ha_(2018)	baseline_carbon_tons / ha_(2019)	baseline_carbon_tons / ha_(2020)	Baseline_carbon_tons / ha_(2021)	baseline_carbon_tons / ha_(2022)
1	ranch#7507e0e3-63c6-45cf-96ac-5fcbc7b407e4	5,624.46	26.16917538	26.12903312	26.13306558	26.15455635	26.16877613
2	ranch#788ba119-0bb4-4e7b-9108-89ea0847e95b	2,020.83	31.52452389	31.84778347	32.2370253	32.55501494	32.89664442
3	ranch#b78a55a8-2a8c-445c-9b69-8bf0e23522cb	12,294.11	31.8781004	32.19820176	32.58030017	32.89095675	33.22575656
4	ranch#7f28cc25-366a-4f98-9d94-4ddf9c6fcd1	14,100.74	34.84550698	34.60006016	34.66299778	34.5626565	34.67073141
5	ranch#d83e05a8-9153-4d06-a6a9-48ba1c40f9b2	9,018.74	62.09963933	61.06733983	60.6167856	60.06610727	59.70252932
6	ranch#1a1435a0-fc2c-4c7a-ae2d-747bf36d09c5	20,732.21			28.51351892	28.5395083	28.62867259
7	ranch#50fb8db7-81ba-40f5-a87e-cb293d19a0a0	4,820.19	57.13839123	56.50355596	55.97975178	55.56678634	55.14803085
8	ranch#15583c60-392f-455e-b9c8-31908a1b3a83	2,720.07	21.71120285	21.69690467	21.73553882	21.75118411	21.77517922
9	ranch#5e01b78d-f1ef-4ae9-b579-1d3a4029ea8d	613.87			22.1003812	22.00850269	21.96440555
10	ranch#a982ef93-5a78-4180-be34-e264dad789bd	341.50	31.29749795	31.07029722	30.97577385	30.851834	30.74957732
11	ranch#1a496d91-9118-4f4e-ad9a-261e1b8edf3d	2,651.16	32.17736682	32.22619549	32.38692107	32.48705869	32.62000632
12	ranch#c87aa97d-7699-44d7-8122-76867e4d8394	5,006.69			58.55015416	58.08226741	57.97491472
13	ranch#1452d0d3-6da4-49d9-b05a-bce0e66c0ba1	94.76	30.24472208	30.05955651	29.95410211	29.87967415	29.79974401
14	ranch#c70ee6d6-e452-410c-a01e-15c174de0463	4,413.81				59.63672382	59.00783513
15	ranch#bd8b932d-8c66-4149-86f8-8af6ea322043	10,027.99			26.71966706	26.59693808	26.57286421
16	ranch#f22c409d-b83e-4bec-b8f0-06adfd406198	1,053.30	56.0865237	55.4920333	55.01588054	54.66307295	54.61317572
17	ranch#ea2d3974-2823-4424-9af2-c3b3068c7602	2,099.09	26.27434844	26.39196589	26.59977845	26.75561306	26.93980698
18	ranch#c9bb647a-b28a-4125-ae0e-c2a2829ac4b8	8.55	31.32084682	30.92506153	30.99743218	31.0855864	31.13901847
19	ranch#604483ca-0906-494a-84dc-b71fb34a8681	16,825.05				33.22523326	32.91337845
20	ranch#88934b73-da0e-4f33-8e1b-237c1946a02d	10,276.19	34.87182444	34.81172252	35.0726928	34.97076675	34.71715535
21	ranch#9a0757a0-d9c7-4ea4-8be9-3805ab9644c7	5,007.23				33.49455424	33.34677113

SL No	Ranch ID	Area (in Ha)	baseline_carbon_tons / ha_(2018)	baseline_carbon_tons / ha_(2019)	baseline_carbon_tons / ha_(2020)	Baseline_carbon_tons / ha_(2021)	baseline_carbon_tons / ha_(2022)
22	ranch#6b1f5c40-ede1-45cc-8a0a-5d209b140c74	1,103.71	53.52135325	52.90999294	52.45227099	52.05176544	51.70066672
23	ranch#961e806a-c74e-4d05-9518-eb3c0ad1d7ef	364.74	26.35364566	26.29120236	26.27717384	26.25904723	26.24075431
24	ranch#b7c82e9b-96f9-46b4-b37c-1b78ba8ede48	1,193.77			55.12295255	55.06022622	55.35298683
25	ranch#807dcaaf-7f8f-42a6-805e-033fd657145f	4,870.99	28.54720977	28.2258236	27.980183	27.77823392	27.58022329
26	ranch#11341265-2d06-4e44-9201-8ebf82117f77	2,645.68	25.62889431	25.37402617	25.17650615	25.01789775	24.86113464
27	ranch#2adeb606-a407-4aaf-b10b-008e74a93817	224.52	28.18817569	27.8649221	27.61248805	27.40395003	27.19950148
28	ranch#8c3e218d-6cc2-42bc-8a20-9fffb3f3dce8	5,863.85	34.29544003	34.18582459	34.45251186	34.34538514	34.17296474
29	ranch#d4dd3cd4-133d-4236-a75b-3db685823748	1,732.27	25.67256064	25.40316422	25.17405517	24.98676503	24.80307185
30	ranch#a17c5c90-8d82-4545-a081-431f419d8711	2,489.04	27.8573884	27.52960499	27.27306997	27.06214884	26.85606065
31	ranch#628fd24e-8f4b-4202-bfee-89cda9bb1f85	6,873.55	27.45125144	27.3122713	27.23484702	27.15835953	27.08661339
32	ranch#5d4a62ff-4a41-4b70-95bf-f47a6793d45f	4,301.82	29.545339	29.24298792	29.01640592	28.83494846	28.65553813
33	ranch#122fc1b0-1707-49e8-aba8-eb08b66344b9	5,391.64			25.28407375	25.24080737	25.26169948
34	ranch#fdc10c2f-6569-402e-b9dc-570110a28189	1,526.68			23.82230825	23.78727251	23.80700891
35	ranch#6183ae23-2a1d-4289-9624-1efce4146934	4,831.89			27.92776591	28.03787372	28.19801927
36	ranch#302971a5-4f41-4d94-8c4d-7868effc86fd	4,003.40	55.09564914	55.15428294	55.49235483	55.72585001	55.98688196
37	ranch#8dd037dd-cb8d-4b31-8023-3624d7a3958d	1,038.39	32.56841762	32.22747914	32.28800065	32.32784556	32.40711383
38	ranch#50024166-28f4-4647-b7fa-3dea5f0290c8	900.70	55.47168606	54.28238792	53.89254716	53.58806454	53.25641574
39	ranch#6bd72296-df02-4e40-957e-6f6963610576	907.13	35.69945987	35.46837463	35.48159696	35.33602589	35.40866295
40	ranch#2b84be37-ad1b-47b5-9d39-3235b6a5aa55	2,888.57	34.10044696	33.76138091	33.70762543	33.51290503	33.49213411
41	ranch#d026243d-ebcd-4d25-becf-c2cc504ba2ce	11,182.90	28.60383471	28.46800267	28.42813885	28.36561887	28.31734102
42	ranch#de2de059-6278-480d-b587-798b468135bc	6,245.17				30.21209339	30.08443719
43	ranch#36ea07af-5e9a-4fdd-b778-d8075c8d8109	5,602.06	25.2057661	25.17974288	25.24268965	25.27173439	25.31947007

SL No	Ranch ID	Area (in Ha)	baseline_carbon_tons / ha_(2018)	baseline_carbon_tons / ha_(2019)	baseline_carbon_tons / ha_(2020)	Baseline_carbon_tons / ha_(2021)	baseline_carbon_tons / ha_(2022)
44	ranch#42a25589-0aeb-485f-9e18-25b60ea903f9	24,367.20	30.67303177	30.52842039	30.43265768	30.33744889	30.24809289
45	ranch#19779b58-bbd8-47f9-aa50-a8166628c743	6,923.20	36.7273186	36.52471544	36.44101702	36.35479443	36.29270252
46	ranch#09ad3eb3-aa1b-4f4a-a907-c35b5d69cb7d	3,819.39				59.62768466	58.93981004
47	ranch#09ab83d0-4afc-408b-826d-23c837c6e517	1,059.48	60.67371258	60.10888049	59.91175031	59.62415417	59.40159394
48	ranch#22ef8dab-179d-4671-aa74-d759fcc89917	3,894.15	56.63149669	56.66039672	56.6420172	56.83017943	57.03271793
49	ranch#5fc7cc53-4a1e-407b-b74e-aab5dc379c69	123.02	31.34043143	31.48369609	31.70010031	31.85351129	32.03751161
50	ranch#14fb6973-5822-477e-af01-285bc42e2085	1,281.84	27.52567455	27.43517171	27.45682089	27.47567329	27.50885272
51	ranch#7d07b3a3-4aed-43e8-9b04-62f4faa26f18	10,697.49	28.89354551	28.76959744	28.69539092	28.59955682	28.52010593
52	ranch#01afa459-ca10-4610-861c-4339501c70a9	2,993.12	34.51216782	34.52218479	34.63802332	34.69712024	34.78890579
53	ranch#92aa7104-9f8c-4163-850d-c471d2c26012	594.67	23.30537831	23.27564089	23.32513075	23.36420816	23.40743495
54	ranch#162c6a96-7dcd-4fed-91f5-624426307e71	199.21	24.54244579	24.44325178	24.41622962	24.36721143	24.32922005
55	ranch#c7f98ddc-cd01-4b6c-a7bc-609aa2ca1819	1,602.02	25.12806273	25.00570482	24.95584928	24.88634161	24.82883316
56	ranch#c58cd28f-b66f-4eb3-88c8-78581949484a	1,697.98	35.13612623	34.95023531	35.04927155	35.11608702	35.25816675
57	ranch#2970ae2f-e481-441c-bc67-86a4064ddfd	3,402.04				32.76756404	32.55914919
58	ranch#c1bc3dcd-30fd-43f5-ae8b-c302859c4944	693.15		56.97951586	56.98764504	57.33794492	57.71550905
59	ranch#b121d998-f0c8-45df-9794-45bc5d0c0ab2	11,760.03	35.99863808	35.7223558	35.62295288	35.48817268	35.3877236
60	ranch#5b0650c8-773a-4488-bc14-5bf4833bfa48	9,810.75	54.01220047	53.49722992	53.12576668	53.06632881	53.02904914
61	ranch#403c5584-3825-424f-84ec-69fad7bf3bb4	1,954.69	38.04656426	37.88817535	37.77200608	37.67406002	37.5931883
62	ranch#5e0e86ae-469d-49b6-9b10-bddf62304811	1,995.25				56.14662888	55.87952687
63	ranch#e2b4323f-9e21-4627-abc4-5a441ddaf41a	479.73	32.008345	31.7633797	31.60323011	31.47436338	31.34340997
64	ranch#3c18e5e8-c027-4e93-b8b8-815b214bab39	1,147.22	54.11015045	53.71535263	53.26866481	53.24579885	53.24349674
65	ranch#5f08ca45-4b9a-4163-9bf5-daa41dde0875	1,171.52	22.31682113	22.27276534	22.30561196	22.30862378	22.32737864

SL No	Ranch ID	Area (in Ha)	baseline_carbon_tons / ha_(2018)	baseline_carbon_tons / ha_(2019)	baseline_carbon_tons / ha_(2020)	Baseline_carbon_tons / ha_(2021)	baseline_carbon_tons / ha_(2022)
66	ranch#df48f5ce-8204-456d-8423-68082c33cda0	1,162.28				29.94917708	29.72731221
67	ranch#e6fdc4e1-3908-4573-891a-a646202911b4	2,253.44	28.3705954	28.23338235	28.1394218	28.06849523	27.98950713
68	ranch#ff63f6b0-d429-47d0-913b-dade3e0fa1b5	3,725.37	28.77924275	28.71474326	28.55833815	28.54597271	28.54091953
69	ranch#ac3ba3ef-5c6c-40ce-8aa6-778f0ad0f82d	6,088.72	28.20676099	28.0032198	27.90139724	27.77472854	27.67333274
70	ranch#dc0f79ab-c88f-498c-ad44-cc300d1c5831	2,474.38				60.97053964	60.13220886
71	ranch#c3b94e9a-8fe3-480b-93b8-e97804c4289d	5,380.84	27.75290843	27.67666726	27.51034716	27.49299546	27.48412911
72	ranch#a7b3a940-6f4a-404d-8d21-2f08f0b69c22	8,083.23		57.4943336	56.76619218	56.29369079	55.79817076
73	ranch#97db29f4-af6c-411f-920a-7c10480fce14	10,067.30	34.56060339	34.27586357	34.12840121	33.94439056	33.79422964
74	ranch#93c54ff5-770e-4b6b-bc52-4e98e3c8ee89	6,095.88	62.5196777	61.89523618	61.62617612	61.40564521	61.2188828
75	ranch#cc5b6da2-4676-42ff-aaf6-51a07166d1ee	5,262.21	35.26273955	35.4150977	35.50706292	35.70981513	35.90578386
76	ranch#99afdd2c-d530-47fd-be66-8a8f050d9149	8,843.18				55.6822962	54.70823584
77	ranch#7148cd4a-15cf-4912-b90c-a27176ac2c47	2,263.54			31.56856635	31.40078861	31.32327804
78	ranch#4a335e2d-de9f-4f33-9416-140438859048	3,422.61	100.4537406	99.16056237	98.63348004	98.22432163	97.85868185
79	ranch#75773be2-812c-4b8f-a970-7c4b5ffb76a9	2,384.97	55.73520826	55.16481989	54.75974623	54.67662762	54.61748883
80	ranch#b7c8dbbd-72bd-4b46-b513-28f011e1e224	7,121.04	35.1100222	34.82149321	34.68884949	34.5765888	34.45194622
81	ranch#eb3ddaca-3329-4dad-a213-671e7e3e287e	6.70	26.46874302	26.55225311	26.61519421	26.70300274	26.80259994
82	ranch#73b5d175-cfad-4d5b-b220-7be51e39a46d	7.71	34.37281567	34.08085227	34.03776986	33.84111954	33.82980561
83	ranch#687ab63d-77d9-4273-a409-7c3c237fbd9	6,352.38	38.17569593	38.29367127	38.10397781	38.29420454	38.47782258
84	ranch#3b27b6fc-4a18-4cf8-84ea-4a63cf899499	12,830.58		30.45333752	30.34077339	30.31095726	30.26591313
85	ranch#97159021-bf72-43f5-9749-7812f9e10aa9	1,962.76		32.75518737	32.57574424	32.49318923	32.39738099
86	ranch#27a7c7ce-6570-4ec3-aced-00de2b54859d	1,133.38		28.32251661	28.24258914	28.26152914	28.26393991
87	ranch#6996984c-e841-4fa9-a0c6-03d35b1539ad	1,871.46	58.19257394	57.9516084	57.87532326	57.85537124	57.87238658

SL No	Ranch ID	Area (in Ha)	baseline_carbon_tons / ha_(2018)	baseline_carbon_tons / ha_(2019)	baseline_carbon_tons / ha_(2020)	Baseline_carbon_tons / ha_(2021)	baseline_carbon_tons / ha_(2022)
88	ranch#3c0b2ea9-a92b-4acc-b346-507ccdd24b47	1,406.45	35.07370603	35.21012856	35.2531416	35.45027923	35.16588497
89	ranch#b3fcb76a-6226-48d4-af45-5399350e4b5e	8,793.38		58.65955605	58.4208488	58.55799755	58.72826811
90	ranch#cfe61517-5429-4123-941c-2b15e00c3880	1,651.44	30.63914026	30.28914114	30.37210322	30.47305245	30.54382053
91	ranch#210eb144-2aa3-4350-94e3-da3e75eaf088	539.04	26.62814057	26.52389479	26.53068464	26.50494542	26.5012075
92	ranch#15c74242-355c-4ae6-b60d-69f89fee7819	1,604.76			23.43460234	23.40686435	23.461197
93	ranch#17220850-7789-48db-b128-f7fca9cfd2f5	1,500.06	30.44455917	30.29143773	30.22823071	30.14197233	30.06966039
94	ranch#bab7ffc3-12ce-47be-b609-8c79d01b79e9	6,956.68	60.27649231	59.44730617	58.83589966	58.2828008	57.73663233
95	ranch#364699ee-1f93-425a-a91d-1acc03790959	2,427.36	28.17747701	27.85452211	27.60777656	27.40537409	27.20722496
96	ranch#21d11b88-7d4b-45c6-b881-c4560c9ac608	18,088.72	30.55940162	30.27341746	30.04930678	29.87175412	29.69592271
97	ranch#1896ca66-ebc1-44b8-b8a8-1fc3fddc213b	1,120.31	29.89560561	29.62636885	29.42004264	29.25871818	29.09837552
98	ranch#9c57e352-3df6-405c-86dc-6bdab199121b	450.47	27.29591408	27.10778645	26.95124634	26.83494335	26.71767955
99	ranch#56e83cd1-4af1-4d70-9584-a10fb465370e	4,709.23	33.92670211	33.94503172	34.1000269	34.18490193	34.3041694
100	ranch#630c47ee-7f8f-4871-b3af-1e4ed9e22122	1,830.94	28.67458323	28.49266907	28.40849145	28.32798789	28.25248576
101	ranch#fbc0da86-369f-43eb-81bf-7a552169a317	408.50	32.83827149	32.68297915	32.57562664	32.49916477	32.44541701
102	ranch#70c11a4c-e324-451c-bbf8-281a949107a1	1,505.09	63.39584102	61.64872061	60.96431584	60.39460083	59.82166124
103	ranch#39d76b13-698e-46de-8ecf-e7fc5ee93399	2,010.03	22.90978965	22.96532954	23.05983422	23.13757353	23.23313342
104	ranch#e046a638-8b84-4a81-86e4-2fb6dd37e93c	10,792.86	29.68241855	29.38364066	29.12455646	28.90784037	28.69435338
105	ranch#afc2cb3a-8b77-4618-aff1-cf59504f1e11	154.43	31.28364732	31.13256771	31.07916993	30.99246571	30.93459813
106	ranch#bf3b8991-8186-4933-af81-4557dae5aa25	308.02	25.24010892	25.40510782	25.49796357	25.68287411	25.86585338
107	ranch#e7f39707-b663-4606-8f9d-a439237cc9d7	755.79	22.31894845	22.25161176	22.27618777	22.27116555	22.28464386
108	ranch#3f915540-1311-4f5e-9894-1abf5691475e	8,069.63	38.09593268	38.20324757	38.35295431	38.47041262	38.61247122
109	ranch#74aae2f6-6156-4306-97ce-cc5abf586c86	560.30	32.7805329	32.71027783	32.70201642	32.68946198	32.69064015

SL No	Ranch ID	Area (in Ha)	baseline_carbon_tons / ha_(2018)	baseline_carbon_tons / ha_(2019)	baseline_carbon_tons / ha_(2020)	Baseline_carbon_tons / ha_(2021)	baseline_carbon_tons / ha_(2022)
110	ranch#a8dad1ed-e772-48c3-9b5e-5260dae4b26f	7,783.91	56.81862918	56.58061417	56.69268243	56.73652294	56.8282747
111	ranch#1c98c253-845b-43ff-a644-cdba25b09fb0	9,011.15	30.77731615	30.49593589	30.58723577	30.65747505	30.76352754
112	ranch#3e9b96fd-cbc5-4c71-a84f-2e22441e56bc	6,013.64	58.93569754	59.10864744	59.54259491	59.95139849	60.38430867
113	ranch#ec1431d0-27f0-4b83-8c46-eef577e19755	3,832.19	31.89846334	31.76687424	31.56364715	31.49845101	31.4459268
114	ranch#92013344-2c71-466c-be1e-134aa099688e	3,731.04	53.46646365	53.21976052	52.96453872	52.93711059	52.2423874
115	ranch#80dd0409-1c82-4f24-95ae-766ab7d16177	450.68	34.08909805	33.84477317	33.91968664	33.83379281	33.95200254
116	ranch#467e6994-6e6a-49bc-8b55-47a6f16eac9d	3,497.44	31.65080063	31.47637239	31.42250406	31.34788286	31.29126228
117	ranch#624976ab-cc15-4e6c-a9f0-5fb92184ee06	293.62	60.82101657	60.33529189	60.18866882	59.94750021	59.76981454
118	ranch#8d6ea812-c22f-4f02-aa9d-a9e5685c1168	164.67	37.9848798	37.83828483	37.73887179	37.88921932	38.04581017
119	ranch#96be2893-ab6e-45fb-8636-4f1784d62a60	1,968.25	34.74985355	34.74724487	34.75044644	34.9133075	35.16448661
120	ranch#c1912552-2a2b-4005-8b97-69ed1e07865f	18.33	32.26770943	32.26398463	32.27719372	32.50380757	32.73059365
121	ranch#84b310ec-0fc1-4af3-83b0-7278c0d4c97b	52.05	38.13066007	38.07557477	38.01058823	38.1106289	38.3136485
122	ranch#5a9f1283-073d-453c-a366-daaee56688a6	2,941.87	36.25820335	36.23482356	36.20527399	36.33057021	36.55419771
123	ranch#07650cba-5bd3-4001-9461-51ecb24cab0c	63.16	32.45258158	32.592792	32.72957546	33.01057949	33.27555754
124	ranch#2d34f411-9013-417e-a5b7-6c1c79f6af20	5.92	37.9848798	37.83828483	37.73887179	37.88921932	38.04581017
125	ranch#b9cdf29c-e1db-4998-98a7-c3f95c479582	12.52	32.26770943	32.26398463	32.27719372	32.50380757	32.73059365
126	ranch#5b2a29c7-ffb5-4e7a-8dfe-4232ec68f945	2,480.05	37.9848798	37.83828483	37.73887179	37.88921932	38.04581017
127	ranch#7d8bc49c-3f5b-4a73-8a19-df41839faabc	667.52	30.92160242	30.65298393	30.45637439	30.27221925	30.09784858
128	ranch#7a5254af-6d73-424e-a243-b54da0f08c79	7,374.46	31.40919467	31.65060214	31.97807124	32.23306065	32.52032806
129	ranch#a8d3b758-c581-41c8-8019-4e708effa8da	1,352.80		30.88607667	30.69728954	30.60413868	30.53800413
130	ranch#7fdbf694-fff3-4dc1-a4f2-18a39f0b3d2b	411.18	31.95766763	32.31554735	32.740362	32.97307491	32.91451426
131	ranch#29d5d7b2-c968-4972-9949-16fabee6634b	208.68	60.57350098	60.02494721	59.79301067	59.51403494	59.29807489

SL No	Ranch ID	Area (in Ha)	baseline_carbon_tons / ha_(2018)	baseline_carbon_tons / ha_(2019)	baseline_carbon_tons / ha_(2020)	Baseline_carbon_tons / ha_(2021)	baseline_carbon_tons / ha_(2022)
132	ranch#533e58a6-d794-4354-b545-e94a09fa00c1	25,414.51			36.62462006	36.38323567	36.36019324
133	ranch#f4d32cdd-d0e9-4749-bdbe-9540905d64f4	1,569.28		38.16988592	37.98984971	38.04993817	38.12041477
134	ranch#660f61ba-f1a1-4197-9b25-1e438fadb89a	59.84		38.0216478	37.8484943	37.91270466	37.98705425
135	ranch#849698a7-5771-4f2b-832d-de37af0f77e2	292.15		38.89416915	38.69941414	38.75103116	38.81377523
136	ranch#070b555b-52d5-4f90-b6a4-56325dd1e570	273.63		34.52713536	34.3646139	34.48859879	34.61569608
137	ranch#c89fe226-7b6e-4d1e-bc4a-389244ce0225	462.77	57.17775401	57.01163884	57.18698355	57.28875084	57.45320701
138	ranch#7f2a51eb-2101-4a56-89eb-096be91f10a6	443.73	30.67355018	30.5155668	30.44423459	30.34990535	30.27001889
139	ranch#678220e7-acfd-46b2-a024-1a1fcb207d26	597.90	37.61793456	37.22735288	37.2828884	37.15510277	37.21722503

(Note: Blank spaces in above table represent the fact that certain ranches have different start years that occur after 2018)

Data / Parameter	$SOC_{wp,i,t}$								
Data unit	t CO ₂ e/unit area								
Description	Areal-average soil organic carbon stocks in the project scenario for sample unit i in year t								
Source of data	Measured in the project area								
Description of measurement methods and procedures to be applied	Remote sensing and/or RothC model (Calculation method noted in the CarbonFocus Algorithm Theoretical Basis Document) $SOC_{bsl,i,t} = f_{soc} (Var A_{bsl,i,t}, Var B_{bsl,i,t}, ...)$ Where, <table> <tr> <td>$SOC_{bsl,i,t}$</td><td>Modeled soil organic carbon stocks pool in the baseline scenario for sample unit i at time t (t CO₂e/unit area)</td></tr> <tr> <td>f_{soc}</td><td>Model predicting carbon dioxide emissions from the soil organic carbon pool (t CO₂e/unit area)</td></tr> <tr> <td>$Var A_{bsl,i,t}$</td><td>Value of model input variable A in the project scenario for sample unit i at time t (units unspecified)</td></tr> <tr> <td>$Var B_{bsl,i,t}$</td><td>Value of model input variable B in the project scenario for sample unit i at time t (units unspecified)</td></tr> </table> See Table 5: Inputs to the models and their sources for variable sources. Soil sampling protocols and practices mentioned in the methodology are followed to collect the data.	$SOC_{bsl,i,t}$	Modeled soil organic carbon stocks pool in the baseline scenario for sample unit i at time t (t CO ₂ e/unit area)	f_{soc}	Model predicting carbon dioxide emissions from the soil organic carbon pool (t CO ₂ e/unit area)	$Var A_{bsl,i,t}$	Value of model input variable A in the project scenario for sample unit i at time t (units unspecified)	$Var B_{bsl,i,t}$	Value of model input variable B in the project scenario for sample unit i at time t (units unspecified)
$SOC_{bsl,i,t}$	Modeled soil organic carbon stocks pool in the baseline scenario for sample unit i at time t (t CO ₂ e/unit area)								
f_{soc}	Model predicting carbon dioxide emissions from the soil organic carbon pool (t CO ₂ e/unit area)								
$Var A_{bsl,i,t}$	Value of model input variable A in the project scenario for sample unit i at time t (units unspecified)								
$Var B_{bsl,i,t}$	Value of model input variable B in the project scenario for sample unit i at time t (units unspecified)								
Frequency of monitoring/recording	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years								
Value applied	Ex post								
Monitoring equipment	Remote sensing and RothC model								

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/QCs available from published handbooks, such as those published by FAO and available on the FAO Soils Portal ¹³² or from the IPCC GPG LULUCF 2003 is recommended.
Purpose of data	Calculation of project emissions
Calculation method	
Comments	The soil organic carbon stocks at time $t=0$ are calculated based on directly measured soil organic carbon content and bulk density at $t=0$ or (back-) modeled to $t=0$ from measurements collected within ± 5 years of $t=0$, or determined for $t=0$ via emerging technologies with known uncertainty, and must be used in both the baseline and with project scenario for the length of the project. Soil organic carbon stocks in the project scenario for sample unit i must be reported every 5 years or less.

Data / Parameter	$\Delta \bullet, t$ and $\bullet \cdot t$
Data unit	t CO ₂ e/unit area
Description	Average emission reductions from pool or source $\bullet$, or stock of pool $\bullet$, in year t
Source of data	calculated values in the project area
Description of measurement methods and procedures to be applied	NA
Frequency of monitoring/recording	Calculations and recording must be conducted at least every five years, or prior to each verification event if less than five years
Value applied	Ex post
Monitoring equipment	

¹³² Food and Agriculture Organization of the United Nations. (n.d.). *Fao.org*. Sampling and laboratory techniques | FAO SOILS PORTAL | Food and Agriculture Organization of the United Nations. <http://www.fao.org/soils-portal/soil-survey/sampling-and-laboratory-techniques/en/>

QA/QC procedures to be applied	Calculation method noted in Boomitra CarbonFocus Algorithm Theoretical Basis Document
Purpose of data	Calculation of emission reductions
Calculation method	Calculation method noted in Boomitra CarbonFocus Algorithm Theoretical Basis Document
Comments	NA

Data / Parameter	$P_{wp,l,i,t}$
Data unit	Head
Description	Population of grazing livestock in the project scenario of type l in sample unit i in year t
Source of data	Livestock register maintained at the ranches and Project participant survey once every 2 years
Description of measurement methods and procedures to be applied	Record numbers of grazing livestock by type.
Frequency of monitoring/recording	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
Value applied	Ex post
Monitoring equipment	NA
QA/QC procedures to be applied	Information will be monitored via direct consultation with, and substantiated with a written attestation from, the rancher or landowner of the sample unit. Any quantitative information (e.g., discrete or continuous numeric variables) on agricultural management practices must be supported by one or more forms of documented evidence pertaining to the selected sample unit and relevant monitoring period (e.g., management logs, receipts or invoices, farm equipment specifications).
Purpose of data	Calculation of project emissions
Calculation method	NA

Comments	NA
Data / Parameter	$Days_{wp,l,i,t}$
Data unit	Days
Description	Average grazing days per head in the project scenario inside sample unit i for each livestock type l in year t
Source of data	Project participant survey
Description of measurement methods and procedures to be applied	Record livestock grazing days by type
Frequency of monitoring/recording	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
Value applied	Ex post
Monitoring equipment	NA
QA/QC procedures to be applied	Information will be monitored via direct consultation with, and substantiated with a written attestation from, the rancher or landowner of the sample unit. Any quantitative information (e.g., discrete or continuous numeric variables) on agricultural management practices must be supported by one or more forms of documented evidence pertaining to the selected sample unit and relevant monitoring period (e.g., management logs, receipts or invoices, farm equipment specifications).
Purpose of data	Calculation of project emissions
Calculation method	NA
Comments	NA

Data / Parameter	LE_t
Data unit	tCO ₂ e
Description	Leakage in year t ;

Source of data	Project participant survey
Description of measurement methods and procedures to be applied	Leakage is equal to zero per the applicability conditions and Section 8.4 of this methodology
Frequency of monitoring/recording	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
Value applied	0
Monitoring equipment	NA
QA/QC procedures to be applied	NA
Purpose of data	Calculation of project emissions
Calculation method	NA
Comments	See leakage section of this PDD

Data / Parameter	ΔP
Data unit	Percent
Description	Change in productivity
Source of data	Project participant survey
Description of measurement methods and procedures to be applied	NA
Frequency of monitoring/recording	Every 10 years
Value applied	0
Monitoring equipment	NA
QA/QC procedures to be applied	NA

Purpose of data	Determination of livestock productivity for leakage analysis
Calculation method	NA
Comments	See leakage section of this PDD

Data / Parameter	$P_{wp,p}$
Data unit	Productivity (e.g., kg) per hectare
Description	Average productivity for product p during the project period
Source of data	Project participant survey
Description of measurement methods and procedures to be applied	Measured using locally available technologies
Frequency of monitoring/recording	Each growing season
Value applied	Ex Post
Monitoring equipment	NA
QA/QC procedures to be applied	Information will be collected via direct consultation with, and substantiated with a written attestation from, the farmer or landowner of the sample unit. Any quantitative information (e.g., discrete or continuous numeric variables) on agricultural management practices must be supported by one or more forms of documented evidence pertaining to the selected sample unit and relevant monitoring period (e.g., management logs, receipts or invoices, farm equipment specifications).
Purpose of data	Determination of project productivity for market leakage analysis
Calculation method	Not applicable
Comments	No comments

Data / Parameter	p
Data unit	Numbers

Description	Livestock count
Source of data	Project Rancher Monitoring Data
Description of measurement methods and procedures to be applied	Not applicable
Frequency of monitoring/recording	Recorded every month
QA/QC procedures to be applied	Not applicable
Purpose of data	Identification of livestock product for market leakage analysis
Calculation method	Not applicable
Comments	No comment

Data / Parameter	ΔPR
Data unit	%
Description	Change in productivity ratio
Source of data	Calculated
Description of measurement methods and procedures to be applied	NA
Frequency of monitoring/recording	Every 10 years
Value applied	Ex post
Monitoring equipment	NA
QA/QC procedures to be applied	NA
Purpose of data	Determination of change in crop/livestock productivity for leakage analysis

Calculation method	As per section 8.4.2 of the methodology
Comments	No comments

Data / Parameter	$RP_{wp,p}$
Data unit	Unitless
Description	Average regional productivity for product p during the same years as the project period
Source of data	Regional productivity data from government
Description of measurement methods and procedures to be applied	Not applicable
Frequency of monitoring/recording	Every 10 years
Value applied	Ex Post
Monitoring equipment	NA
QA/QC procedures to be applied	Not applicable
Purpose of data	Determination of project productivity ratio for market leakage analysis
Calculation method	Not applicable
Comments	No comments

Data / Parameter	$Buffer_t$
Data unit	tCO _{2e}
Description	Number of buffer credits to be contributed to the AFOLU pooled buffer account in year t
Source of data	The number of buffer credits to be contributed to the AFOLU pooled buffer account must be determined by applying the latest version of the <i>VCS AFOLU Non-Permanence Risk Tool</i>

Description of measurement methods and procedures to be applied	NA
Frequency of monitoring/recording	Monitoring must be conducted at least every five years, or prior to each verification event if less than five years
Value applied	Ex-post
Monitoring equipment	
QA/QC procedures to be applied	The number of buffer credits to be contributed to the AFOLU pooled buffer account will be determined by applying the latest version of the <i>VCS AFOLU Non-Permanence Risk Tool</i> for every verification.
Purpose of data	Calculation of project emissions
Calculation method	The number of buffer credits to be contributed to the AFOLU pooled buffer account will be determined by applying the latest version of the <i>VCS AFOLU Non-Permanence Risk Tool</i>
Comments	NA

Sustainable Development Goal parameters

Data / Parameter	Sustainable development Goal 2: Zero Hunger
Data unit	%
Chosen parameter Description	Zero Hunger: 2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.
Source of data	Monitoring surveys
Description of measurement methods and procedures to be applied	The project activity improves soil quality by increasing Soil Organic Carbon (SOC). Higher SOC content leads to better productivity and improved soil fertility, making agricultural production more climate resilient.

Frequency of monitoring/recording	Before every monitoring period
Value applied	Ex post
Monitoring equipment	NA
QA/QC procedures to be applied	Monitoring staff will be trained to monitor this parameter
Purpose of data	To evaluate SDG impact
Calculation method	Increased pasture productivity: There will be an improvement in good quality forage availability to the cattle and this quality forage will improve the overall health of the cattle. Ranchers have certain methods to assess the health of the cattle in terms of height, weight, health conditions, etc. Healthy cattle bring a better price for the rancher when sold. Overall, ranchers will have better returns on cattle selling. This will be accounted by doing a monitoring survey.
Comments	A qualitative analysis of this parameter will be done through surveys

Data / Parameter	Sustainable development Goal 6: Clean Water and sanitation
Data unit	NA
Chosen parameter Description	6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes
Source of data	Monitoring surveys
Description of measurement methods and procedures to be applied	Increases in soil organic matter improve soil aggregates and structural stability, which help water infiltration into the soil by increasing soil aeration. This reduces excess runoff.
Frequency of monitoring/recording	Before every monitoring period
Value applied	Ex post
Monitoring equipment	NA

QA/QC procedures to be applied	Monitoring staff will be trained to monitor this parameter
Purpose of data	To evaluate SDG impact
Calculation method	Check the availability of water and whether conditions are improved compared to baseline. This can also be studied by proxy through the vegetation cover present on the land – improved water leads to improved vegetation cover.
Comments	A qualitative analysis of this parameter will be done through the surveys

Data / Parameter	Sustainable development Goal 8: Decent Work and economic growth
Data unit	Currency
Chosen Parameter Description	8.6 By 2020, substantially reduce the proportion of youth not in employment, education or training
Source of data	Employment records
Description of measurement methods and procedures to be applied	The project provides employment to local communities during the implementation and monitoring process
Frequency of monitoring/recording	Before every monitoring period
Value applied	Ex post
Monitoring equipment	NA
QA/QC procedures to be applied	Employment records maintained by implementation partner
Purpose of data	To evaluate SDG impact
Calculation method	Number of people employed to implement and monitor the activity.
Comments	Total salaries paid to the employees will be reported

Data / Parameter	Sustainable development Goal 15 Life on Land
Data unit	NA
Chosen parameter Description	15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world
Source of data	Study by trained expert in that domain
Description of measurement methods and procedures to be applied	Through rotational grazing practices, vegetation is allowed to grow and stay on the ground for more time, thereby allowing for degraded grasslands to be gradually restored, and reversing desertification.
Frequency of monitoring/recording	Before every monitoring period
Value applied	Ex post
Monitoring equipment	NA
QA/QC procedures to be applied	A professional with relevant background will conduct a survey in project area to study the impact on this SDG
Purpose of data	To evaluate the impact of SDG
Calculation method	Sample Study by trained expert in that domain
Comments	NA

SDG 13: Climate Action is covered in the other parameters and hence is not required to be reported separately.

5.3 Monitoring Plan

The monitoring process involves measuring, recording, storing, aggregating, collating, and reporting data as per VCS methodology requirements. The adaptive management plan includes plan to mitigate the potential risks to the project or any other risks associated with the project. Boomitra oversees project management and training while ground partners monitor rancher activities on ground, conduct surveys, and assist in audits. Rigorous QA/QC procedures ensure accurate and conservative GHG removal measurement. Capacity-building programs involve ranchers in data collection and planning. Advanced technology, including apps and cloud-based systems, aids information verification. Land and ranching activity (monitoring) parameters are collected and verified. Data is securely stored in encrypted cloud storage for at least two years post-project completion. A diverse monitoring team, including project

managers, field workers, and IT professionals, ensures precise data collection and reporting. Boomitra has created a monitoring process as per the requirements. The detailed overall monitoring process is outlined below.

5.3.1 Organizational structure and responsibilities

As discussed in section 1.11.1 of this PDD, the overall project is managed by Boomitra with the help of implementation partners on the ground. Boomitra, as project proponent, will support the ground team in every aspect of the project implementation and monitoring. Boomitra will be responsible to do the following activities:

- Identify the monitoring parameters and device the monitoring plan.
- All activities related to Quantification Approach 1 of the methodology (including remote sensing measurement of soil carbon stocks)
- Provide trainings to ground staff on collection of monitoring data.
- Set up QA/QC procedures for internal audit.
- Device policies required for oversight and accountability of monitoring activities.
- Preparing monitoring reports and other relevant reports for issuance

Ground partners are responsible for below mentioned activities.

- Contact and visit ranchers regularly (at minimum twice a year) to monitor the activities undertaken by them.
- Record the monitoring parameter data collected as a part of regular visit in database.
- Conduct trainings, workshops, awareness creation activities to the ranchers.
- Conduct surveys as per sampling plan requirements (decided by Boomitra)
- Assist Boomitra and VVB to undertake third party audit

The overall monitoring has been split into two parts. Part one consists of data captured at the ranch level and part two consists of data capture from digital sources. Part one is again divided into two parts: permanent ranch level management activity monitoring through questionnaires, and sample surveys to evaluate SDG parameters.

5.3.2 Policies for oversight and accountability of monitoring activities

The MRV plan will be updated as and when latest scientific approaches are available to increase the overall effectiveness of existing practices systematically. The latest high quality satellite images are procured to calculate carbon removals and to assess any serious changes in LULC parameters.

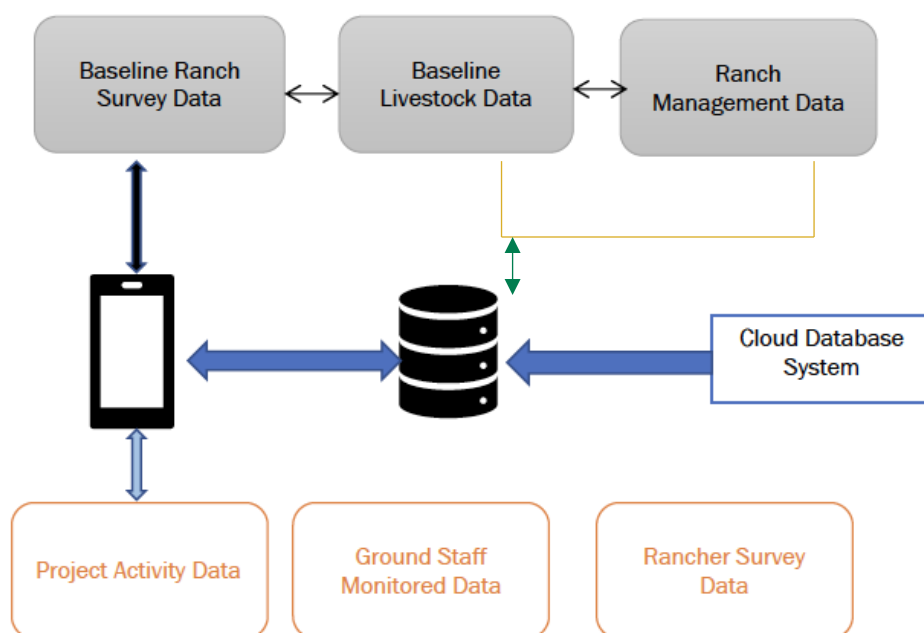
5.3.3 Procedures for internal auditing and Quality Assurance/Quality Control

Boomitra will develop a rigorous QA/QC system to ensure the long-term accuracy of the data that is collected, to ensure a robust data storage and to create a systematic data management structure. This

will be reviewed biennially during internal audits to guarantee the quality of data collected as part of the monitoring process.

5.3.4 Land Unique ID

Each ranch will be clearly demarked using geospatial techniques and will be assigned a unique land ID for easy identification. All the activities undertaken are well-documented in a cloud database. Boomitra is in the process of developing both mobile app and web-based tools and applications for data aggregation. On the ground, wherever mobile phone/computer access is not available, ranchers will maintain a diary to record project activity data, and our ground staff will collect this data and upload it to the database. The proposed monitoring process is based on the latest technology, which can be scaled up at ease. App and cloud-based systems will provide relevant information on a project level, such as: ranch and ranch owner name, latitude and longitudinal boundaries of the grazing land, current livestock population, paddocks, dates related to project activities, etc. All these details can be easily exported to a spreadsheet for validation and verification.



According to methodology requirements, land specific parameters such as i ; l ; A_i ; $P_{wp,i,t}$ and $P_{bsl,i,t}$ are collected directly from the individual ranchers, along with a host of parameters describing their management practices, which are all attested as accurate by the individual private landowners for private ranches and by an Ejidatario with the requisite authority to make such assertions in an Ejido. An example of the data collection form that is completed and signed by the ranchers with the support of the ground implementation staff is provided separately.

The procedures for measurement and monitoring of $SOC_{bsl,i,t}$, $SOC_{bsl,i,t-1}$, $SOC_{wp,i,t}$, and $SOC_{wp,i,t-1}$ are noted in the CarbonFocus Algorithm Theoretical Basis Document (ATBD), and RothC Model Validation Report.

All of the aforementioned parameters in this section are measured for every ranch (for the rancher-specific info), or even on a sub-acre level within a ranch (for SOC, for example) in some cases. Beyond these, there are a few parameters that are planned to be sampled: $P_{wp,p}$; $P_{bsl,p}$. $P_{wp,p}$ only needs to be measure and used along with $P_{bsl,p}$ every 10 years for the productivity change analysis. A sufficient amount of random sampling (as per the prevailing sample procedures at that time) is taken to ensure that the average productivity measured in the project instance at the time of productivity evaluation has a 95% confidence interval whose half-width falls within 15% (the same uncertainty standard used for net GHG reductions and removals by the VCS methodology used by the project). Individual ranch values are determined by consultation with randomly sampled ranchers. These are then averaged with equal weighting to determine $P_{wp,p}$ or $P_{bsl,p}$.

5.3.5 Anticipated frequency of monitoring and anticipated definition of “year”

The anticipated frequency of monitoring is every two years, and a year is defined from Sep 4 to Sept 3.

5.3.6 10-year baseline re-evaluation plan

An interview will be held with a local expert on what is common practice outside of the carbon project, in order to evaluate whether the baseline scenario is still applicable. If it is determined otherwise, the baseline scenario will be changed to match the scenario outlined by the local expert.

Regional agricultural production data will be sourced from peer-reviewed scientific literature and/or official state government or federal government documents as a first priority. If these are unavailable, then a local expert’s statement will be used as evidence.

5.3.7 Quality assurance and quality control (QA/QC) procedures

Data collected from the ranchers with their own attestation will be screened for basic accuracy with simple checks – such as comparisons to the ranges reported by other ranchers. For example, if 500 cattle are stated to be maintained on 20,000 acres by one ranch and 5,000 cattle are stated to be maintained on 10,000 acres by an adjacent ranch, there would be concerns of data quality, which will then require the monitoring team to revisit the affected ranches to re-confirm accuracy of the collected data.

The equations utilized in this project for quantifications of net greenhouse gas reductions and removals are all converted to computer code and this computer code is tested with sample data repeatedly before real data is supplied for the quantifications required by the project. Once the quantifications for the real data are produced, a further series of sanity checks are used to determine accuracy. Some of these include checking whether the final credits quantified per acre fall near the typical ranges expected for grassland carbon reductions and removals.

In order to QA/QC the remote sensing technology utilized in this project for SOC stock and bulk density determinations before every verification of the project, two checks are introduced: one with respect to technology calibration and the other with respect to technology validation. The first check is directed towards ensuring the overall generalizability of the remote sensing to current locations and times within

the project, and the second check ensures that the technology works correctly for the real project areas in practice.

With respect to the technology calibration, as shown in Section 4.1, the calibration dataset displays a general spatial coverage across the grouped project boundary and covers the climate zones and soil textures found within the initial project areas. Given the theoretical basis of the technology (covered in the remote sensing report) and the stated input data sources for calculations (which are dynamic, having global coverage and long-term support from their respective publishers), the technology is built to be generalizable across time, within the context of the data sources used and the coverage of the calibration dataset. Hence, a key QA/QC procedure with respect to the calibration is to ensure that calibration dataset contains the necessary climate zones and soil textures found within any new project areas added during any verification of the project. This QA procedure is implemented in reverse in this project – by setting up an eligibility criteria for the grouped project such that new project instances can only be added if their climate zones and soil textures are covered by the calibration of the remote sensing technology. This will ensure that the technology can be appropriately representative of all project areas, throughout the course of the project.

With respect to technology validation, new validation soil datasets are collected prior to each verification of the project. These validation datasets consist of soil organic carbon weight percent (SOCwt%), and bulk density (BD) of the fine soil fraction, measured from physical soil samples taken on the project areas. Then, the remote sensed numbers determined with the Boomitra technology are compared with these numbers to compute a root mean squared error to be the uncertainty of the Boomitra technology at the current verification event, for the SOCwt%, BD, and total SOC stock (tons CO₂e/acre). This exercise ensures that the remote sensing calculations continue to be fully representative of the real soil carbon stocks in the project areas on an ongoing basis.

In the case of the SOCwt%, soil samples are taken from demarked geocoded locations at a depth of 30cm with augers and then transported within 2-3 days to the collection facility of the testing lab used, for a dry combustion analysis of SOCwt%. In the case of BD, measurements are made near the field by the ground team, using the soil samples immediately after sampling.

Soil sampling locations are selected using a stratification based on the soil texture types found within the project areas. The reason for this type of stratum is that the purpose of the soil sampling is primarily for the QA/QC of the remote sensing technology. Based on the scientific framework presented in Section 3 of the remote sensing report provided to the VVB and Verra, some of the main parameters affecting the physical process (See Fig 2 in the report) are the parameters having to do with the soil texture. Hence, we must ensure during soil sampling that all the soil textures in the project are individually sampled to the necessary level. In practice, the project area polygons are masked in a GIS tool by a soil texture layer computed using state-of-the-art peer-reviewed ISRIC soil data maps¹³³ to develop a soil-texture based stratum:

¹³³ Soilgrids.org

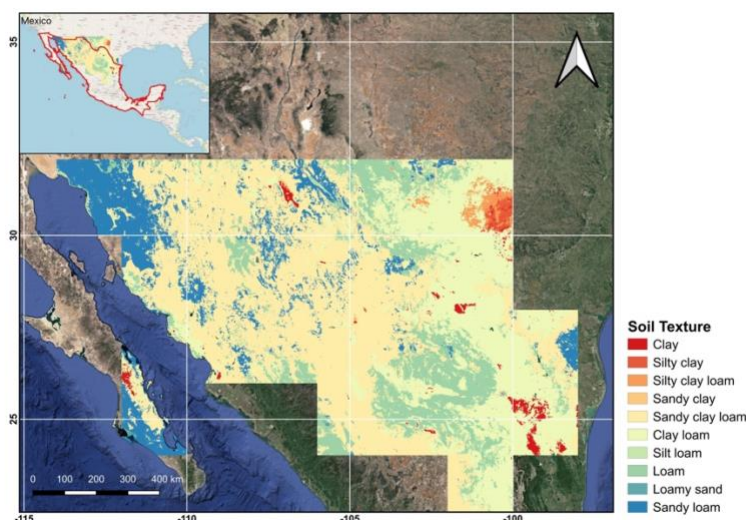


Figure 28. Soil textures in the project region

Within each such soil texture stratum found within the project, the required number of soil sample locations is selected randomly with GIS software. The specific number of soil samples within each strata is determined as per the equations of Section 4.2.5 of the remote sensing report – the number is selected to ensure that a statistically significant correlation can be measured between the remote sensing measurements and the conventional sampling. It is necessary to establish such a statistically significant correlation in order to ensure that the outputs of the Boomitra remote sensing technology will ensure an accurate and conservative calculation of ERRs.

An SOP for the specific soil sampling techniques carried out by the ground sampling team is provided as a supplementary document for review.

The soil testing lab must be selected based on its ability to make determinations of soil carbon levels in an accurate manner, as seen through third-party accreditations or otherwise through consistency of results and minimization of errors. Ideally, the same lab is used throughout the crediting period of the project. In this project, for the first monitoring period, we have used Agrolab¹³⁴, a reputed Mexican lab currently accredited by multiple organizations including FDA (of the USA), CONAGUA, A2LA, SENASICA, COFEPRIS and EMA. We foresee continuing to use Agrolab throughout the crediting period of the project, to ensure consistency of results.

Further information related to the QA/QC procedures of to the pixel-level soil carbon measurement are outlined in detail in the CarbonFocus Algorithm Theoretical Basis Document (ATBD), in Section 4.2.5 and Section 5.1.3.

Finally, all of these procedures and processes are independently checked by separate teams within Boomitra and ground partners. For example, data collection by ground partners may be periodically

¹³⁴ Agrolab.com.mx

checked by Boomitra teams traveling to the project area. Similarly, soil carbon quantifications produced by a single member of the Boomitra geospatial team are re-run and checked by another member for redundancy.

5.3.8 Data archiving procedures

All data is directly archived in an encrypted format using cloud storage services provided by Amazon Web Services (AWS), Google Cloud Platform (GCP) or Microsoft Azure. All of these cloud service providers guarantee 99.9%+ uptime and data availability. In most cases, when ranchers interact with Boomitra through our apps, data is automatically uploaded to the cloud seamlessly. In some instances where data is manually collected by ground staff, the data is later transferred to the cloud for storage. Furthermore, all ancillary processing required for monitoring that uses computer code, including QA/QC data, is conducted purely using the cloud services of the aforementioned companies and is subsequently also stored in the cloud.

Rancher-specific information that is not an image is stored in an encrypted cloud database – currently AWS DynamoDB, a NoSQL database, is used. AWS offers excellent data portability and data transfer methods between internal and external resources, so even in the event of an update to data formats, AWS will have the support. All information that is in image format is stored as PNG, JPEG or TIFF files with AWS Simple Cloud Storage (AWS S3) in encrypted buckets or the Microsoft/Google cloud in encrypted folders. A change in image data formats is not anticipated over the course of this project. Further project-specific text documentation, such as this PDD and ancillary process description documentation is also stored in encrypted buckets or folders in the PDF format, to allow continued portability and support into the future without any anticipated updates to electronic file formats.

All data will be kept for at least two years after the end of the last project crediting period, which could be up to 2038 if there is only one crediting period, or 2118 if all 4 extensions to the crediting period are used.

5.3.9 Monitoring Team

The monitoring team follows the project implementation structure shown in Section 1.11 Project Organizational Setup. The same parties involved in the implementation and project management are also involved in the monitoring. The ground implementation staff work with ranchers directly and collect any necessary inputs required from the ranchers through direct consultation with the ranchers, along with getting their attestation for their inputs. The regional managers ensure that the monitoring is occurring correctly in their regions of interest and the director/CEO/chairman/president of the ground partner organization ensures that monitoring is streamlined for the monitoring undertaken by that ground partner. Simultaneously the IT team of the ground partner or of Boomitra ensures that information can be collected efficiently from the ground through apps, spreadsheets and other means. Finally, the monitoring of soil carbon is conducted by Boomitra's geospatial data science team, utilizing other inputs from the ground and following the process outlined in the CarbonFocus Algorithm Theoretical Basis Document.

Title	Responsible entity	Roles and responsibilities
Project Manager	Implementation partner	1. Field monitoring 2. Leakage monitoring 3. Review data received from the field worker 4. Record control 5. QA/QC procedures 6. Report the status of the project activities regularly to Boomitra
Field Workers	Implementation partner	1. Monitoring the activities implemented by ranchers 2. Training ranchers 3. Data collection from ranchers 4. QA/QC procedures 5. Documentation management
IT professional	Implementation partner/ Boomitra	1. Store the data securely 2. QA/QC procedures 3. Documentation management 4. Generate the reports required for reporting
Accountant	Implementation partner/ Boomitra	Manage all the financial activities related the project
Regional Manager	Boomitra	Manage all the project activities related to project
Carbon Project Lead	Boomitra	Prepare reports related to MRV and conduct third party audit
Geospatial Data Scientist	Boomitra	Geospatial analysis of the rancher areas, estimate the carbon removal as per registered PDD

Boomitra's Carbon Project Development Lead, Boomitra's COO and Boomitra's CEO ensure that all processes occur smoothly throughout the entire monitoring process for the entire grouped project.

5.3.10 Project activity monitoring

Rotational grazing is the principal project activity promoted in this project along with water management activities. As discussed in the section 1.11, rotational grazing includes moving cattle through a series of paddocks so that the initial paddock has recovered enough to allow the rotation to resume when they have finished grazing the last pasture in the series. Hence, paddock demarcation is one of the main activities to be monitored. At present, all the information on paddock demarcation for rotational grazing has been recorded manually in the notebook at the ranch level. It has been planned, with the help of Carbon Finance, to digitize all data collection related to rotational grazing.

Many ranchers do not have a permanent fencing system. Wired fences are made temporarily, and these fences are kept moving throughout the year. Since there is no permanent fencing system, it is not easy

to geotag the paddocks permanently. However, it has been decided to monitor the rotational grazing pattern by geotagging the paddocks whenever grazing is happening, through a mobile application. This enables the establishment of a correlation between rotation grazing and the time of year where the grazing has been done.

In order to monitor project activities and leakage from it, local representative will visit at least once in year to record the livestock count and paddocking systems adopted. In addition, a logbook will be maintained at the ranchers place to record the livestock count regularly and the same will be updated in the digital rancher dashboard. If there is any substantial decrease in the livestock counts, the reason for the decrease will be recorded and verified by one of the representatives of the implementation partner.

Ranchers systematically monitor other critical parameters such as soil moisture, vegetation health in paddocks, water levels in streams and ponds, and livestock. This multifaceted approach encompasses routine visual inspections, and the analysis of satellite imagery. By extending the monitoring scope to include grasslands, paddocks, and water management, ranchers gain a holistic understanding of ecosystem dynamics and resource utilization. This comprehensive strategy enables proactive identification of leakage issues (ex; *cattle grazing beyond the specified paddocks*) and water scarcity challenges, fostering the preservation and resilience of diverse grassland ecosystems. Moreover, integrating water management practices within the monitoring framework empowers ranchers to optimize irrigation efficiency, mitigate runoff, and conserve precious water resources, thereby ensuring the long-term viability and sustainability of their ranching enterprises.

5.3.11 Sample Design

As discussed above, measurements are done for each project participant rancher separately, which implies 100% sampling. Hence, there is no requirement for this project to adopt any sampling techniques for project areas. Furthermore, unless otherwise mentioned, stratification of the project is done to a ranch level. Each ranch is carrying out practices independently of other ranches, and hence each ranch is its own independent sample unit and stratum. Boomitra does not foresee any nonconformance on the monitoring plan with regard to SOC measurement since 100% of the project area is covered in the monitoring plan.

5.3.12 Modeling Plan

The RothC model is chosen for this project. RothC has been shown to be applicable in grasslands around the world, for various management conditions including continuous grazing^{135,136} and rotational

135 Smith, S. W., Vandenbergh, C., Hastings, A., Johnson, D., Pakeman, R. J., Wal, R. van der, & Woodin, S. J. (2013, December 6). Optimizing carbon storage within a spatially heterogeneous upland grassland through sheep grazing management - ecosystems. SpringerLink. <https://link.springer.com/article/10.1007/s10021-013-9731-7>

136 Jebari, A., Álvaro-Fuentes, J., Pardo, G., Almagro, M., & Prado, A. del. (n.d.). Estimating soil organic carbon changes in managed temperate moist grasslands with Rothc. PLOS ONE. <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0256219>

grazing^{137,138}. Several peer-reviewed field trial datasets exist for the proper validation of the model within the climate zones and soil textures found in this project^{139,140}. The baseline conditions include continuous grazing in native grasslands, and these are well represented in the potential model validation datasets available. Furthermore, the number of livestock present on each ranch at the start date of activities on that ranch is collected and attested by each participating rancher, which is the necessary information required from the rancher to successfully initiate the model. Livestock numbers are also monitored yearly from the ranchers. The other required input variables are either acquired from the literature or publicly available datasets, as noted in their respective parameter tables.

The remote sensed soil carbon stock is used only as an input to the RothC model. The remote sensed soil carbon stocks are used by the RothC model to produce an output of soil carbon stock for the start of every monitoring period (or the start date of the project activity in the sample unit, which ever is later), and an output at the end of every monitoring period, along with an output for each of the intervening year. These outputs are then used the modeled SOC stock values in the subsequent equations of the methodology. In the special case of the project scenario, repeat remote sensed measurements of soil carbon stocks will be available at a frequency of 5 years or more frequently, and will be used to recalibrate and true-up the RothC whenever they are available.

Further information on the modeling plan is also available in the draft Model Validation Report provided to the VVB and Verra for review at the time of validation, and the full Model Validation Report that will be reviewed at the time of verification.

Beyond the Model Validation Report and meeting the requirements of VMD0053, since this project uses remote sensing of soil carbon and bulk density as one of the inputs to the RothC, the propagation of remote sensing error through RothC shown in Section 4.4 ('Combined Error') must be carried out in every verification.. Accordingly, then, the appropriate uncertainty propagation equations noted in that sections must be used for uncertainty calculations and final GHG ERR calculations.

137 Author links open overlay panelDe Li Liu a c, a, c, b, AbstractRecently, Bolinder, M. A., Chan, K. Y., Farage, P. K., Janssen, P. H. M., Jeffrey, S. J., Kemmitt, S. J., Lal, R., Lima, A. M. N., Liu, D. L., Moore, A. D., Paul, K. I., Smith, P., Bertora, C., Brumme, R., ... Coleman, K. (2011, August 4). Simulation of soil organic carbon dynamics under different pasture managements using the ROTHC carbon model. *Geoderma*. <https://www.sciencedirect.com/science/article/pii/S0016706111001947>

138 Poeplau, C. (2016, August 24). Estimating root: Shoot ratio and soil carbon inputs in temperate grasslands with the ROTHC model - plant and Soil. SpringerLink. <https://link.springer.com/article/10.1007/s11104-016-3017-8>

139 Ryan C. Byrnes, Danny J. Eastburn, Kenneth W. Tate, & Leslie M. Roche. (2018). *Journal of Environmental Quality - ACSESS - Wiley Online Library*. <https://access.onlinelibrary.wiley.com/doi/abs/10.2134/jeq2017.08.0313>

140 M. Abdalla, A. Hastings, & D.R. Chadwick. (2017, November 6). Critical review of the impacts of grazing intensity on soil organic carbon storage and other soil quality indicators in extensively managed grasslands. *Agriculture, Ecosystems & Environment*. <https://www.sciencedirect.com/science/article/pii/S0167880917304693>

APPENDIX 01: STAKEHOLDER MEETING DETAILS

Due to pandemic restrictions, a virtual zoom meeting was conducted as per VCS requirements. The meeting was conducted on 31st January 2022. The date and time of the meeting was informed to stakeholders through invitation letters, emails and other appropriate means. Ranchers were also invited verbally or by phone as this was the most effective means to ensure participation of the stakeholders, specifically the targeted beneficiaries of the project. A digital newspaper advertisement was published to inform larger local stakeholders.

The meeting was formally organized to create awareness of the project and potential environmental benefits among a broad array of stakeholders. The main agenda of the session that was organized was about the “carbon removal through soil” project using AI and Satellite technology.

The agenda of the meeting was as follows:

- Opening of the meeting
- Explanation of the project.
- PPT presentation on project specifics
- Questions and Answers session.
- Conclusion of the meeting.

Mr. Aadith Moorthy, CEO of Boomitra, inaugurated the meeting and Mr. Subramaniam Satyamoorthy, COO of Boomitra, welcomed the meeting participants with an official welcome note. Boomitra’s CEO explained the objective of the project and how ranchers will benefit from this project. He emphasized the importance of improving soil organic carbon and how this project simultaneously contributes to sustainable development of rancher communities. A PowerPoint presentation (PPT) was shown to the participants by one of the implementation partners, Pronatura, which is the largest Mexican environmental conservation group, about the project activities (rotational grazing and water conservation measures) and information on Boomitra’s and their roles in this project.

A detailed explanation was provided on the overall process (PD development, third party audit, documents required, etc.) and the mechanism for on-going communication with local stakeholders. The grievance mechanism established for this project was also explained as part of the on-going communication process.

A digital feedback form was shared with all participants to seek their feedback on this project. There was a question-and-answer session at the end of the virtual meeting and a few of the participants requested clarification on various aspects of the program:

SL NO	Questions from participant	Conclusion
1	How will we be transparent between Boomitra, Pronatura and landowners? Will we use CCB? Can we implement in Sonora desert?	We will give each partner to access the dashboard where then can see the progress of each ranchers which includes the comparison of carbon level with timelines. We will provide a similar system to each rancher to see their own specific progress and timelines. Implementing CCB takes time, probably in subsequent years we may include CCB component based on availability of the data to meet CCB requirements. Yes, we can implement the project in Sonora desert.
2	Does grassland project should be with 30 years, or any other land also require 30 years of agreement.	Every carbon project needs an agreement, regardless of the type of land and the agreement length is 30 years of agreement. Every 10 years the baseline will be revaluated and agreements are revisited.
3	How can we get started?	You can enroll your ranch to this project through our implementation partners by providing consent to the terms and conditions enlisted in the agreement.

As we can see from the above table, the questions from the stakeholders are on the procedural aspects and a few on CCB certification. The proper clarifications were provided. There were no comments from the stakeholders which had to be addressed to update or amend the overall project design. Hence there is no requirement to change the project design. With on-going consultations, further comments received will be addressed or considered in terms of amending the project design where necessary.

Invitación a la Reunión de Partes Interesadas del Proyecto de Carbono de Pastoreo Sostenible

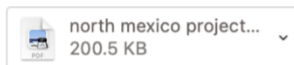
← ⏪ →



✓ Aadith Moorthy <aadith@boomitra.com>

Thursday, January 20, 2022 at 4:59 PM

To: marco.heredia@semarnat.gob.mx; maria.ortiz@semarnat.gob.mx; mexico.ets@semarnat.gob.mx



[Download All](#) • [Preview All](#)

Querido Señor Heredia, Señora Ortiz,

Es un placer para mí invitarlos a la reunión de consulta de partes interesadas de Boomitra para su iniciativa de pastoreo sostenible y cultivo de carbono en el norte de México. ¡Lo hemos identificado como un actor clave y valioso, y solicitamos respetuosamente su asistencia a este evento!

Desde 2016, Boomitra ha estado trabajando con agricultores y ganaderos de todo el mundo para ayudarlos a ser sostenibles frente al cambio climático. Trabajamos en millones de acres en todo el mundo, lo que permite a los agricultores y ganaderos producir más con menos y mejorar la salud de su suelo al aumentar el carbono orgánico del suelo. Luego, convertimos sus aumentos en el carbono del suelo en créditos de carbono y los vendemos internacionalmente, proporcionando una nueva fuente de ingresos para los agricultores y ganaderos!

En el norte de México, estamos trabajando con ganaderos en varios cientos de miles de acres para promover el manejo sostenible de los pastizales, en forma de prácticas mejoradas de pastoreo de ganado y medidas de conservación del agua para proteger y restaurar los pastizales. Ahora estamos midiendo los aumentos de carbono del suelo logrados por los ganaderos y convirtiéndolos en créditos de carbono certificados por terceros, lo que ayudará a aumentar los ingresos de estos ganaderos de manera espectacular.

Solicitamos su participación en nuestra reunión para compartir sus pensamientos y comentarios sobre esta iniciativa. A la luz de la pandemia actual de COVID-19 y la variante Omicron, esta reunión se llevará a cabo virtualmente en Zoom, a las 10:30 am Centro el 31 de enero de 2022.

Enlace de zoom: <http://tiny.cc/ix4nuz>

Hora: 10:30am Centro, 31 de enero de 2022

La agenda del programa es la siguiente:

- Palabras de apertura del CEO de Boomitra, Aadith Moorthy
- Explicación de la iniciativa
- Proceso de certificación de terceros
- Preguntas y respuestas y debate

Hemos adjuntado una descripción general de la iniciativa a este mensaje para su lectura.

Esperamos sinceramente que pueda asistir a la reunión. ¡No dude en enviarme un correo electrónico con cualquier pregunta, comentario o retroalimentación sobre la iniciativa y la reunión!

Atentamente,

Aadith Moorthy
Founder & CEO, Boomitra
[Learn more at boomitra.com](http://boomitra.com)

Figure 29. Invitation sent to the Designated National Authority of Mexico – SEMARNAT

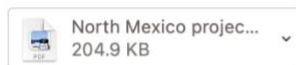
Invitation for Sustainable Grazing Stakeholder's Meeting



Aadith Moorthy <aadith@boomitra.com>

Thursday, January 20, 2022 at 5:24 PM

To: Enrique Gonzalez Aguilar



[Download All](#) • [Preview All](#)

Dear Enrique,
Belated happy new year! I hope that you are doing fine and staying healthy! Hope things are ok in Guadalajara!

It is my pleasure to invite you to Boomitra's stakeholder consultation meeting for its sustainable grazing and carbon farming initiative in northern Mexico. We have identified you as a key and valued stakeholder, and respectfully request your attendance at this event!

Since 2016, Boomitra has been working with farmers and ranchers around the world to help them become sustainable in the face of climate change. We work across millions of acres worldwide, enabling farmers and ranchers to produce more with less and improve their soil health by increasing soil organic carbon. We then turn their increases in soil carbon into carbon credits and sell the credits internationally, providing a new source of income for the farmers and ranchers!

In Northern Mexico, we are working with ranchers across several hundred thousand acres to promote sustainable grassland management, in the form of improved cattle grazing practices and water conservation measures to protect and restore the grasslands. We are now measuring the soil carbon increases achieved by the ranchers and converting them into 3rd-party certified carbon credits, which will help increase these ranchers' incomes dramatically!

We request your participation at our meeting to share your thoughts and feedback on this initiative. In light of the current COVID-19 pandemic and the Omicron variant, this meeting will be held virtually on Zoom, at 10:30am Centro on the 31st of January, 2022.

Link: <http://tiny.cc/x4nuz>

Time: 10:30am Centro, Jan 31st 2022

The Agenda of the programme is as follows:

- Opening remarks by CEO of Boomitra, Aadith Moorthy
- Explanation of the Initiative
- 3rd party Certification Process
- Q&A and Discussion

We have attached a general description of the initiative to this message for your perusal.

We sincerely hope you will be able to attend the meeting. Feel free to email me with any questions, comments or feedback on the initiative and meeting!

Thanks again,
Aadith Moorthy
Founder & CEO, Boomitra
[Learn more at boomitra.com](http://boomitra.com)

Figure 30. Invitation sent to an executive at an important agribusiness in Mexico

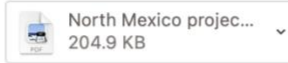
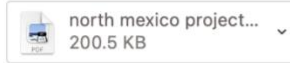
Invitation for Sustainable Grazing Stakeholder's Meeting



Aadith Moorthy <aadith@boomitra.com>

Friday, January 21, 2022 at 8:37 PM

To: cortega@uach.mx



[Download All](#) • [Preview All](#)

Dear Dr. Ortega

Belated happy new year! I hope that you are doing fine and staying healthy.

This is Aadith Moorthy from Boomitra (Boomitra.com) – I visited El Roble along with the Pronatura team last August and you might recall we were talking about the possibility for your ranch and many others to earn carbon credits for your good management practices. I hope that you remember me!

It is my pleasure to invite you to Boomitra's stakeholder consultation meeting for our sustainable grazing and carbon credits initiative in northern Mexico. We have identified you as a valued stakeholder for this project, given your background as both a successful rancher and Director of Animal Sciences at UACH.

We request your participation at our meeting to share your thoughts and feedback on this initiative. In light of the current COVID-19 pandemic and the Omicron variant, this meeting will be held virtually on Zoom, at 10:30am Centro on the 31st of January, 2022.

Link: <http://tiny.cc/ix4nuz>

Time: 10:30am Centro, Jan 31st 2022

I have attached a general description of the initiative to this message for your perusal, in both English and Spanish. I can also share a calendar invite of the meeting if you are able to make it. Even if you are unable to, but think someone else at UACH might be able to attend, please let me know and they can also participate.

Please feel free to email me with any questions, comments or feedback on the initiative and meeting! I also look forward to working more closely with you as our sustainable grazing project progresses – there are quite a few areas of synergy with the great research being done at El Roble and also with UACH!

Thanks again,
Aadith Moorthy
Founder & CEO, Boomitra
Learn more at boomitra.com



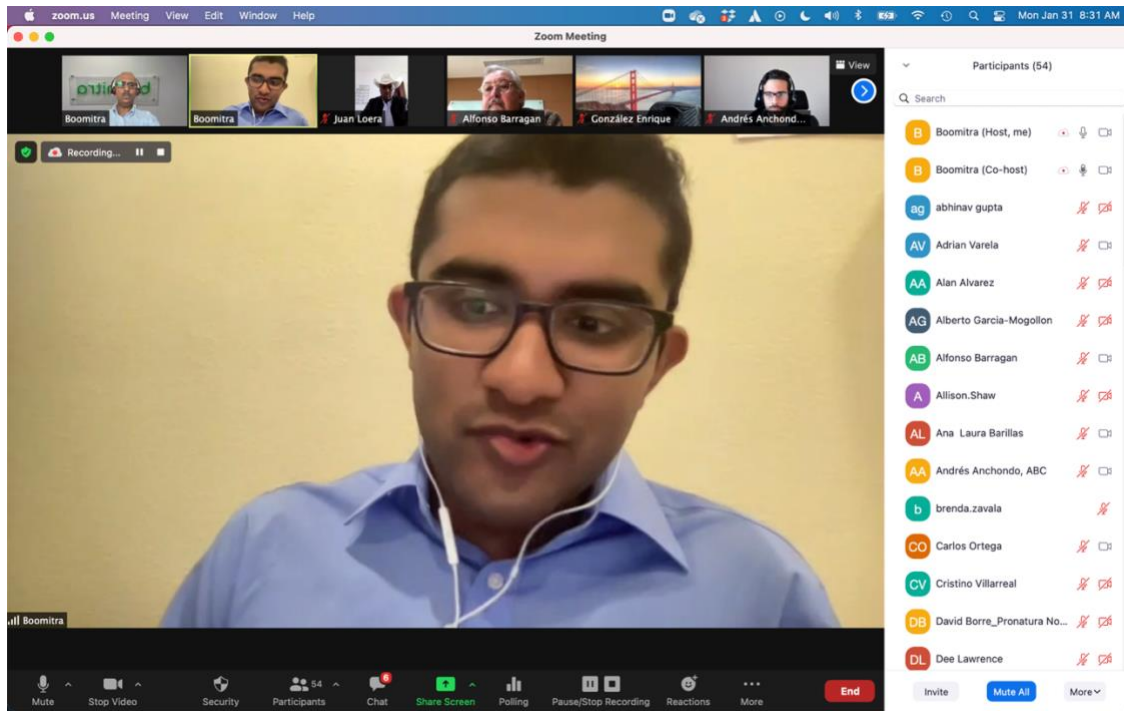
Figure 31. Invitation sent to a director of a department at the Autonomous University of Chihuahua

There were nearly 59 participants in the virtual meeting. Participants included ranchers, Boomitra staff, Pronatura staff, government officials, agribusiness executives, carbon credit purchases, conservation nonprofits etc.

Digital newspaper advertisement published on 28th January 2022.



Power point presentation and Glimpses of meeting



Recording...
You are viewing Rosario Alvarez's screen
View Options
View

ALGUNAS ACCIONES DE MANEJO / CONSERVACIÓN



RETENCION DE SUELO



INFRAESTRUCTURA



MONITOREO



CAPACITACIÓN





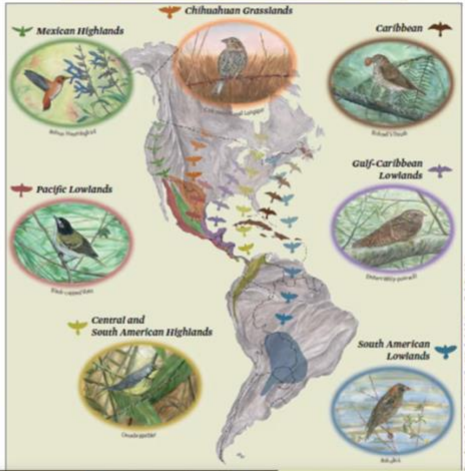
Rosario Alvarez

Mute Stop Video
Security
Participants 66
Chat
Share Screen
Polling
Pause/Stop Recording
Reactions
More
End

AVES

Las **aves migratorias** juegan un papel importante: son **depredadores de insectos** y vertebrados, dispersores de semillas y **polinizadores** de muchas plantas. (PIF, 2016)

WINTER GEOGRAPHIC AREAS FOR WATCH LIST SPECIES










Ganesh

Feedback forms

We have received 3 online feedback forms from the ranchers. There we no negative comments from them.

APPENDIX 02: FLORA AND FAUNA

	
Bighorn Sheep	Mexican Grey Wolf
	
Golden Eagle	Mexican Prairie Dog
	
Shrub vegetation	Herbaceous Vegetation

APPENDIX 03: BASELINE QUESTIONNAIRE

Baseline Rancher Information Collection

Date:	
-------	--

Name of Respondent	
Role of Respondent (Owner, Ejido Council Head etc.)	
Phone Number	
Email	
Legal Address	

Ranch Name	
Ranch Ownership (Private, Ejido, Ejido Subdivision)	
Ranch Coordinates	
Area	
Average Yearly Rainfall (mm)	
Temperature range (year)	
Years working with Regenerative Practices	

Livestock Type and Count			
Cattle	Type	Count	Breed(s)
Horses	Type	Count	Breed(s)
Sheep	Type	Count	Breed(s)
	Type	Count	Breed(s)

Livestock Type and Count					
Donkeys					
Goats	Type	Count	Breed(s)		
Other	Type	Count	Breed(s)		
What is the theoretical livestock carrying capacity of the ranch (if known)					
Livestock Number Changes (if any)					
Year					
Total Livestock Population					

Management Practices				
Number of Herds				
Herd 1 Avg Time Per Paddock	Grazing (Days)		Rest (Days)	
Herd 2 Avg Time Per Paddock				
Herd 3 Avg Time Per Paddock				
Herd 4 Avg Time Per Paddock				
Herd 5 Avg Time Per Paddock				
Herd 6 Avg Time Per Paddock				
Animal Welfare Practices Used (Optional)				
Are Wormers Used? Which? (Optional)				
Average Body Condition Score (BCS)? (1-5) (Optional)		At any given time, are there 10% of the animals below BCS 2? (Optional)		\
Permanent Fence (Non-electric) (Km)		Number of Permanent Paddocks		
Permanent Electric Fence (Km)				
Portable Fence Paddocks, Average Number per year				
Changes to Management Practices/Investments since 2017 (Eg. 30 Km of				

Management Practices			
fence purchased, 5 more paddocks etc.)			
Source of electricity for electric fence	☐ Diesel ☐ Natural Gas ☐ Gasoline ☐ Solar ☐ Grid ☐ Other (mention below)	Average Electricity consumption per month	
If fossil fuels are used for electricity production, average number of liters of fossil fuel consumed per month			
If Solar electricity, provide the wattage/power output of a panel & number of panels			

Water Conservation		
What sources of water are available for animals to drink		
Water Distribution	Type And Size Of Pipe	KM
Water Storage Tanks	Size	Count
Drinkers	Size	Count
Keyline (Y/N)? If Yes, Describe.		
Trenches (Y/N)? If Yes, Describe.		
Gabions (Y/N)? If Yes, Describe.		

APPENDIX 04: BASELINE SURVEY LIVESTOCK DATA (ANIMAL TYPE AND COUNT)

The Baseline Survey furnished data on the livestock stocking rate from 2015 to 2021. The table below presents the annual count of grazed livestock on the ranch, spanning three years prior to project commencement and three years following its initiation.

Sl. No	Ranch ID ^{141,142}	Total Livestock Population						
		2021	2020	2019	2018	2017	2016	2015
1	01afa459-ca10-4610-861c-4339501c70a9	829	975	1650	1850	2150	2000	2200
2	09ad3eb3-aa1b-4f4a-a907-c35b5d69cb7d	152	150	155	154	148	150	150
3	11341265-2d06-4e44-9201-8ebf82117f77	35	35	140	50	50	50	50
4	1452d0d3-6da4-49d9-b05a-bce0e66c0ba1	311	250	105	153	120	120	120
5	15583c60-392f-455e-b9c8-31908a1b3a83	259	252	232	272	269	269	270
6	162c6a96-7dcd-4fed-91f5-624426307e71	97	94	78	104	105	100	100
7	17220850-7789-48db-b128-f7fca9cfd2f5	37	40	45	50	50	60	60
8	19779b58-bbd8-47f9-aa50-a8166628c743	230	230	220	180	140	140	140
9	1a1435a0-fc2c-4c7a-ae2d-747bf36d09c5	920	870	750	750	700	700	700

¹⁴¹ Each ranch participating in the project has been allocated a unique ID and the ranch currently not part of the 1st instance of the project is also provided with a temporary ranch ID for the purpose of unique identification.

¹⁴² The name of the ranch can be identified using the Ranch ID in the ER Calculation sheet.

Sl. No	Ranch ID ^{141,142}	Total Livestock Population						
		2021	2020	2019	2018	2017	2016	2015
10	1a1435a0-fc2c-4c7a-ae2d-747bf36d09c5	25	25	25	25	25	25	25
11	1a496d91-9118-4f4e-ad9a-261e1b8edf3d	1242	975	1650	1850	2150	2000	2000
12	1c98c253-845b-43ff-a644-cdba25b09fb0	150	150	150	160	140	150	around 140-150
13	22ef8dab-179d-4671-aa74-d759fcc89917	2100	2100	2000	2000	1800	1600	1500
14	2970ae2f-e481-441c-bc67-86a4064ddfde	110	100	100	120	110	110	110
15	29d5d7b2-c968-4972-9949-16fabee6634b	2170	2170	2170	2163	1750	1700	1500
16	2adeb606-a407-4aaf-b10b-008e74a93817	121	80	110	70	100	100	100
17	2b84be37-ad1b-47b5-9d39-3235b6a5aa55	221	270	270	260	260	260	280
18	302971a5-4f41-4d94-8c4d-7868effc86fd	55	55	51	51	40	40	40
19	364699ee-1f93-425a-a91d-1acc03790959	107	150	185	210	220	220	220
20	36ea07af-5e9a-4fdd-b778-d8075c8d8109	215	215	215	215	150	150	150
21	39d76b13-698e-46de-8ecf-e7fc5ee93399	298	276	132	182	140	140	140
22	3c0b2ea9-a92b-4acc-b346-507ccdd24b47	500	550	600	650	700	650	650
23	3c18e5e8-c027-4e93-b8b8-815b214bab39	135	135	135	140	150	150	150
24	3e9b96fd-cbc5-4c71-a84f-2e22441e56bc	112	100	94	87	80	80	80

Sl. No	Ranch ID ^{141,142}	Total Livestock Population						
		2021	2020	2019	2018	2017	2016	2015
25	3f915540-1311-4f5e-9894-1abf5691475e	180	170	140	120	129	130	130
26	403c5584-3825-424f-84ec-69fad7bf3bb4	340	450	412	320	310	300	300
27	42a25589-0aeb-485f-9e18-25b60ea903f9	90	83	83	83	57	55	50
28	50024166-28f4-4647-b7fa-3dea5f0290c8	380	270	180	120	80	75	75-80
29	50fb8db7-81ba-40f5-a87e-cb293d19a0a0	125	128	130	130	135	140	140
30	533e58a6-d794-4354-b545-e94a09fa00c1	65	60	60	54	50	45	40
31	5b0650c8-773a-4488-bc14-5bf4833bfa48	130	130	130	130	130	130	130
32	5d4a62ff-4a41-4b70-95bf-f47a6793d45f	220	210	200	190	180	170	170
33	5e01b78d-f1ef-4ae9-b579-1d3a4029ea8d	770	700	630	600	600	600	600
34	5e0e86ae-469d-49b6-9b10-bddf62304811	180	180	180	180	180	180	180
35	5f08ca45-4b9a-4163-9bf5-daa41dde0875	120	120	120	120	90	85	80
36	5fc7cc53-4a1e-407b-b74e-aab5dc379c69	350	360	370	380	187	190	190
37	604483ca-0906-494a-84dc-b71fb34a8681	188	250	300	300	350	350	300
38	6183ae23-2a1d-4289-9624-1efce4146934	405	375	350	450	490	480	480
39	628fd24e-8f4b-4202-bfee-89cda9bb1f85	900	1000	1350	1300	1200	1200	1200

Sl. No	Ranch ID ^{141,142}	Total Livestock Population						
		2021	2020	2019	2018	2017	2016	2015
40	630c47ee-7f8f-4871-b3af-1e4ed9e22122	431	431	200	250	280	290	290
41	678220e7-acfd-46b2-a024-1a1fcb207d26	695	591	492	453	427	430	430
42	687ab63d-77d9-4273-a409-7c3c237fbd9	200	300	300	300	300	290	270
43	6996984c-e841-4fa9-a0c6-03d35b1539ad	200	200	200	200	200	200	200
44	6bd72296-df02-4e40-957e-6f6963610576	95	80	80	70	60	70	70
45	70c11a4c-e324-451c-bbf8-281a949107a1	55	60	60	70	70	65	60
46	7148cd4a-15cf-4912-b90c-a27176ac2c47	147	120	227	206	175	150	150
47	73b5d175-cfad-4d5b-b220-7be51e39a46d	170	200	280	260	260	260	260
48	74aae2f6-6156-4306-97ce-cc5abf586c86	500	500	500	550	600	Not sure	Not able to recollect
49	7507e0e3-63c6-45cf-96ac-5fcbb7b407e4	290	285	282	282	260	250	250
50	75773be2-812c-4b8f-a970-7c4b5ffb76a9	170	170	170	180	200	200	200
51	788ba119-0bb4-4e7b-9108-89ea0847e95b	50	50	50	50	50	50	50
52	7a5254af-6d73-424e-a243-b54da0f08c79	240	280	240	220	200	200	200
53	7d07b3a3-4aed-43e8-9b04-62f4faa26f18	63	40	145	115	68	70	70
54	7d8bc49c-3f5b-4a73-8a19-df41839faabc	280	250	300	350	450	280	280

Sl. No	Ranch ID ^{141,142}	Total Livestock Population						
		2021	2020	2019	2018	2017	2016	2015
55	7fdbf694-fff3-4dc1-a4f2-18a39f0b3d2b	260	260	260	260	220	220	200
56	807dcaaf-7f8f-42a6-805e-033fd657145f	199	160	142	131	123	120	120
57	80dd0409-1c82-4f24-95ae-766ab7d16177	165	140	140	125	120	120	120
58	88934b73-da0e-4f33-8e1b-237c1946a02d	840	840	840	832	700	650	600
59	8c3e218d-6cc2-42bc-8a20-9fffb3f3dce8	840	840	840	837	700	670	600
60	8dd037dd-cb8d-4b31-8023-3624d7a3958d	350	310	290	300	280	250	250
61	92013344-2c71-466c-be1e-134aa099688e	350	350	400	400	400	400	400
62	92aa7104-9f8c-4163-850d-c471d2c26012	405	380	380	350	350	350	350
63	93c54ff5-770e-4b6b-bc52-4e98e3c8ee89	244	218	189	189	192	160	155
64	961e806a-c74e-4d05-9518-eb3c0ad1d7ef	214	128	117	105	105	110	110
65	96be2893-ab6e-45fb-8636-4f1784d62a60	2680	2680	2680	2680	2500	2450	2400
66	97db29f4-af6c-411f-920a-7c10480fce14	100	200	200	200	200	200	200
67	99afdd2c-d530-47fd-be66-8a8f050d9149	122	108	106	108	110	120	Around 120
68	9a0757a0-d9c7-4ea4-8be9-3805ab9644c7	350	400	500	300	300	Around 450 +	Around 450 +
69	a3d74b32-d955-4ea7-935d-27c44847942f	68	76	84	86	94	90	84

Sl. No	Ranch ID ^{141,142}	Total Livestock Population						
		2021	2020	2019	2018	2017	2016	2015
70	a7b3a940-6f4a-404d-8d21-2f08f0b69c22	400	500	550	550	500	500	500
71	a8d3b758-c581-41c8-8019-4e708effa8da	42	42	42	42	42	42	42
72	a982ef93-5a78-4180-be34-e264dad789bd	250	243	220	213	215	215	215
73	ac3ba3ef-5c6c-40ce-8aa6-778f0ad0f82d	235	170	150	150	150	150	150
74	afc2cb3a-8b77-4618-aff1-cf59504f1e11	935	850	800	700	550	550	550
75	b121d998-f0c8-45df-9794-45bc5d0c0ab2	501	470	410	350	340	300	300
76	b3fcb76a-6226-48d4-af45-5399350e4b5e	690	690	680	680	600	530	500
77	b78a55a8-2a8c-445c-9b69-8bf0e23522cb	50	50	50	50	50	50	50
78	b7c82e9b-96f9-46b4-b37c-1b78ba8ede48	250	120	100	100	70	Unable to recollect	Unable to recollect
79	b7c8dbbd-72bd-4b46-b513-28f011e1e224	400	450	500	550	550	550	550
80	bab7ffc3-12ce-47be-b609-8c79d01b79e9	60	60	60	60	60	60	60
81	bd8b932d-8c66-4149-86f8-8af6ea322043	0	104	104	104	104	100	90 to 100
82	bf3b8991-8186-4933-af81-4557dae5aa25	180	170	140	120	120	120	120
83	c1bc3dcd-30fd-43f5-ae8b-c302859c4944	571	500	430	320	300	300	300
84	c3b94e9a-8fe3-480b-93b8-e97804c4289d	789	820	715	593	540	540	540

Sl. No	Ranch ID ^{141,142}	Total Livestock Population						
		2021	2020	2019	2018	2017	2016	2015
85	c58cd28f-b66f-4eb3-88c8-78581949484a	225	225	189	206	201	200	200
86	c70ee6d6-e452-410c-a01e-15c174de0463	90	90	110	130	130	Not sure	I am unable to recollect
87	c7f98ddc-cd01-4b6c-a7bc-609aa2ca1819	146	139	118	151	149	150	150
88	c87aa97d-7699-44d7-8122-76867e4d8394	450	400	380	320	250	250	Don't remember
89	c89fe226-7b6e-4d1e-bc4a-389244ce0225	65	70	50	30	28	28	30
90	cc5b6da2-4676-42ff-aaf6-51a07166d1ee	366	350	370	330	320	330	330
91	cfe61517-5429-4123-941c-2b15e00c3880	243	442	354	345	345	345	345
92	d026243d-ebcd-4d25-becf-c2cc504ba2ce	200	150	220	220	200	200	200
93	d4dd3cd4-133d-4236-a75b-3db685823748	125	120	120	120	92	92	80
94	d7db8d25-ed98-49e2-bcc2-78cf07315d2e	70	70	70	70	65	60	50
95	d83e05a8-9153-4d06-a6a9-48ba1c40f9b2	105	105	115	115	115	115	110
96	dc0f79ab-c88f-498c-ad44-cc300d1c5831	200	190	180	180	170	170	170
97	df48f5ce-8204-456d-8423-68082c33cda0	442	439	439	439	350	325	300
98	e046a638-8b84-4a81-86e4-2fb6dd37e93c	20	30	30	20	45	45	45
99	e2b4323f-9e21-4627-abc4-5a441ddaf41a	185	170	165	170	150	150	150

Sl. No	Ranch ID ^{141,142}	Total Livestock Population						
		2021	2020	2019	2018	2017	2016	2015
100	e6fdc4e1-3908-4573-891a-a646202911b4	120	240	240	240	240	240	240
101	e7f39707-b663-4606-8f9d-a439237cc9d7	150	130	130	120	120	120	120
102	eb3ddaca-3329-4dad-a213-671e7e3e287e	920	776	656	546	546	600	600
103	f22c409d-b83e-4bec-b8f0-06adfd406198	140	140	125	125	105	105	105
104	f4d32cdd-d0e9-4749-bdbe-9540905d64f4	115	101	95	95	95	95	95
105	f7153b1f-e29d-4aee-90c6-313127ab9d91	2040	2030	2030	2030	1750	1700	1700
106	fdc10c2f-6569-402e-b9dc-570110a28189	110	100	100	110	100	100	100
107	ba107	112	135	120	92	89	90	90
108	ba108	250	120	70	70	70	80 to 85	90
109	ba109	911	969	996	722	668	Not able to recollect	Not able to recollect
110	ba110	80	80	75	75	60	55	50
111	ba111	79	130	103	81	68	75-80	around 80
112	ba112	170	140	130	120	120	120	120
113	ba113	324	330	335	338	340	340	340
114	ba114	1519	1600	1700	1795	1800	Not able to recollect	Not able to recollect

Sl. No	Ranch ID ^{141,142}	Total Livestock Population						
		2021	2020	2019	2018	2017	2016	2015
115	ba115	160	160	149	149	135	130	130
116	ba116	3500	3800	3000	2500	2000	2000	2000
117	ba117	1132	2374	1508	1539	1477	1400	1400
118	ba118	175	190	162	148	120	I don't remember	I don't remember
119	ba119	140	120	120	150	150	150	150
120	ba120	350	350	350	350	350	350	350
121	ba121	240	250	217	150	298	298	298
122	ba122	260	340	320	300	280	280	280
123	ba123	110	90	90	80	80	80	80
124	ba124	360	365	313	300	280	280	280
125	ba125	200	160	140	120	100	100	100
126	ba126	64	50	60	75	70	Not sure	I don't remember
127	ba127	196	214	242	189	190	190	Not able to recollect
128	ba128	20	20	30	30	30	30	30
129	ba129	350	350	300	280	260	260	270

Sl. No	Ranch ID ^{141,142}	Total Livestock Population						
		2021	2020	2019	2018	2017	2016	2015
130	ba130	170	170	170	180	200	200	200
131	ba131	627	627	627	627	627	627	627
132	ba132	640	640	640	640	640	640	640
133	ba133	232	232	175	150	122	122	122
134	ba134	16	16	16	16	13	12	10
135	ba135	130	130	126	126	106	95	90
136	ba136	125	125	155	160	165	165	165
137	ba137	189	153	165	165	165	165	165
138	ba138	240	250	217	150	298	230	230
139	ba139	500	550	600	650	650	650	650
140	ba140	203	190	175	225	245	245	245
141	ba141	203	190	175	225	245	245	245
142	ba142	102	98	88	105	105	105	105
143	ba143	1070	1000	750	600	450	420	420
144	ba144	2960	2960	2960	2960	2960	2960	2960

Sl. No	Ranch ID ^{141,142}	Total Livestock Population						
		2021	2020	2019	2018	2017	2016	2015
145	ba145	700	700	700	750	750	750	750
146	ba146	1200	1200	1200	1200	1200	1200	1200
147	ba147	1319	1504	1372	1691	1499	1499	1499
148	ba148	186	170	170	170	175	175	175
149	ba149	245	240	240	245	245	240	240
150	ba150	90	90	110	130	130	130	130
151	ba151	481	428	722	627	592	550	550
152	ba152	260	200	220	260	260	260	260
153	ba153	500	550	550	550	550	550	550
154	ba154	150	130	130	120	120	120	120
155	ba155	49	88	81	72	85	90	90
156	ba156	350	330	310	300	300	300	300
157	ba157	800	800	750	700	650	700	750
158	ba158	900	950	950	1200	1200	1250	1250
159	ba159	23	23	30	30	30	25	25

Sl. No	Ranch ID ^{141,142}	Total Livestock Population						
		2021	2020	2019	2018	2017	2016	2015
160	ba160	150	130	130	120	120	120	120
161	ba161	90	90	90	85	85	90	90
162	ba162	210	180	150	120	120	120	120
163	ba163	70	75	75	78	80	80	80
164	ba164	60	50	52	30	30	30	30
165	ba165	20	60	60	70	70	70	70
166	ba166	90	100	100	100	110	110	110
167	ba167	50	40	40	30	50	50	50
168	ba168	130	130	125	125	130	130	130
169	ba169	50	50	50	50	50	50	50
170	ba170	205	205	250	420	120	130	130
171	ba171	179	150	170	120	80	85	80

Below is the presentation of the animal types and their populations at each ranch surveyed.

Sl. No	Ranch ID ¹⁴¹	Cattle					Horses					Sheep		Donkey		Goat	
		Bulls	Cows	Helpers	Steers	calf	Stallion	Mares	Horses	Filles	Mules	Ram	Ewes	Jacks	Jennies	Bucks	Nannies
1	01afa459-ca10-4610-861c-4339501c70a9	28	384	417	—	—	—	7	8	—	—	—	—	—	—	—	—
2	09ad3eb3-aa1b-4f4a-a907-c35b5d69cb7d	7	100	20	25	—	—	—	—	—	—	—	—	—	—	—	—
3	11341265-2d06-4e44-9201-8ebf82117f77	13	135	—	—	—	—	—	3	—	—	—	—	2	—	1	10
4	1452d0d3-6da4-49d9-b05a-bce0e66c0ba1	24	276	10	8	—	—	2	5	—	—	—	—	—	—	—	—
5	15583c60-392f-455e-b9c8-31908a1b3a83	15	193	51	0	0	—	—	—	—	—	—	—	—	—	—	—
6	162c6a96-7dcd-4fed-91f5-624426307e71	6	72	19	0	0	—	—	—	—	—	—	—	—	—	—	—
7	17220850-7789-48db-b128-f7ca9cfd2f5	2	30	5	—	—	—	—	—	—	—	—	—	—	—	—	—
8	19779b58-bbd8-47f9-aa50-a8166628c743	—	40	70	120	—	—	—	3	—	—	—	—	—	—	—	—
9	1a1435a0-fc2c-4c7a-ae2d-747bf36d09c5	50	750	120	—	—	2	20	20	—	—	2	15	—	—	—	—
10	1a1435a0-fc2c-4c7a-ae2d-747bf36d09c5	1	20	4	0	—	—	—	—	—	—	—	—	—	—	—	—
11	1a496d91-9118-4f4e-ad9a-261e1b8edf3d	42	575	625	—	—	1	4	9	—	—	—	—	—	—	—	—
12	1c98c253-845b-43ff-a644-cdba25b09fb0	5	105	20	20	—	—	1	3	—	—	—	—	3	5	—	—
13	22ef8dab-179d-4671-aa74-d759fcc89917	200	1300	400	100	—	4	10	40	—	—	1	4	3	10	—	—
14	2970ae2f-e481-441c-bc67-86a4064ddfde	13	120	—	—	—	—	2	2	—	—	—	—	—	—	—	—

Sl. No	Ranch ID ¹⁴¹	Cattle					Horses					Sheep		Donkey		Goat	
		Bulls	Cows	Helpers	Steers	calf	Stallion	Mares	Horses	Filles	Mules	Ram	Ewes	Jacks	Jennies	Bucks	Nannies
15	29d5d7b2-c968-4972-9949-16fabee6634b	95	1798	270	—	—	4	25	30	—	—	—	—	—	2	—	18
16	2adeb606-a407-4aaf-b10b-008e74a93817	—	74	30	—	—	—	—	—	—	—	—	—	—	—	—	—
17	2b84be37-ad1b-47b5-9d39-3235b6a5aa55	13	178	30	—	—	—	—	5	—	—	—	—	—	—	—	—
18	302971a5-4f41-4d94-8c4d-7868effc86fd	2	45	4	—	—	2	3	—	—	—	—	—	—	1	—	—
19	364699ee-1f93-425a-a91d-1acc03790959	5	100	7	—	—	1	—	—	—	—	—	—	—	—	—	—
20	36ea07af-5e9a-4fdd-b778-d8075c8d8109	15	200	—	—	—	—	—	—	—	—	—	—	—	—	—	—
21	39d76b13-698e-46de-8ecf-e7fc5ee93399	8	233	38	53	—	2	—	—	—	—	—	—	—	—	—	—
22	3c0b2ea9-a92b-4acc-b346-507ccdd24b47	50	250	80	120	—	1	10	20	—	—	2	5	1	—	—	—
23	3c18e5e8-c027-4e93-b8b8-815b214bab39	13	135	—	—	—	—	—	—	3	—	—	—	2	—	—	—
24	3e9b96fd-cbc5-4c71-a84f-2e22441e56bc	2	80	30	0	—	1	0	1	—	—	0	0	0	0	0	0
25	3f915540-1311-4f5e-9894-1abf5691475e	3	80	20	65	—	—	—	1	—	—	—	—	—	—	—	—
26	403c5584-3825-424f-84ec-69fad7bf3bb4	18	220	68	57	—	2	13	6	—	—	2	26	—	—	—	—
27	42a25589-0aeb-485f-9e18-25b60ea903f9	7	65	11	—	—	2	—	—	—	—	—	—	—	—	—	—
28	50024166-28f4-4647-b7fa-3dea5f0290c8	14	352	72	11	—	1	6	3	—	—	—	—	—	—	—	—
29	50fb8db7-81ba-40f5-a87e-cb293d19a0a0	4	102	18	—	—	1	1	2	—	—	8	30	0	0	2	36

Sl. No	Ranch ID ¹⁴¹	Cattle					Horses					Sheep		Donkey		Goat	
		Bulls	Cows	Helpers	Steers	calf	Stallion	Mares	Horses	Filles	Mules	Ram	Ewes	Jacks	Jennies	Bucks	Nannies
30	533e58a6-d794-4354-b545-e94a09fa00c1	4	40	10	0	0	-	3	-	-	-	-	-	-	-	-	-
31	5b0650c8-773a-4488-bc14-5bf4833bfa48	12	130	-	-	-	-	-	-	-	-	-	-	-	-	-	-
32	5d4a62ff-4a41-4b70-95bf-f47a6793d45f	7	180	33	-	-	5	4	-	-	-	-	-	-	-	-	-
33	5e01b78d-f1ef-4ae9-b579-1d3a4029ea8d	24	600	100M	50	-	-	-	8	-	-	0	-	0	0	0	0
34	5e0e86ae-469d-49b6-9b10-bddf62304811	5	50	120	120	-	-	-	6	-	-	-	-	2	-	-	-
35	5f08ca45-4b9a-4163-9bf5-daa41dde0875	10	110	-	-	-	-	-	-	-	-	-	-	-	-	-	-
36	5fc7cc53-4a1e-407b-b74e-aab5dc379c69	23	380	30	70	-	-	1	5	-	-	-	-	-	-	1	1
37	604483ca-0906-494a-84dc-b71fb34a8681	8	150	30	0	-	-	-	-	-	-	-	-	-	-	-	-
38	6183ae23-2a1d-4289-9624-1efce4146934	20	350	35	4	-	1	5	5	-	-	-	-	-	-	-	-
39	628fd24e-8f4b-4202-bfee-89cda9bb1f85	80	600	220	-	-	-	40	50	-	-	6	70	-	-	1	50
40	630c47ee-7f8f-4871-b3af-1e4ed9e22122	15	285	60	60	-	-	2	3	7	-	-	-	-	-	-	-
41	678220e7-acfd-46b2-a024-1a1fcb207d26	25	550	187	128	-	2	6	8	-	-	-	-	-	-	-	-
42	687ab63d-77d9-4273-a409-7c3c237fbd9	8	300	-	100	-	-	1	2	-	-	1	4	-	-	-	-
43	6996984c-e841-4fa9-a0c6-03d35b1539ad	6	-	100	100	-	1	2	-	-	-	-	-	-	-	-	-
44	6bd72296-df02-4e40-957e-6f6963610576	5	80	10	0	-	-	-	1	-	-	-	-	-	-	-	-

Sl. No	Ranch ID ¹⁴¹	Cattle					Horses					Sheep		Donkey		Goat	
		Bulls	Cows	Helpers	Steers	calf	Stallion	Mares	Horses	Filles	Mules	Ram	Ewes	Jacks	Jennies	Bucks	Nannies
45	70c11a4c-e324-451c-bbf8-281a949107a1	2	33	19	1	–	2	3	2	–	–	–	–	–	–	–	–
46	7148cd4a-15cf-4912-b90c-a27176ac2c47	3	62	30	52	–	1	4	2	–	–	4	3	–	1	1	4
47	73b5d175-cfad-4d5b-b220-7be51e39a46d	9	167	35	30	–	–	–	3	–	–	–	–	–	–	–	–
48	74aae2f6-6156-4306-97ce-cc5abf586c86	10	210	30	200	–	1	5	10	–	–	14	15	1	–	0	0
49	7507e0e3-63c6-45cf-96ac-5fcbc7b407e4	6	254	17	5	–	2	4	4	–	–	2	40	–	–	2	25
50	75773be2-812c-4b8f-a970-7c4b5ffb76a9	13	170	0	0	0	–	3	–	–	–	–	–	–	–	–	–
51	788ba119-0bb4-4e7b-9108-89ea0847e95b	2	50	12	6	–	0	2	0	–	–	–	–	–	–	–	–
52	7a5254af-6d73-424e-a243-b54da0f08c79	17	240	20	–	–	–	–	4	–	–	–	–	–	–	–	–
53	7d07b3a3-4aed-43e8-9b04-62f4faa26f18	1	35	14	10	–	2	1	0	–	–	–	–	–	1	–	–
54	7d8bc49c-3f5b-4a73-8a19-df41839faabc	11	80	181	8	–	–	–	–	–	–	–	–	–	–	–	–
55	7fdbf694-fff3-4dc1-a4f2-18a39f0b3d2b	–	–	260	–	–	–	–	–	–	–	–	–	–	–	–	–
56	807dcaaf-7f8f-42a6-805e-033fd657145f	9	140	20	–	–	1	6	5	–	–	3	11	–	–	–	–
57	80dd0409-1c82-4f24-95ae-766ab7d16177	10	150	15	0	–	–	2	4	–	–	–	–	–	–	–	–
58	88934b73-da0e-4f33-8e1b-237c1946a02d	21	420	174	217	–	15	62	–	32	–	–	–	12	38	–	–
59	8c3e218d-6cc2-42bc-8a20-9fffb3f3dce8	16	515	214	92	–	–	–	–	–	–	–	–	–	–	–	–

Sl. No	Ranch ID ¹⁴¹	Cattle					Horses					Sheep		Donkey		Goat	
		Bulls	Cows	Helpers	Steers	calf	Stallion	Mares	Horses	Filles	Mules	Ram	Ewes	Jacks	Jennies	Bucks	Nannies
60	8dd037dd-cb8d-4b31-8023-3624d7a3958d	15	285	50	-	-	-	-	4	-	-	-	-	-	-	-	-
61	92013344-2c71-466c-be1e-134aa099688e	10	240	50	50	-	0	0	2	-	-	0	0	1	-	-	-
62	92aa7104-9f8c-4163-850d-c471d2c26012	18	315	71	-	-	-	-	4	-	2	-	-	1	-	-	-
63	93c54ff5-770e-4b6b-bc52-4e98e3c8ee89	4	0	150	70	-	0	2	2	-	-	-	-	-	-	-	-
64	961e806a-c74e-4d05-9518-eb3c0ad1d7ef	11	203	-	-	-	-	2	2	-	-	-	-	-	-	-	-
65	96be2893-ab6e-45fb-8636-4f1784d62a60	180	1900	600	-	-	3	40	50	-	-	-	-	-	-	-	-
66	97db29f4-af6c-411f-920a-7c10480fce14	14	200	30	30	-	8	6	-	-	-	-	-	-	-	-	-
67	99afdd2c-d530-47fd-be66-8a8f050d9149	3	118	4	10	-	3	13	5	-	-	-	-	1	7	-	-
68	9a0757a0-d9c7-4ea4-8be9-3805ab9644c7	15	280	80	70	-	0	1	8	-	-	1	0	0	0	0	0
69	a3d74b32-d955-4ea7-935d-27c44847942f	2	58	7	1	-	1	3	-	-	-	-	-	-	-	-	-
70	a7b3a940-6f4a-404d-8d21-2f08f0b69c22	20	200	120	30	-	1	10	-	-	-	-	-	-	-	-	-
71	a8d3b758-c581-41c8-8019-4e708effa8da	2	32	6	-	-	-	-	-	-	-	-	-	-	-	-	-
72	a982ef93-5a78-4180-be34-e264dad789bd	10	170	56	-	-	1	3	3	-	-	-	-	-	-	-	-
73	ac3ba3ef-5c6c-40ce-8aa6-778f0ad0f82d	15	155	65	3	-	1	4	-	-	-	-	-	-	-	-	-
74	afc2cb3a-8b77-4618-aff1-cf59504f1e11	55	830	50	-	-	-	18	-	-	-	4	-	1	-	-	-

Sl. No	Ranch ID ¹⁴¹	Cattle					Horses					Sheep		Donkey		Goat	
		Bulls	Cows	Helpers	Steers	calf	Stallion	Mares	Horses	Filles	Mules	Ram	Ewes	Jacks	Jennies	Bucks	Nannies
75	b121d998-f0c8-45df-9794-45bc5d0c0ab2	–	490	50	–	–	–	4	–	–	–	–	–	–	–	–	–
76	b3fcb76a-6226-48d4-af45-5399350e4b5e	17	520	130	13	–	6	–	–	–	–	–	–	–	–	–	–
77	b78a55a8-2a8c-445c-9b69-8bf0e23522cb	2	50	12	6	–	0	2	0	–	–	–	–	–	–	–	–
78	b7c82e9b-96f9-46b4-b37c-1b78ba8ede48	7	242	–	–	–	–	–	2	–	–	–	–	–	–	–	–
79	b7c8dbbd-72bd-4b46-b513-28f011e1e224	20	200	30	–	–	–	–	–	–	–	–	–	–	–	–	–
80	bab7ffc3-12ce-47be-b609-8c79d01b79e9	3	27	–	–	–	2	4	–	–	–	–	–	–	–	–	–
81	bd8b932d-8c66-4149-86f8-8af6ea322043	4	80	20	–	–	–	–	2	–	–	–	–	–	–	–	–
82	bf3b8991-8186-4933-af81-4557dae5aa25	3	80	20	65	–	–	–	1	–	–	–	–	–	–	–	–
83	c1bc3dcd-30fd-43f5-ae8b-c302859c4944	4	242	315	10	–	–	1	8	–	–	–	–	–	7	–	–
84	c3b94e9a-8fe3-480b-93b8-e97804c4289d	33	510	127	118	–	–	4	20	–	–	–	–	–	–	–	–
85	c58cd28f-b66f-4eb3-88c8-78581949484a	2	187	–	–	–	–	–	–	–	–	–	–	–	–	–	–
86	c70ee6d6-e452-410c-a01e-15c174de0463	3	52	30	5	–	0	1	2	–	–	0	0	1	0	0	0
87	c7f98ddc-cd01-4b6c-a7bc-609aa2ca1819	9	108	29	0	0	–	–	–	–	–	–	–	–	–	–	–
88	c87aa97d-7699-44d7-8122-76867e4d8394	20	300	100	50	–	–	10	10	–	–	–	–	–	–	–	–
89	c89fe226-7b6e-4d1e-bc4a-389244ce0225	3	65	10	25	–	–	–	–	–	–	–	–	–	1	–	–

Sl. No	Ranch ID ¹⁴¹	Cattle					Horses					Sheep		Donkey		Goat	
		Bulls	Cows	Helpers	Steers	calf	Stallion	Mares	Horses	Filles	Mules	Ram	Ewes	Jacks	Jennies	Bucks	Nannies
90	cc5b6da2-4676-42ff-aaf6-51a07166d1ee	17	269	30	50	—	—	4	4	—	—	—	—	—	—	—	—
91	cfe61517-5429-4123-941c-2b15e00c3880	46	167	125	—	—	1	9	16	—	—	—	—	—	—	—	—
92	d026243d-ebcd-4d25-becf-c2cc504ba2ce	9	130	60	20	—	—	—	4	—	—	—	—	1	—	—	—
93	d4dd3cd4-133d-4236-a75b-3db685823748	10	110	—	—	—	—	—	—	—	—	—	—	—	—	—	—
94	d7db8d25-ed98-49e2-bcc2-78cf07315d2e	20	45	—	—	10	—	—	—	—	—	171	—	—	—	—	—
95	d83e05a8-9153-4d06-a6a9-48ba1c40f9b2	5	95	—	—	—	—	—	4	—	—	—	—	—	—	—	—
96	dc0f79ab-c88f-498c-ad44-cc300d1c5831	12	150	30	0	—	1	3	4	—	—	—	—	—	—	1	80
97	df48f5ce-8204-456d-8423-68082c33cda0	27	248	96	68	—	—	—	5	—	—	—	—	—	—	—	—
98	e046a638-8b84-4a81-86e4-2fb6dd37e93c	1	15	3	—	—	1	7	—	—	—	—	—	—	—	—	—
99	e2b4323f-9e21-4627-abc4-5a441ddaf41a	8	188	18	—	—	—	3	—	—	—	—	—	—	—	2	14
100	e6fdc4e1-3908-4573-891a-a646202911b4	12	108	—	—	—	3	6	—	—	—	—	—	—	—	—	—
101	e7f39707-b663-4606-8f9d-a439237cc9d7	8	100	30	0	0	—	4	—	—	—	—	—	—	—	—	—
102	eb3ddaca-3329-4dad-a213-671e7e3e287e	40	736	144	6	460	2	8	7	3	4	0	0	0	0	0	0
103	f22c409d-b83e-4bec-b8f0-06adfd406198	5	125	10	0	—	0	4	1	—	—	—	—	1	0	—	—
104	f4d32cdd-d0e9-4749-bdbe-9540905d64f4	5	90	90	—	—	—	—	8	—	—	—	—	—	—	—	—

Sl. No	Ranch ID ¹⁴¹	Cattle					Horses					Sheep		Donkey		Goat	
		Bulls	Cows	Helpers	Steers	calf	Stallion	Mares	Horses	Filles	Mules	Ram	Ewes	Jacks	Jennies	Bucks	Nannies
105	f7153b1f-e29d-4aee-90c6-313127ab9d91	57	753	540	680	—	12	63	—	38	—	—	—	—	—	—	—
106	fdc10c2f-6569-402e-b9dc-570110a28189	4	50	20	0	—	—	1	—	—	—	—	—	—	1	—	—
107	ba107	6	66	20	17	—	1	6	2	—	—	—	—	—	—	—	—
108	ba108	15	180	70	15	—	1	1	3	—	—	—	—	—	—	—	—
109	ba109	60	510	60	160	—	1	5	20	—	—	—	—	1	—	—	—
110	ba110	—	40	—	—	35	—	—	—	—	—	—	—	—	—	—	—
111	ba111	3	55	14	10	—	1	11	4	—	—	—	1	1	—	1	2
112	ba112	12	120	30	—	—	1	4	2	—	—	—	—	—	—	—	—
113	ba113	15	200	50	30	—	0	4	7	—	—	1	4	3	5	—	—
114	ba114	15	600	230	100	—	—	300	10	—	—	8	45	—	—	7	204
115	ba115	9	100	40	—	—	1	3	7	—	—	X	—	1	0	1	15
116	ba116	200	2400	600	300	—	0	4	27	—	—	1	54	23	15	—	—
117	ba117	66	462	182	9	—	—	3	10	—	—	—	5	1	1	—	—
118	ba118	4	101	44	25	—	0	2	2	—	—	—	—	—	—	—	—
119	ba119	18	150	12	—	—	—	1	3	—	—	—	—	—	—	—	—

Sl. No	Ranch ID ¹⁴¹	Cattle					Horses					Sheep		Donkey		Goat	
		Bulls	Cows	Helpers	Steers	calf	Stallion	Mares	Horses	Filles	Mules	Ram	Ewes	Jacks	Jennies	Bucks	Nannies
120	ba120	25	350	60	60	–	0	2	12	–	–	–	–	–	–	–	–
121	ba121	6	109	73	29	–	1	7	7	–	–	–	–	4	1	–	–
122	ba122	21	260	25	–	–	–	–	5	–	–	–	–	–	–	–	–
123	ba123	8	80	20	–	–	–	–	2	–	–	–	–	–	–	–	–
124	ba124	20	350	80	–	–	–	2	8	–	–	–	–	1	0	–	–
125	ba125	14	150	45	0	–	1	3	4	–	–	–	–	–	–	–	–
126	ba126	4	45	15	0	–	–	–	2	–	–	–	–	–	–	–	–
127	ba127	20	191	102	–	–	1	5	3	–	–	–	–	–	–	–	–
128	ba128	2	15	5	–	–	–	–	1	–	–	–	–	–	–	–	–
129	ba129	26	350	25	–	–	–	–	6	–	–	–	–	–	–	–	–
130	ba130	13	170	–	–	–	–	3	5	–	–	–	–	–	–	–	–
131	ba131	32	295	200	100	–	1	4	6	–	–	–	–	–	–	–	–
132	ba132	30	410	100	100	–	1	8	6	–	–	–	–	–	–	–	–
133	ba133	7	200	20	4	–	–	–	–	–	–	–	–	–	–	–	–
134	ba134	1	10	5	0	–	1	2	–	–	–	–	–	1	10	–	–

Sl. No	Ranch ID ¹⁴¹	Cattle					Horses					Sheep		Donkey		Goat	
		Bulls	Cows	Helpers	Steers	calf	Stallion	Mares	Horses	Filles	Mules	Ram	Ewes	Jacks	Jennies	Bucks	Nannies
135	ba135	2	80	36	8	–	–	–	–	–	–	–	–	–	–	–	–
136	ba136	8	100	17	–	–	–	–	–	–	–	–	–	–	–	–	–
137	ba137	2	163	20	4	–	–	–	–	–	–	–	–	–	–	–	–
138	ba138	6	109	73	29	–	1	7	7	–	–	–	–	4	1	–	–
139	ba139	20	394	25	12	–	–	–	4	–	–	6	11	–	–	–	2
140	ba140	10	175	17	1	–	0	0	5	–	–	–	–	–	–	–	–
141	ba141	10	175	17	2	–	–	–	5	–	–	–	–	–	–	–	–
142	ba142	6	76	20	–	–	–	–	–	–	–	–	–	–	–	–	–
143	ba143	38	800	232	–	–	1	8	10	–	–	1	2	1	–	1	1
144	ba144	80	1600	640	640	–	5	20	46	–	–	–	–	–	–	–	–
145	ba145	0	350	350	230	–	1	3	10	–	–	–	–	1	2	–	–
146	ba146	60	1200	250	–	–	3	18	23	–	–	–	–	–	1	–	–
147	ba147	34	890	283	173	–	1	7	2	–	–	0	2	1	2	–	0
148	ba148	16	160	10	–	–	–	6	6	–	–	–	–	1	3	–	–
149	ba149	4	121	70	50	–	6	22	9	–	–	–	–	–	–	–	–

Sl. No	Ranch ID ¹⁴¹	Cattle					Horses					Sheep		Donkey		Goat	
		Bulls	Cows	Helpers	Steers	calf	Stallion	Mares	Horses	Filles	Mules	Ram	Ewes	Jacks	Jennies	Bucks	Nannies
150	ba150	3	52	30	5	–	0	1	2	–	–	0	0	1	0	0	0
151	ba151	10	251	126	73	–	–	–	4	–	–	–	–	–	–	–	–
152	ba152	9	110	50	50	–	0	0	4	–	–	0	0	0	2	–	–
153	ba153	20	500	140	140	–	1	6	8	–	–	2	200	1	10	1	10
154	ba154	8	100	30	–	–	–	–	–	–	4	1	6	–	–	–	–
155	ba155	3	49	–	–	–	–	–	1	–	–	–	–	–	–	–	–
156	ba156	8	200	75	75	–	–	1	2	–	–	–	–	–	–	–	–
157	ba157	93	500	300	–	–	1	8	–	–	–	–	–	–	–	–	–
158	ba158	120	900	300	–	–	2	24	16	–	–	2	200	–	1	–	–
159	ba159	9	233	74	33	–	3	14	6	–	–	–	–	–	–	–	–
160	ba160	8	100	30	–	–	–	–	4	–	–	–	–	–	–	–	–
161	ba161	6	118	56	33	–	8	52	12	–	–	–	–	–	–	3	9
162	ba162	7	160	30	3	–	–	–	–	–	–	–	–	–	–	–	–
163	ba163	4	55	10	–	–	–	1	2	–	–	–	–	–	–	–	–
164	ba164	4	76	16	–	–	–	–	3	–	–	–	–	–	–	–	–

Sl. No	Ranch ID ¹⁴¹	Cattle					Horses					Sheep		Donkey		Goat	
		Bulls	Cows	Helpers	Steers	calf	Stallion	Mares	Horses	Filles	Mules	Ram	Ewes	Jacks	Jennies	Bucks	Nannies
165	ba165	1	10	10	–	–	–	–	1	–	–	–	–	–	–	–	–
166	ba166	4	70	7	2	–	0	0	2	–	–	1	9	–	–	–	–
167	ba167	–	50	–	–	–	–	–	–	–	–	–	–	–	–	–	–
168	ba168	7	69	24	17	–	–	2	–	–	–	–	–	–	–	–	–
169	ba169	2	50	12	6	–	0	2	0	–	–	–	–	–	–	–	–
170	ba170	7	161	21	14	–	–	–	2	–	–	–	–	–	–	–	–
171	ba171	5	120	50	4	–	1	3	4	–	–	–	–	–	–	–	–

Table 9: Animal Type and Count

APPENDIX 05: SEQUESTRATION RATES ACROSS DIFFERENT VEGETATION STRATA IN RANCHES IN NORTHERN MEXICO

This study wished to report the soil carbon sequestration across different types of vegetation in Northern Mexico, and understand any potential differences across the types.

The ranches in Northern Mexico were first stratified into 3 different vegetation types – Semi-Arid (sparse vegetation), Dense short Vegetation and Tree Cover. This stratification was developed from land use/land cover classifications in the Global Land Analysis and Discovery (GLAD) dataset¹⁴³, produced by a research group at the University of Maryland, which is considered one of the state-of-the-art high resolution LULC datasets (0.00025 degree lat/lon resolution, roughly 30m). Given the small size of the vegetation features in this project, it is required to use a high resolution LULC map to differentiate between different types and levels of vegetations. In this grassland project, the important types of vegetation are denoted in three major classes - sparse/semi-arid areas with low to moderate vegetation cover (<75% cover); dense short vegetation areas with high vegetation cover (>=75% cover); and areas with tree cover of height 3 meter or above¹⁴⁴.

The GLAD dataset has built a machine learning system for doing these classifications, trained with an expert-labeled satellite image dataset¹⁴³. Similarly, for validating the system, 950 pixel locations were sampled around the world, stratified by land use/cover classes, and expert-labeled¹⁴⁴. Of these, 200 were from semi-arid areas, 100 from dense short vegetation areas and 300 from tree cover, and the model exhibits pixel-level validation precisions of **86.73%**, **70.45%** and **73.13%** respectively on these types¹⁴⁴. Given that the model has more than a dozen LULC classes, these values are relatively high for a global model. Beyond the published global validation data, we have also undertaken a region-specific validation to Northern Mexico, leveraging the 100 randomized ground soil sampling point locations from 2022 previously noted in the PDD. During the ground sampling, the field team took note of the land cover and recorded it as a percentage of vegetation cover and the presence or absence of trees, allowing for a direct mapping to the vegetation classes mentioned above. The results of the ground team also closely match observations of the vegetation on the point locations from the current Google Earth satellite images, as of September 2024, when the specified imagery dates for the ranches on Google Earth were in 2022 and 2023. Based on these validation ground locations, we found that the GLAD dataset has an

¹⁴³ Potapov P., Hansen M.C., Pickens A., Hernandez-Serna A., Tyukavina A., Turubanova S., Zalles V., Li X., Khan A., Stolle F., Harris N., Song X.-P., Baggett A., Kommareddy I., Kommareddy A. (2022) The global 2000-2020 land cover and land use change dataset derived from the Landsat archive: first results. *Frontiers in Remote Sensing*

¹⁴⁴ M.C. Hansen, P.V. Potapov, A.H. Pickens, A. Tyukavina, A. Hernandez-Serna, V. Zalles, S. Turubanova, I. Kommareddy, S.V. Stehman, X-P Song (2022) Global land use extent and dispersion within natural land cover using Landsat data. *Environmental Research Letters*, 17(3)

observed precision of **94%**, **100%** and **100%**, across the sampled locations, for semi-arid, dense short vegetation and tree cover respectively. Observe that these are high precisions for within the region. The only locations that were misclassified were locations classified as semi-arid that were labeled as dense short vegetation, and upon closer inspection were revealed to be locations that had a dense vegetation patch that was too small to be resolved in a 30x30m pixel dataset, or otherwise on the border between the dense short vegetation and semi-arid classes (very close to 75% vegetation cover threshold, making classification difficult). The validation locations we used are summarized again in the figure below. The global validation of the dataset from the peer-reviewed paper, and the subsequent validation in this work specific to the northern Mexico region, establish the GLAD LULC as a valid dataset to use in this region for understanding vegetation and tree cover and accordingly stratifying the ranch polygons.

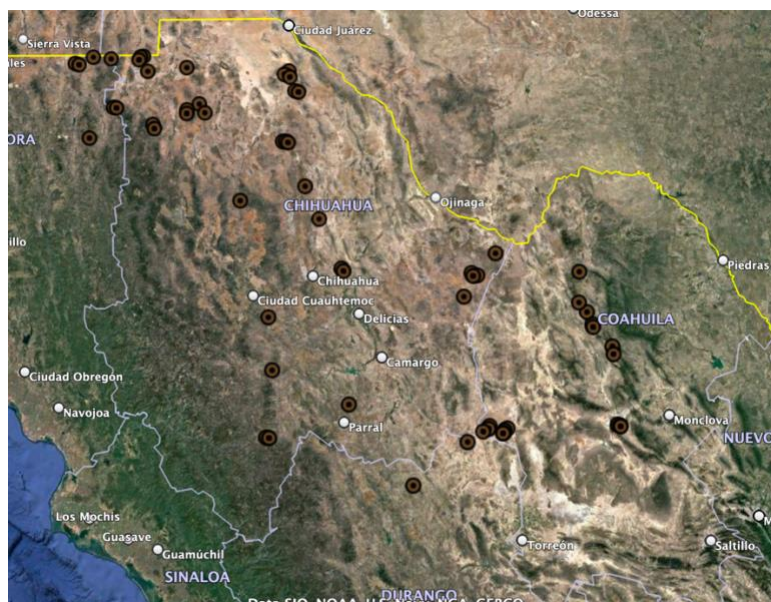


Figure 32. Locations of soil samples (brown markers) taken in Northern Mexico in 2022, across the project ranches. Figure copied from ATBD.

The GLAD dataset is thus used for each ranch to identify semi-arid, dense short vegetation and tree cover areas, to develop stratified sub-polygons for each ranch polygon. The resultant KML of the stratified polygons is separately available. Here is an example from the Ranch “Quelite”, located in the southern part of the state of Chihuahua.

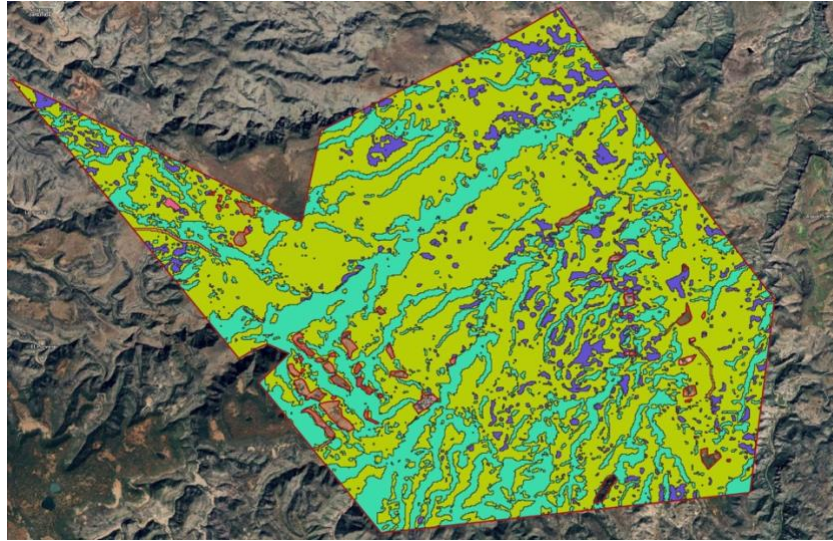


Figure 33. Quelite ranch, with stratification by vegetation type. Purple areas represent semi-arid, the green are tree cover and the yellow are dense short vegetation.

We then run our remote sensing SOC calculation algorithm on these strata, for a given ranch, and arrive at SOC change across the monitoring period (2018-2022) for each stratum. The results of this process are summarized for 4 different example ranches in the table below:

Ranch Name	Stratum	Ranch Area Fraction	SOC% increase
San Felipe	Dense Short Vegetation	0.5663	0.205479765
	Semi-Arid	0.214	0.201837757
	Tree Cover	0.2197	0.038887251
El Candido	Dense Short Vegetation	0.4753	0.020907507
	Semi-Arid	0.4227	0.017882591
	Tree Cover	0.102	-0.007806952
El Pinito	Dense Short Vegetation	0.262	-0.216068588
	Semi-Arid	0.3352	-0.199018553
	Tree Cover	0.4029	-0.228044207
El Quelite	Dense Short Vegetation	0.633	0.044556261
	Semi-Arid	0.0652	0.025998279
	Tree Cover	0.3018	0.018557982

These ranches were especially selected for their significant diversity in vegetation strata. Most ranches in Northern Mexico do not have this level of diversity and are primarily dominated by one class.

We observe that, in general, there are differences in sequestration rates between the strata, with tree cover seeing the least sequestration rates over the monitoring period, and dense short vegetation the most. This is what is already expected scientifically – areas with dense short vegetation will produce the

most biomass, and when rotational grazing is carried out, more of that biomass ends up in the soil resulting in higher carbon. Over the course of the project the dense short vegetation is expected to increase as well, at the expense of semi-arid areas as grass cover is restored.

On the other hand, areas with trees have lower sequestration rates, likely due to the trees absorbing a significant amount of nutrients from the soil and preventing the accumulation of more carbon in the soil. This matches existing scientific literature that shows that grasslands have much higher soil carbon stocks than woodlands¹⁴⁵.

Nevertheless, this study provides an insight into how the observed sequestration rates may vary between strata. To ensure that there is no emission leakage caused by livestock displacement driven by the rotational grazing activity, it is important to include all types of vegetation present within a ranch in the analysis of carbon.

It is important to note that the ranch-level results upon stratification are theoretically the same as the ranch-level results without stratification, but that in practice, the ranch-level results without stratification may be more accurate (and likely more conservative) than those with stratification. The calculation process of remote sensed soil organic carbon on the ranch level uses pixel-level data across the entire ranch, including all vegetation class. The process for stratum-level calculation does the same process for the individual strata, which are then combined to ranch-level with areal averaging. Thus, the final results are theoretically the same across both processes. However, in practice, the error of the results produced from the stratum-specific calculation might be higher compared to the direct ranch-level calculation, because of any errors associated with the calculation of pixels, which have a finite and defined size, that are contained within the spatial features of the strata. As can be seen in Fig 2, strata can be quite small, sometimes as small as the resolution of the LULC map itself (~30m). Across every boundary of a stratum that has its constituent pixels averaged, there are errors introduced in calculating the pixels that are interior to a stratum. For example, a given pixel may be located fully within the ranch polygon, and thus rightly included within the calculation of the ranch-level results without stratification, but may in fact have a stratum boundary crossing it, resulting in it not being included in any stratum's calculation, and thus not in the final ranch-level result produced with stratification. This source of error only occurs with the introduction of stratification, and is amplified by the amount that the summed perimeters of the constituent strata exceed the perimeter of the original polygon. These values are summarized below for the 4 example ranches noted earlier:

Ranch Name	Combined Perimeters across Strata (meters)	Ranch Perimeter (meters)
San Felipe	661,000	34,000
El Candido	963,000	54,700
El Pinito	1,930,000	172,000
El Quelite	2,490,000	308,000

¹⁴⁵ Guo, L.B. and Gifford, R.M. (2002), Soil carbon stocks and land use change: a meta analysis. *Global Change Biology*, 8: 345-360. <https://doi.org/10.1046/j.1354-1013.2002.00486.x>

As can be seen in the table above, the total combined perimeters of the strata are an order of magnitude higher than the ranch-level perimeter. All of these extra internal borders within the ranch have a potential to contribute to certain pixels being excluded in the strata-level calculations, while being rightly included in the ranch-level calculations done without stratification. Thus, although the ranch results with and without stratification are theoretically the same, there are greater errors introduced through the matching of pixels with strata that results in reduced accuracy in practice under the stratification approach. This reduced accuracy also increases the likelihood of a potential overestimation (and underestimation) of the carbon sequestration. Thus the ranch-level calculation with pixel-level data aggregated without vegetation stratification is both more accurate and likely more conservative.